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FOR LECTURE AND LABORATORY USE IN THE STUDY OF PHYSICS CHEMISTRY BIOLOGY AND GENERAL SCIENCE FOR UNIVERSITY AND OTHER EXAMINATIONS

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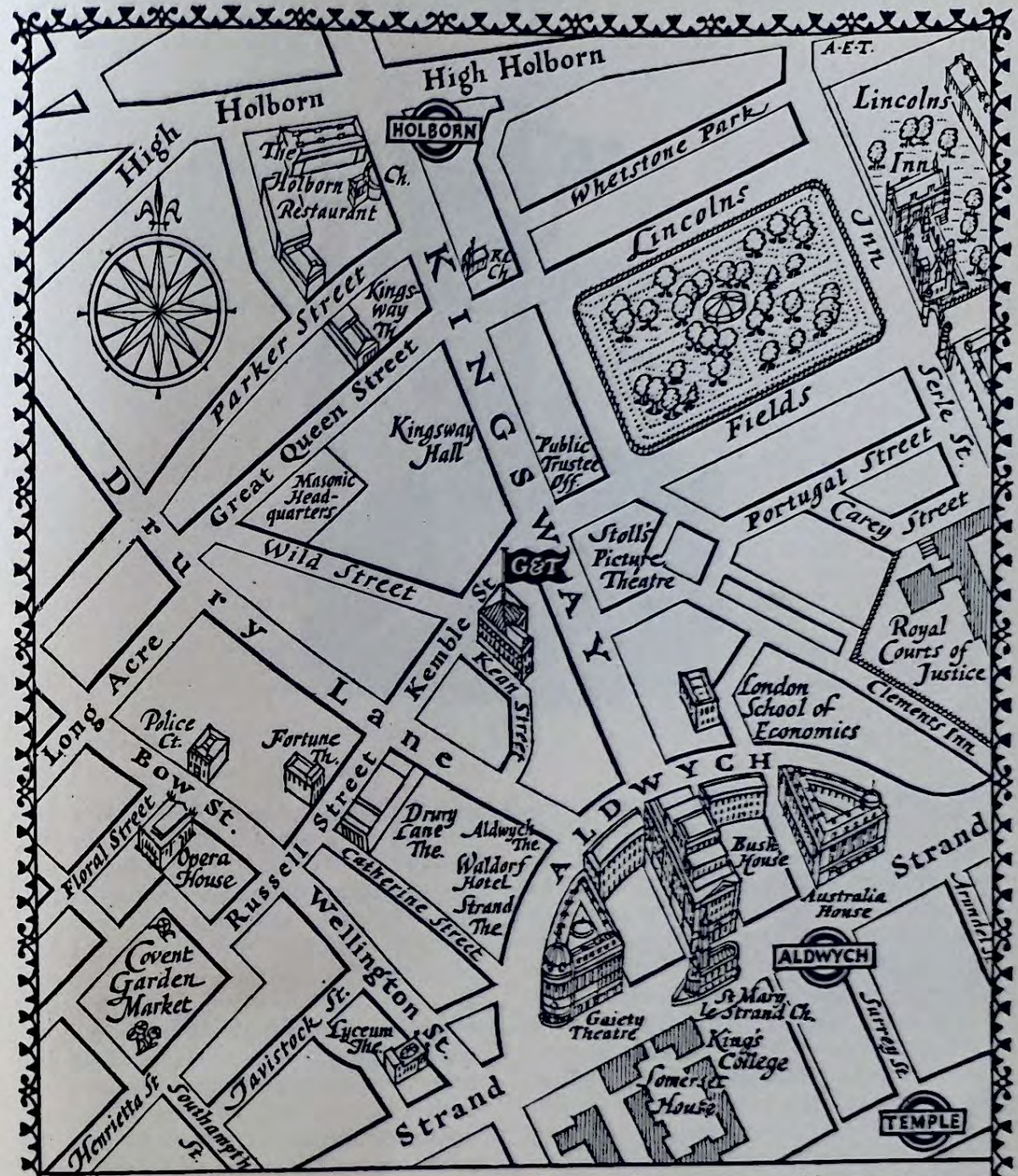

A Plan showing the Approaches to

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The Head Office and London Showroom of Griffin & Tatlock *Limited are indicated by a banner thus* G&T

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THE House of Griffin was first established in Glasgow in 1826, when John Joseph Griffin, F.C.S., a writer on technical subjects, received requests from his readers for scientific apparatus. The curious print here reproduced is taken from "The Book of Trades or Circle of the Useful Arts" (4th Ed.), published in 1837. In it the business is described as Griffin's Bazaar, a description, fashionable at the time, intended to indicate the great variety of Scientific Apparatus held in stock by the firm. The name Griffin's Chemical Museum was used alternatively.

The business was removed to London and conducted there by the sons of its founder at various addresses under the name of John J. Griffin & Sons (incorporated as a private limited liability company in 1889). Its importance grew rapidly during the XIX Century with the increasing application of Science to Industry and the growth of scientific education.

In 1925 old-established businesses in Glasgow, Manchester and Edinburgh were brought into the organisation and since 1928 the united businesses, with branches and agencies in many countries abroad, have been conducted solely under the name of Griffin and Tatlock Limited.

In 1944 the business of Standley Belcher and Mason Limited in Birmingham became associated with

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FOR ADDRESSES SEE TITLE PAGE



MICROID



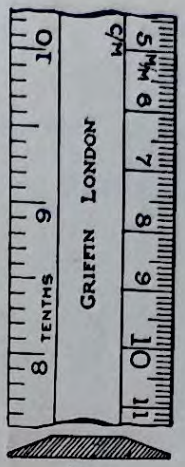
Registered Trade Marks of

GRIFFIN & TATLOCK LIMITED

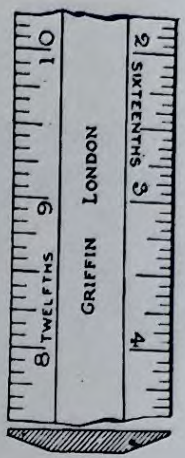
Metrology



A 11-050.



Front.



Back.

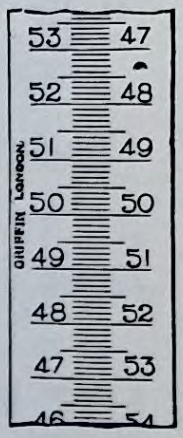
A 11-055.



A 11-060.



A 11-065.



A 11-070.

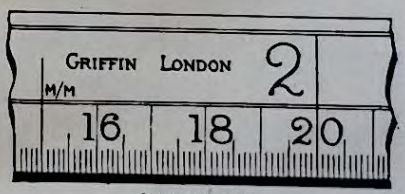
A 11-050. RULES, Boxwood, 12 in. long, $1\frac{1}{8}$ in. wide, both edges bevelled, one edge divided in mm., cm. and decimetres, the other in 10ths in. The back of the rule has four scales in 4ths, 8ths, 12ths, 16ths in., with protractor 30° to 90° .. *each* (*a*) 1/5 ; *dozen* — £ 0 15 0

A 11-055. Ditto, 12 in. long, $1\frac{1}{8}$ in. wide, both edges bevelled, **with four scales.** The front is graduated throughout in mm. and 10ths in., the back throughout in 12ths in. and 16ths in. .. .. *each* (*a*) 1/5 ; *dozen* — £ 0 15 0

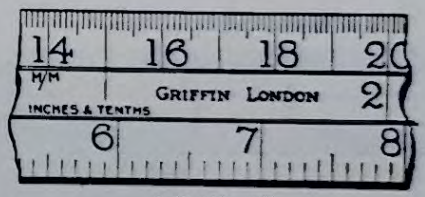
A 11-060. RULE, Boxwood, vertical reading, 1 metre long, 25 mm. wide, (for barometer tubes, etc.), with millimetre divisions on both edges, 2 sets of figures .. .. .. £ 0 5 6

A 11-065. Ditto, with one central set of figures .. .. £ 0 5 0

A 11-070. Ditto, divided down the centre in mm., figured every cm. up and down .. £ 0 5 0



A 11-090—095.



A 11-120—125.



A 11-170—180.

A 11-090. RULES, Boxwood, horizontal reading, 1 metre long, 25 mm. wide, divided throughout in mm. .. .. .. *each* 3/9 ; *dozen* — £ 1 19 0

A 11-095. Ditto, $\frac{1}{2}$ **metre long** .. .. *each* 2/- ; *dozen* — £ 1 1 0

A 11-120. RULES, Boxwood, 1 metre long, 25 mm. wide, double scale throughout, one edge in mm., the other in 10ths in. *each* 3/6 ; *dozen* — £ 1 17 6

A 11-125. Ditto, $\frac{1}{2}$ **metre long** .. .. *each* 2/- ; *dozen* — £ 1 1 0

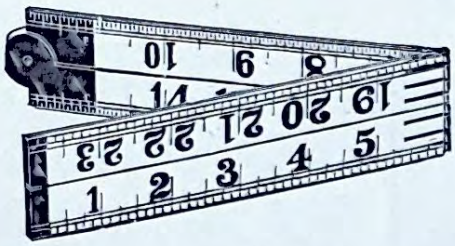
A 11-140. RULES, Boxwood, 1 metre long, 25 mm. wide, divided on both edges in mm., figured every cm., one edge reading left to right, the other right to left .. .. *each* 4/- ; *dozen* — £ 2 2 0

A 11-150. RULES, Boxwood, 36 in. long, 1 in. wide, divided on one edge in 8ths in. *each* 4/6 ; *dozen* — £ 2 9 0

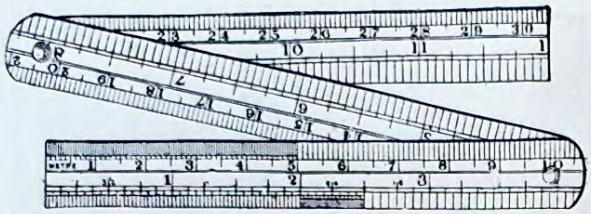
A 11-170. RULES, Manometer, Boxwood, suitable for use as U-tube manometer scales, direct reading, 1 in. figured as 2 in. so that rule is direct reading from one meniscus. Total length 24 in., both edges divided in 0·1 in. ; figured either side of zero up to 24 in. *each* 3/- ; *dozen* — £ 1 12 0

A 11-180. Ditto, total length 50 cm., both edges divided in mm., figured either side of zero up to 50 cm. .. .. *each* 3/- ; *dozen* — £ 1 12 0

LENGTH

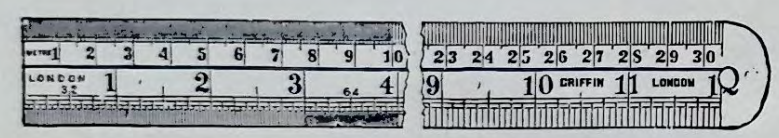


A 11-215.



A 11-230—235.

	£	s.	d.
A 11-215. RULE, Boxwood, Four-fold, 2 ft. long, $\frac{9}{16}$ in. wide, inches in 8ths, 16ths, 10ths and 12ths; cm. in mm.	0	2	9
A 11-230. RULE, Steel, Three-fold, machine divided, 12 in. long, $\frac{1}{2}$ in. wide, **marked on one side,** one edge inches in 8ths, 16ths, 32nds, 64ths, other edge cm. in mm. and 0·5 mm.	0	2	9
A 11-235. Ditto, Rustless Steel	0	3	9
A 11-240. Leather Case for **A 11-230—235**	0	0	6
A 11-250. RULE, Steel, Three-fold, machine divided, 12 in. long, $\frac{1}{2}$ in. wide, **marked on both sides** showing inches in 16ths, 32nds, 64ths, 10ths, 20ths, 50ths, and cm. in mm. and 0·5 mm.	0	4	6
A 11-255. Leather Case for above	0	0	6

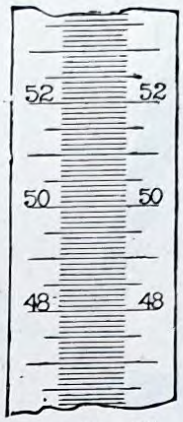


A 11-290.

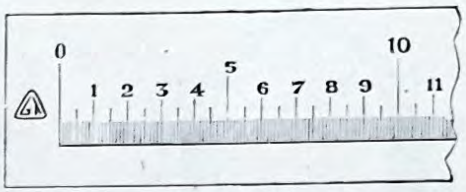
	£	s.	d.
A 11-290. STRAIGHT EDGE, Rustless Steel, best quality, machine-divided, cm. in mm. and 0·5 mm., inches in 10ths, 20ths and 50ths.			
Length 6 12 *in.*			
3/6 5/- *each.*			
A 11-325. STRAIGHT EDGE, Steel, machine divided, 1 metre long. Divided on one edge in cm., mm. and 0·5 mm. The other edge inches in 16ths, 32nds and 64ths	*r* 0	19	6
A 11-380. STRAIGHT EDGE, Stainless Steel, 1 metre long, with one bevelled edge, machine-divided in cm. and mm. Accuracy of dividing = 1 in 10,000. Tolerance for straightness ± 0·0008 in. and for parallelism ± 0·0016 in. per metre. Coefft. expansion of Stainless Steel average 6·2 × 10^{-6} per °F. Complete in stained wood case	*t* 5	5	0



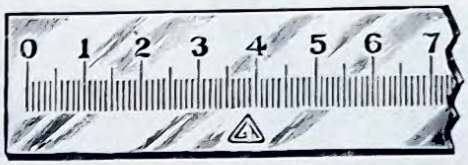
A 11-405—410.



A 11-415—420.



A 11-425—430.



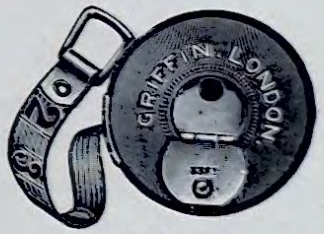
A 11-460—465.



A 11-480—485.

	£	s.	d.
A 11-405. SCALE, Paper, 1 metre long, vertical, with mm. divisions both edges, figures in centre, width 38 mm.	0	0	6
A 11-410. Ditto, ½ metre long	0	0	4
A 11-415. Ditto, 1 metre long, vertical, with mm. divisions in the centre, figured both edges. Total width of printed portion 38 mm.	0	0	6
A 11-420. Ditto, ½ metre long	0	0	4
A 11-425. SCALE, Paper, 1 metre long, horizontal, accurately divided in mm., printed direct from copperplate, width of graduated scale 30 mm.	0	0	6
A 11-430. Ditto, ½ metre long	0	0	4
A 11-460. SCALE, Glass, horizontal, 18 × 2·5 cm., graduated in mm. up to 15 cm.	0	4	6
A 11-465. Ditto, with silvered back	0	5	6
A 11-480. SCALE, Glass, vertical, 18 × 2·5 cm., graduated in mm. up to 15 cm.	0	4	6
A 11-485. Ditto, with silvered back	0	5	6


A 11-705—710.



A 11-780—785.

	£	s.	d.
A 11-705. RULE, Spring-Flex. A concavo-convex steel rule **under definite control, both coming out and going into the case.** The steel case is finished black and the sliding tip or stop permits accuracy both for "end on" or "hook over" measuring. Divided inches in 8ths, figured feet and inches. Length 6 ft.	*r* 0	5	0
A 11-710. Ditto, divided inches in 16ths. Length 6 ft.	*r* 0	5	0

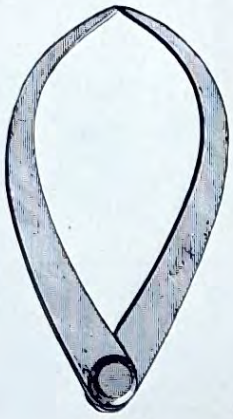
TAPE MEASURES, in leather case with folding handle. Marked both sides, metric measure on one side, English on the other.

Length	33	66	100 *ft.*
A 11-780. Woven Linen Tape, 9/16 in. wide	*r* **7/6**	**12/6**	**16/-** *each*
A 11-785. Metallic Wired Tape, § in. wide	*r* **12/6**	**18/6**	**25/-** *each*

LENGTH



A 11-850.



A 11-855.



A 11-860.



A 11-930.

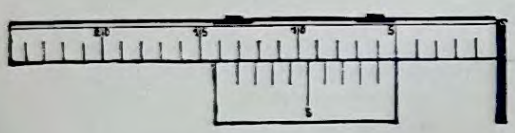
CALLIPERS, Steel.

Length ..		3	4	5	6	*in.*
A 11-850. Inside ..	*p*	14/6	17/6	23/-	27/-	*dozen*
	p	1/6	1/9	2/3	2/6	*each*
A 11-855. Outside ..	*p*	14/6	17/6	23/-	27/-	*dozen*
	p	1/6	1/9	2/3	2/6	*each*

£ s. d.

A 11-860. GAUGE, Thickness, direct reading, for measurement of thickness of plates, lenses, etc. Calibrated 0–14 mm. in 0·01 mm., with adjusting screw, clamping screw and pointer. Overall length $8\frac{3}{4}$ in. .. .. *t* 0 16 6

A 11-930. CALLIPERS, Vernier, inside and outside, nickel plated steel, reading $5\frac{1}{2}$ in. Double scale 16ths and mm., with verniers reading to 128th in., and 0·1 mm. Depth gauge reading from either vernier .. .. *each t* 0 14 0



A 11-950.

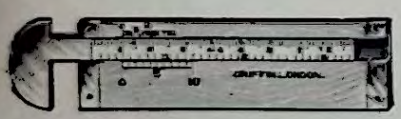


A 11-960.

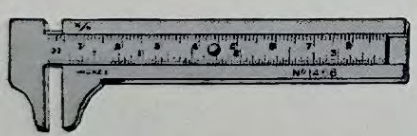
£ s. d.

A 11-950. VERNIER, Boxwood, 30 cm. long, divided in cm., with vernier reading to 0·1 of a scale division, *i.e.*, 1 mm. 0 12 6

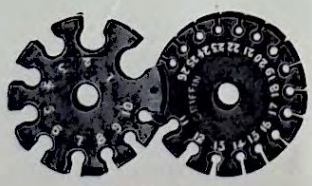
A 11-960. VERNIER, Boxwood, double form, 12 in. long, reading to 100ths in. and 0·1 mm. 0 10 6



A 11-970.



A 11-980.



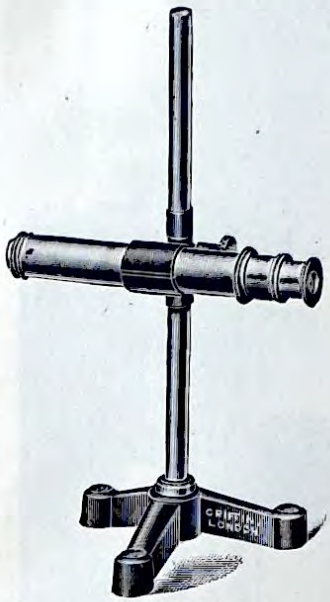
A 11-990.

£ s. d.

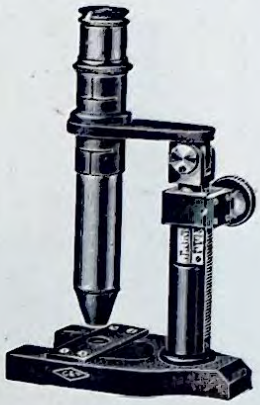
A 11-970. CALLIPERS, Vernier, Boxwood, with brass ends and slider, 4 in. long, divided in 10ths in. and mm., with verniers reading to 100ths in. and 0·1 mm. *each* 4/6; *dozen* 2 8 0

A 11-980. GAUGE, Calliper, brass, measuring to 3 in. in 32nds in., and 8 cm. in mm. *each t* 3/-; *dozen* 1 13 0

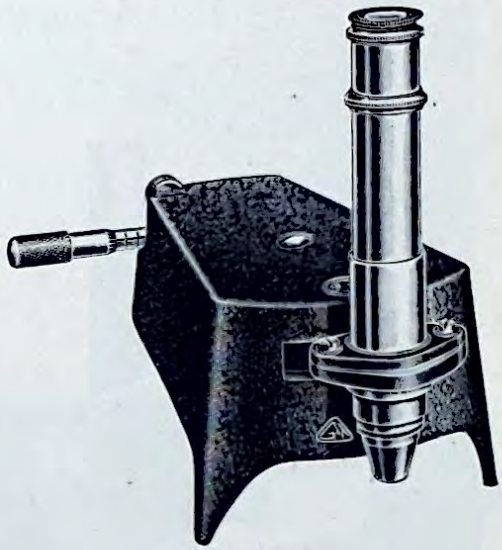
A 11-990. GAUGE, Standard Wire, double circular form. Gauges 1–36 .. .. *each r* 0 12 6



A 12-150.



A 12-160.



A 12-190.

	£	s.	d.
A 12-150. MICROSCOPE, Reading, on tripod stand 18 in. high, with holes for fixing to bench. Micrometer scale in eyepiece reading 10 mm. in 0·1 mm., fitted with 32, 48, or 64 mm. objective **A 12-290 b**	6	0	0

We supply with 32 mm. objective unless otherwise ordered.

A 12-160. MICROSCOPE, Reading, designed for measurement of Newton's rings, determination of refractive index by real and apparent depth method, etc. On horse-shoe base, pillar fitted with graduated scale and vernier reading to 0·1 mm. ; adjustable for height by rack and pinion. The microscope is a sliding fit in a sprung holder and is inclinable through a right-angle. With 32 mm. objective and eyepiece fitted with cross wires .. *r* 9 10 0

A 12-190. MICROID MICROMETER MICROSCOPE. A lever with equal arms, each 10 cm. long, is pivoted at its centre on a large ball bearing. One end is fitted with a microscope body having 32 mm. objective, and eyepiece with micrometer scale and cross wires. A micrometer, range 25 mm. × 0·01 mm., bears against a ball mounted on the opposite end of the lever, which is spring loaded. The mechanism is housed in a neat cast case supported on three feet .. .. *r* 16 0 0

There has long been a need for an inexpensive type of microscope reading more accurately than the usual type, for use in measuring small distances, such as diameters of capillary tubes, angle of Fresnel's biprism, diameters of Newton's rings, etc. The mechanical construction of this new Microid instrument has been greatly simplified by arranging the microscope body to move in the arc of a circle. Since the radius of this circle is 10 cms., the error involved in small measurements is quite negligible for most educational purposes.

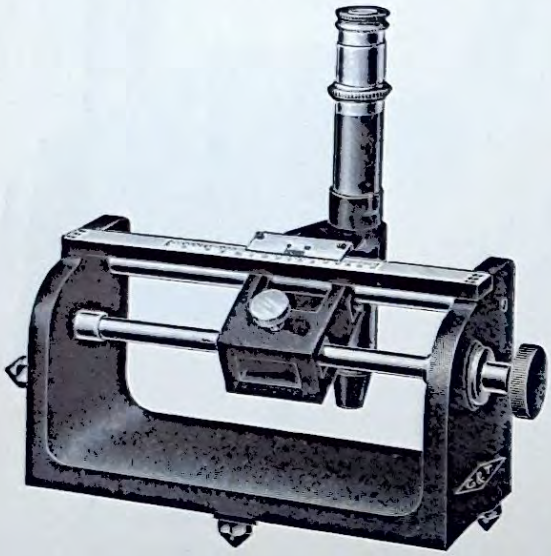
The screw shown in centre top of case can be removed and a rod, threaded at one end, substituted for it. To this rod small objects, such as a Fresnel biprism, can be attached and their angles measured to an accuracy > 0·01°. The rod is stored in the lever beneath the microscope.

Reading Telescopes and Cathetometers, see p. 9.

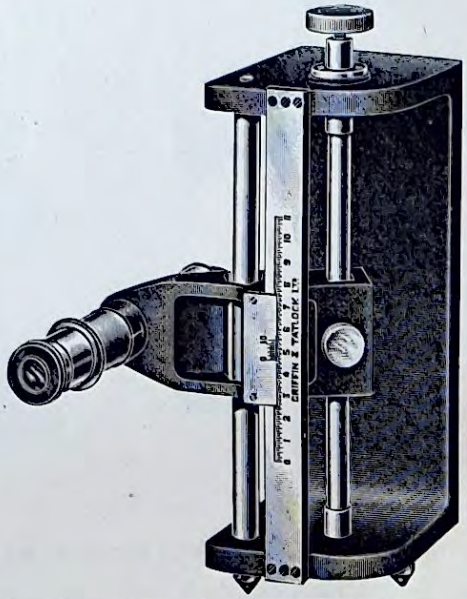
MICROID VERNIER MICROSCOPES

Accurate and inexpensive models

Registered Design No. 777521



A 12-260—265.—Vertical position with horizontal traverse.



A 12-260—265.—Horizontal position with vertical displacement.

SPECIFICATION OF SIMPLE MODEL.

The base supporting the microscope is a heavy casting $8\frac{3}{4} \times 3\frac{1}{2} \times 4\frac{1}{4}$ in., open at the top and sides, the ends being braced together by a stainless steel rod $\frac{3}{8}$ in. diam. and by an L-section bar which carries the scale. The microscope body is held in a carriage by a sprung tube in which it may be adjusted. The carriage slides on two rods, one of which is fixed and the other, to which the carriage may be clamped after it has been roughly adjusted, is movable. The latter rod is located at each end in a sleeve, one sleeve containing a spring which is in compression against the end of the rod and the other sleeve a fine pitch screw. When the carriage is clamped to the rod, rotation of the screw causes a movement of the microscope which, owing to the fine pitch of the screw, may be accurately controlled.

A vernier fitted to the carriage moves with this over the scale and enables readings to 0·1 mm. to be taken. Feet are fitted to the under side of the base casting and to one end of it thus enabling the microscope to be used in either a vertical or a horizontal position.

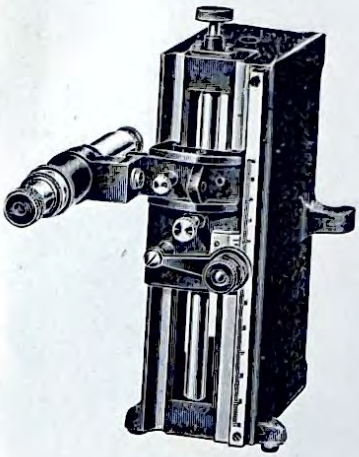
	£ s. d.
A 12-260. MICROID VERNIER MICROSCOPE, Simple Model, for use in two positions, with 32 mm. objective, eyepiece with crosswires, silvered scale graduated 0–11 cm., vernier reading to 0·1 mm.	*r* 5 15 0
A 12-265. Ditto, but with vernier reading to 0·05 mm.	*r* 6 5 0
A 12-270. T-Adapter for above, to enable microscope body to be set parallel with scale and measurements to be taken vertically with vertical displacement, for refractive index by real and apparent depth method, etc.	*r* 0 10 0

Accessories for A 12-150—265

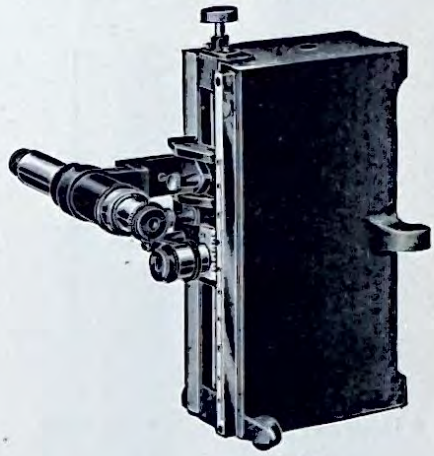
A 12-280 a. Telescope Objective, to replace the microscope objective, thus converting the instrument into a reading telescope or table cathetometer .. .. *r* 1 7 6

" " **b. Objectives, Vernier Microscope.**

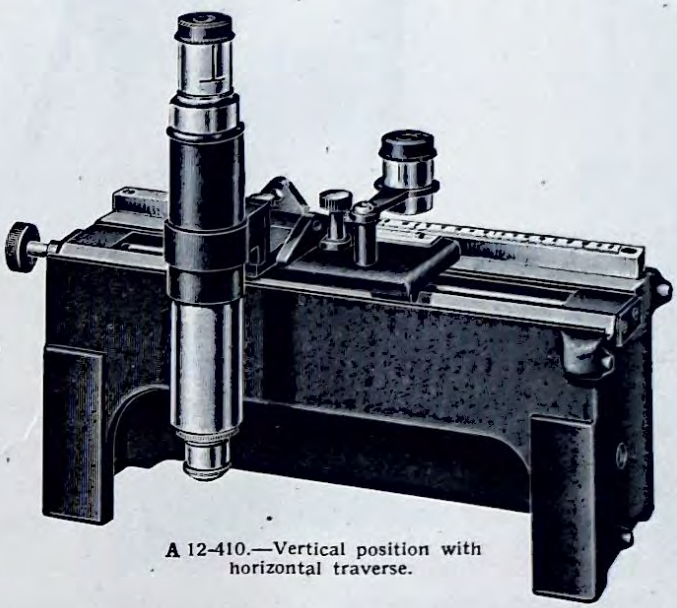
Focal length approx.	16	32	48	64	96	*mm.*
Working distance approx.	11·5	35	72	96	215	*mm.*
	20/-	25/-	30/-	37/6	40/-	*each*



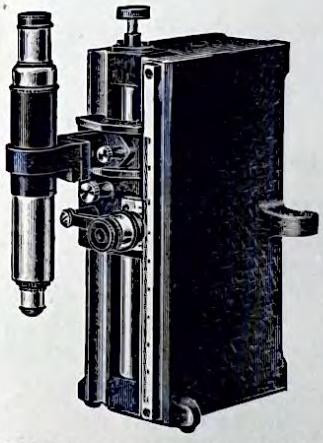
A 12-410.—Horizontal position, vertical displacement.



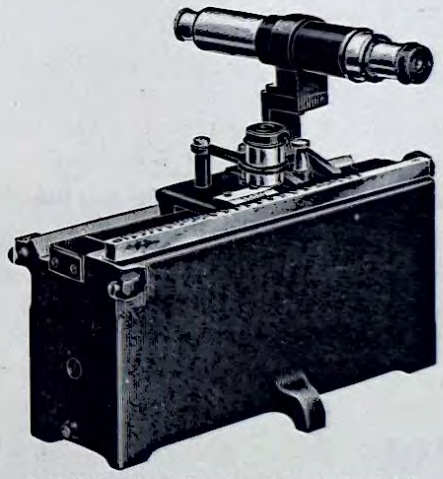
A 12-410.—Alternative horizontal position, vertical displacement.



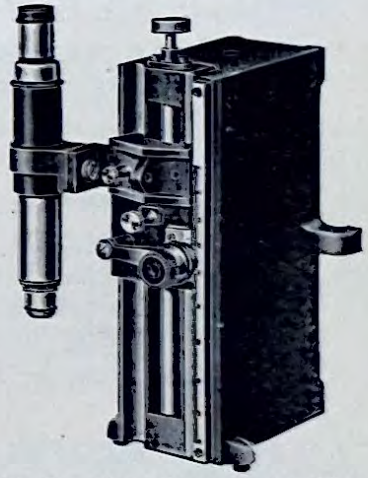
A 12-410.—Vertical position with horizontal traverse.



A 12-410.—Vertical position, vertical displacement.



A 12-410.—Horizontal position, horizontal traverse.



A 12-410.—Alternative vertical position, vertical displacement.

		£	s.	d.
A 12-410. VERNIER MICROSCOPE, for use in six positions. The base is an iron casting with a vee, and a flat machined on the top surface. The microscope is mounted on a travelling carriage sliding along this surface and can be clamped to a spring-controlled bar. Fine adjustment is provided by a fine pitch screw bearing against the end of the bar. For any given position of the base the microscope body is adjustable in three directions at right angles. Fitted with sliding focussing, scale 16·5 cm. long with vernier reading to 0·02 mm., magnifier for reading vernier, one objective 16, 32 or 48 mm. and eyepiece with crosswires	*t*	10	0	0
A 12-415. Ditto, but with rack and pinion focussing	*t*	11	10	0

We supply with 32 mm. objective unless otherwise ordered.

Accessories for Vernier Microscope A 12-410—415

A 12-420 a. Case, wood		1	10	0
„ „ **b. Telescope Objective,** to replace the microscope objective, thus converting the instrument into a reading telescope, or table cathetometer	*t*	1	7	6

LENGTH



A 12-710—720.



A 12-725.



A 12-750.



A 12-920—925.



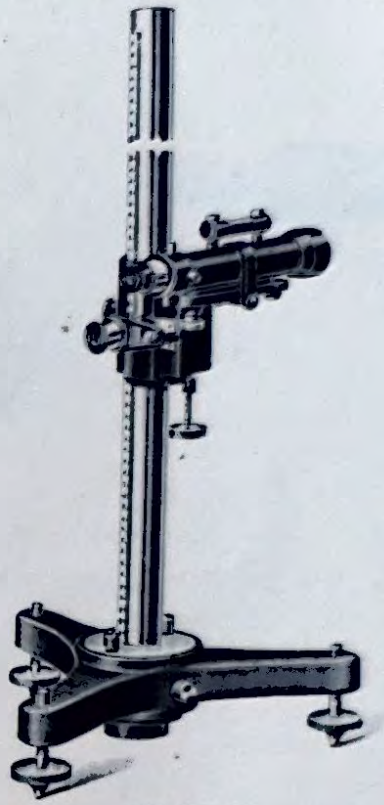
A 12-940.

	£	s.	d.
A 12-710. EYEPIECE MICROMETER, glass disc 21 mm. diam., with 10 mm. scale, divided into 0·1 mm.	0	15	0
A 12-715. **Ditto**, with 5 mm. scale, divided into 0·05 mm.	0	15	0
A 12-720. **Ditto**, with 2 mm. scale, divided into 0·02 mm.	0	15	0
A 12-725. **Ditto**, with 10 mm. scale, divided into 0·1 mm., and with crosslines .. .. *tx*	0	17	6
A 12-750. EYEPIECE MICROMETER, step, glass disc 21 mm. diam., divided into 0·1 mm. *tx*	0	17	6
A 12-770. EYEPIECE SCALE, squared, glass disc 21 mm. diam., with circle 17 mm. diam. ruled in squares 0·25, 0·5, or 1 mm. *(Please state size of square when ordering)* .. *tx*	0	14	0
A 12-775. GLASS DISC, 21 mm. diam., ruled with crosslines .. .. *tx*	0	7	0
A 12-805. EYEPIECE, Huyghenian type, to take any of the above eyepiece micrometers or scales. With focussing eye-lens, magnification × 6	1	7	6
A 12-810. STAGE MICROMETER, on 3 × 1 in. slide, scale 10 mm. long, divided into 1 mm. The last mm. divided into 0·1 mm.	1	1	0
A 12-820. **Ditto**, scale 1 mm. long, divided into 0·1 mm. The last 0·1 mm. divided into 0·01 mm. .. .. *tx*	0	18	9
A 12-830. **Ditto**, scale 0·1 in. long, divided into 0·01 in. The last 0·01 in. divided into 0·001 in. *tx*	0	18	9
A 12-920. SCALEOMETER, a pocket measuring microscope. When laid on the object or depression which it is required to measure, the length is read off directly on the finely divided scale which is in the focal plane of the eye-lens. In velvet lined case, with two scales 10 mm. in 0·1 mm. and $\frac{1}{2}$ in. in 0·01 in. and with handle .. .. *t*	1	15	0
A 12-925. Scales only, for **A 12-920**, reading to 0·1 mm., 0·01 in., or 0·001 in. .. *each t*	0	7	0
When ordering please state type of scale required.			
A 12-940. SCALEOMETER MICROMETER, similar to **A 12-920**, but provided with an optical system to give a magnification of 25. Screw focussing for scale, and sliding focussing combined with screw focussing fine adjustment for the object. In mahogany case with one scale either 10 mm. in 0·1 mm., $\frac{1}{2}$ inch in 0·01 in., or 0·25 inch in 0·001 in. .. *t*	2	6	0
When ordering please state type of scale required.			
A 12-945. **Ditto**, fitted with circuric illumination attachment for viewing dark objects, in case with lamp, battery and switch .. .. *t*	3	6	0

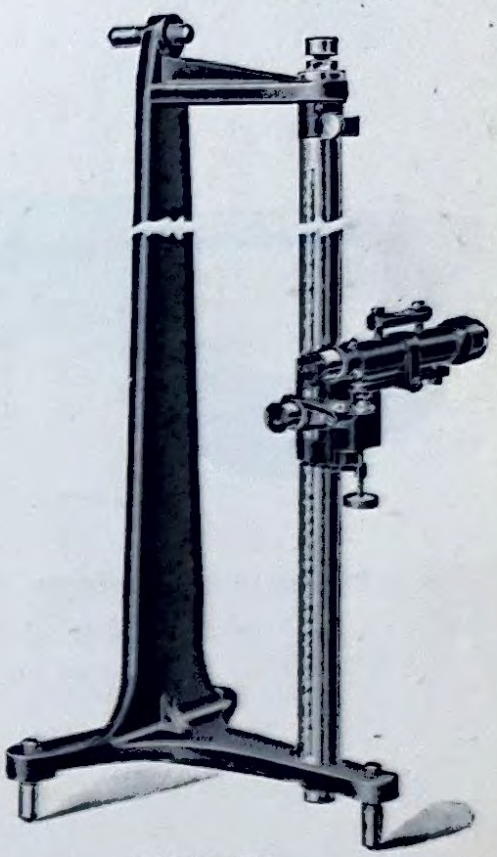
Customers abroad may be assured that their orders will receive particular and individual attention. Orders for Export are handled in a department organised for the purpose, and packing is carried out with special care. Orders for goods other than our own may be included and will be charged at makers' prices.



A 13-150.



A 13-180—185.



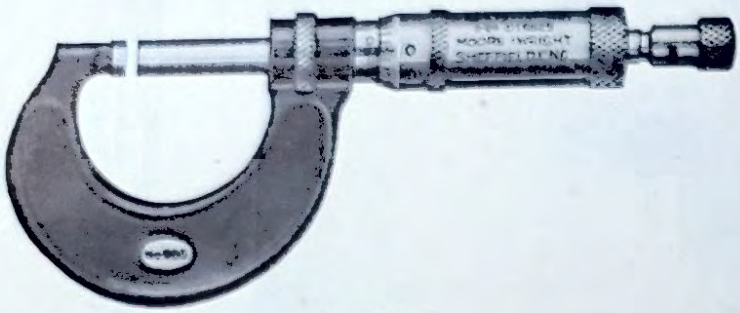
A 13-210—225.

		£	s.	d.
A 13-150.	**TELESCOPE, Reading,** on tripod stand, 12 in. high, with objective 24 mm. diam., cross wires, horizontal and vertical movements, on fully universal joint, adjustable from 3 ft. to infinity	4	0	0
A 13-160.	**Ditto,** with spirit level fitted to telescope	4	15	0
A 13-180.	**CATHETOMETER,** with 50 cm. scale reading by vernier to 0·02 mm. A round brass bar with engraved scale in mm. is mounted on a brass disc which rotates on an iron tripod fitted with levelling screws. Fine adjustment is obtained by an auxiliary slide actuated by micrometer screw. The telescope has objective 1¼ in. aperture, about 6 in. focus, Ramsden eyepiece with cross-webs, and is capable of focussing objects at 3 ft. to infinity. It is fitted with spirit level and has fine thread screw for horizontal adjustment	16	0	0
A 13-185.	**Ditto,** reading to 0·01 mm.	18	0	0
A 13-210.	**CATHETOMETER** similar to **A 13-180,** but having strong iron support for use in **vertical or horizontal** position. The brass bar, divided in mm., rotates on two centres and can be clamped in any position. With 50 cm. scale reading to 0·02 mm.	16	0	0
A 13-215.	**Ditto,** reading to 0·01 mm.	18	0	0
A 13-220.	**Ditto,** with 100 cm. scale reading to 0·02 mm.	22	0	0
A 13-225.	**Ditto,** with 100 cm. scale reading to 0·01 mm.	25	0	0

Extra Parts for Cathetometers A 13-180—225

A 13-240 a.	**Rack and Pinion** to telescope	1	10	0
" " **b.**	**Telescope, mounted in Vees** for reversing	2	10	0
" " **c.**	**Micrometer Head to Slide,** giving a direct reading to 0·01 mm. for a length of 13 mm.	3	0	0
" " **d.**	**Polished Wood Case** for 50 cm. Cathetometer	3	0	0
" " **e.**	**Ditto,** for 100 cm. Cathetometer	4	0	0

Reading Microscopes, see p. 5



A 13-750.



A 13-780.

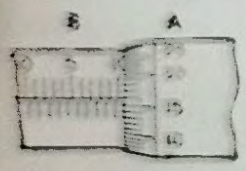
A 13-750. GAUGES, Micrometer Screw, precision made, with hardened and ground screw, black enamelled, I-section frame, light, but strong. Decimal equivalents engraved on thimble. With ratchet and lock nut. In sliding-lid wood box, with setting key.

Range	0-1 *in.*	0-25 *mm.*
Reading in	0·001 *in.*	0·01 *mm.*
	t 34/-	34/- *each*

£ s. d.

A 13-780. GAUGE, Micrometer Screw, precision made, with hardened and ground screw, bright steel throughout, decimal equivalents engraved on frame. With ratchet and lock nut. Range 0-0·5 in., reading in 0·001 in. In leather covered steel case with spanner .. *t* 1 14 0

HOW TO READ A MICROMETER GRADUATED TO 0·01 mm.



The screw in these micrometers for metric measurement has a pitch of 0·50 mm. One complete turn of the screw advances the head 0·50 mm.

To the spindle is attached a thimble A, the edge of which is bevelled and divided into 50 parts, each of which thus represents one hundredth of a millimetre. On the inner sleeve B is engraved a line parallel to the axis of the screw. This is called the datum line and when the micrometer is closed the zero mark on the thimble coincides with it. All measurements are taken from this point. The sleeve is graduated with a number of transverse lines, and with each complete revolution of the thimble a new transverse line comes into view, *i.e.*, each transverse line denotes an opening of the micrometer of 0·50 mm. It should be noted that the top row of graduations, which represent mm., are numbered every fifth graduation, the bottom row of graduations sub-divides the mm. graduations and represents 0·50 mm. The reading on the illustration shown is 1·006 cm.

The same procedure is used with a micrometer screw gauge reading in inches.

Griffin and Tatlock Limited are complete Laboratory outfitters and design and manufacture Laboratory Furniture and Apparatus of the most varied character.



A 13-840.



A 13-890.

	£	s.	d.
A 13-840. SPHEROMETER, 0·5 mm. pitch screw, with head divided in 100 parts. To read to 0·005 mm. Feet 4 cm. apart .. .. *p*	0	12	6
A 13-845. Glass Plate, with ground edges, 4 in. square, ¼ in. thick, for use with above ..	0	3	0

A 13-890. MICROMETER SPHEROMETER, Direct Reading. This new spherometer takes advantage of the high engineering precision to which micrometer screws are made. It is easier to read than the conventional type, is accurate, and maintains that accuracy indefinitely, owing to the long bearing in which the screw travels.

The base is a stout casting provided with three legs based on a circle of 65 mm. diameter. The pitch of the screw is 0·5 mm. and the cylindrical thimble is divided into 50 parts thus giving 0·01 mm. as the value for each graduation, with the possibility of accurate setting to 0·001 mm. The range of the screw is 25 mm. The zero is set at 5 mm., enabling both concave and convex surfaces to be measured. The screw is removable for use on other apparatus when desired. A backlash adjustment is incorporated *r* 3 0 0



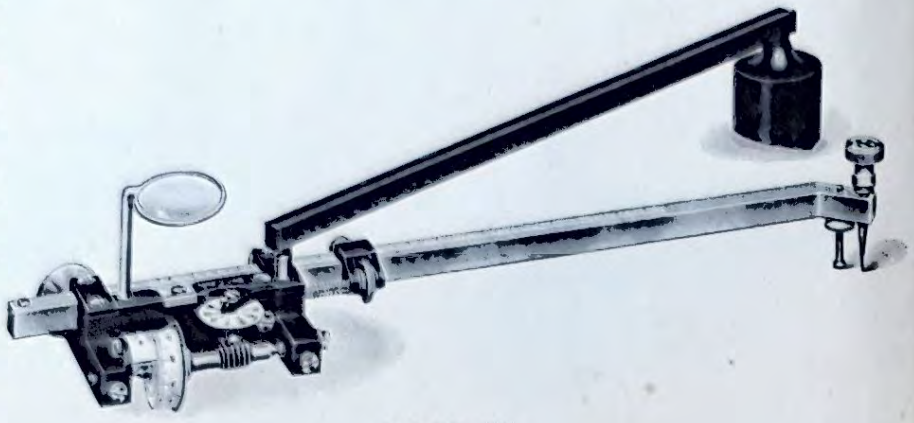
A 13-930.



A 13-940.

	£	s.	d.
A 13-930. OPTICAL LEVER, simple form, having points on a plane with the optically worked plane mirror, 1 cm. diam., fixed at right angles to the plane of the base. The distance from the single ball point behind the mirror to the line joining the other two (about 1 in.) may conveniently be measured from the impressions on a sheet of paper, which will be sufficiently accurate for most purposes .. .. *r*	0	8	6
A 13-940. OPTICAL LEVER, best quality. The base and support for the mirror is a solid casting. The mirror, ¾ in. diam., of specially selected glass, is supported in adjustable pivots and can be rotated so that the zero in any experiment may be rapidly adjusted. Two fixed feet are provided beneath the mirror. A third adjustable foot with fine pitch screw actuated by milled head provides fine adjustment of zero	2	7	6

PLANIMETERS, Polar, Allbrit, Sliding Bar Pattern, British Made, for the measurement of areas direct from plans to any of the following scales, full size : square cms. ; square in. ; acres to scales of 1/2500, 1/500 ; 6 in. = 1 mile ; square ft. to scales of $\frac{1}{8}$, $\frac{1}{4}$, $\frac{3}{8}$, $\frac{1}{2}$ in. to one foot. The required setting is obtained by reference to the table supplied with each instrument. Complete in case with test bar and magnifier which can be attached to enable either vernier to be read with ease, with book of instructions. Weight of instrument 11 oz., size of case 10 × $3\frac{1}{2}$ × $1\frac{3}{4}$ in.



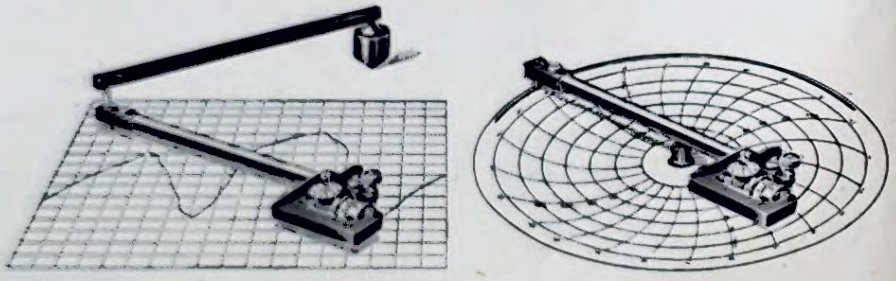
A 14-150—155.

	£	s.	d.
A 14-150. Planimeter, as specified above, range, maximum 28 in. diam.	6	8	0
A 14-155. Ditto, range, maximum 45 in. diam.	8	13	4

A 14-160. PLANIMETER, Polar, Allbrit, Fixed Index Pattern, similar in general construction to Sliding Bar Pattern **A 14-150**, but with fixed carriage. The instrument records in either square in., or square cm. only. For areas other than full size, conversion tables are necessary to find the true area. Complete in case with test bar and book of instructions. Weight of instrument 8 oz., size of case 8 × 3 × 2 in. Range, maximum 20 in. diam. 5 4 0

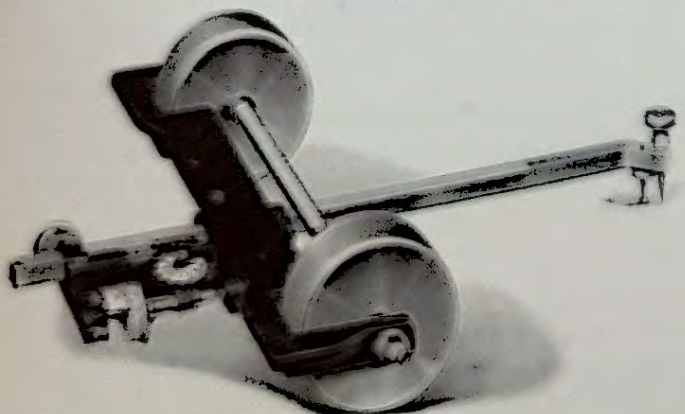
Please state whether required for square in., or square cm., when ordering.

A 14-170. PLANIMETER, Allbrit, Standard Radial Pattern, for integrating circular charts only, where the radial lines of the chart are equally spaced. Complete in case, with book of instructions. Maximum radius $6\frac{3}{4}$ in. £7 0 0



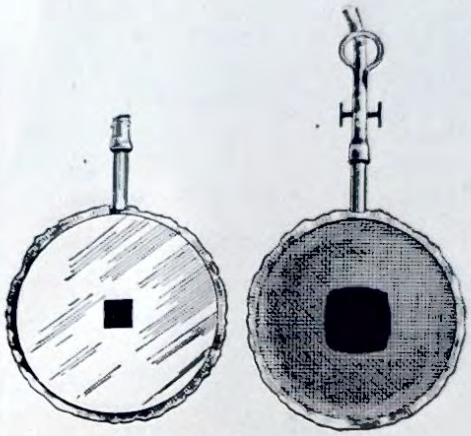
A 14-180.

	£	s.	d.
A 14-180. PLANIMETER, Allbrit, Universal Pattern. This instrument consists of a radial planimeter equipped with a pole arm, and combines the functions of the Fixed Index and Standard Radial Planimeters. Complete in case, with book of instructions. Weight of instrument 9 oz., size of case $11\frac{1}{4}$ × 3 × $1\frac{3}{4}$ in. Range, on circular charts 8 in. diam., as polar instrument, maximum 31 in. diam.	8	13	4

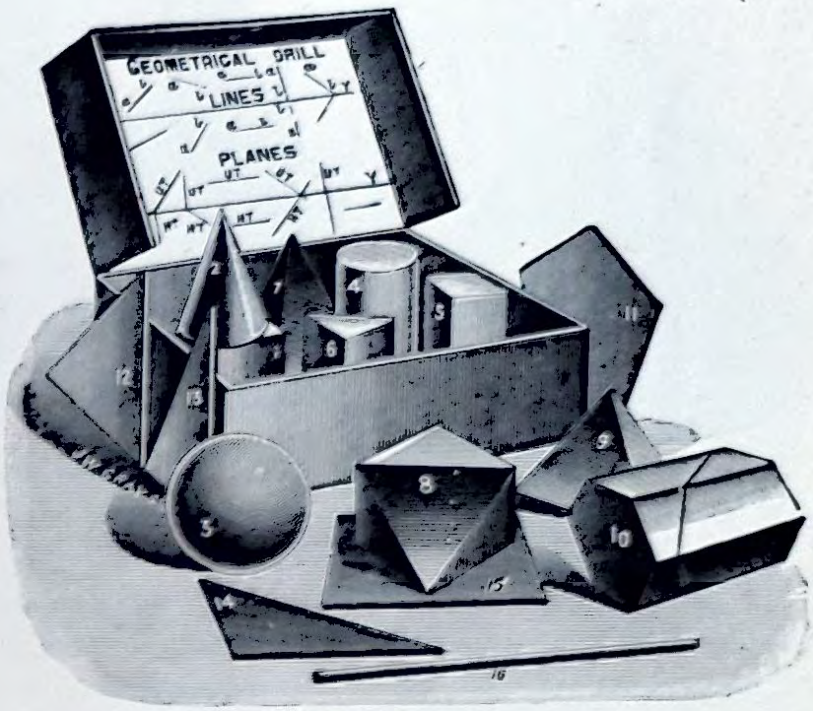


A 14-190.—Planimeter with Pole Wagon.

A 14-190. Pole Wagon, an accessory to the Sliding Bar, Fixed Index, or Universal Planimeters, for facilitating the measurement of the area of a strip of any length: *e.g.* to find the mean reading of a long indicator diagram. The wagon has a central pivot which replaces the pivotal end of the usual pole-arm and keeps the planimeter in a perfectly straight course. Complete in case. Weight of instrument 2 lb., size of case $8\frac{1}{2}$ × $5\frac{1}{2}$ × $3\frac{1}{2}$ in. .. £3 13 4



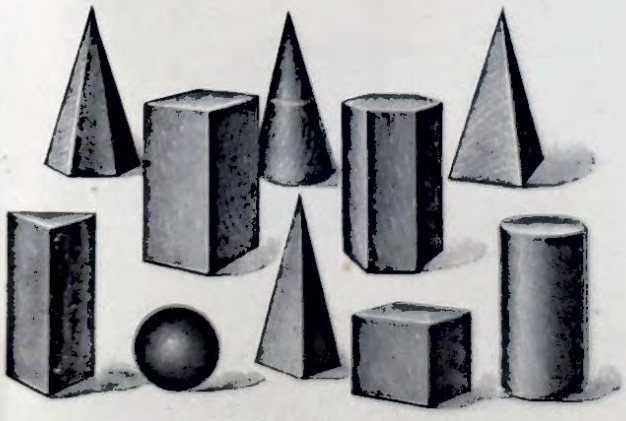
A 14-350



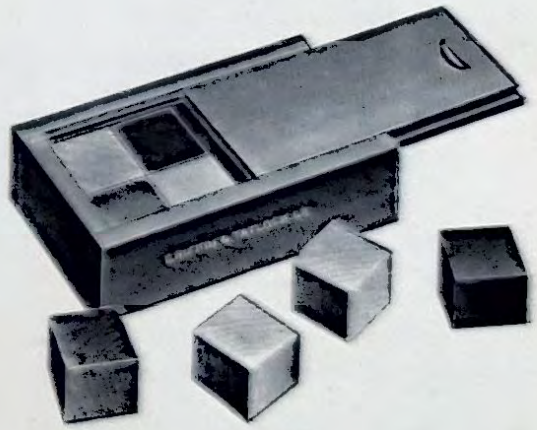
A 14-390.

A 14-350. AREA OF SPHERE APPARATUS to show that the area of a sphere is four times that of the hemispherical section. A circular elastic bag which can be inflated to the shape of a sphere. It will be found that the black square has an area on the inflated sphere equal to four times that before inflation .. .. *p* 0 10 0

A 14-390. GEOMETRICAL MODELS, The "Pupil's Set," in cardboard box. Containing fifteen accurately finished wood models and cardboard figures and metal straight rod
Price on application.



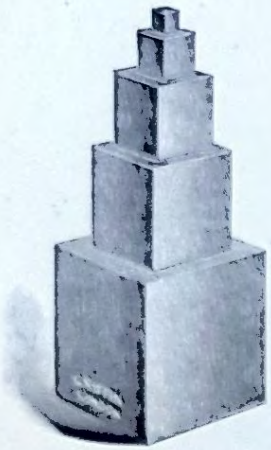
A 14-420.



A 14-430.

A 14-420. SOLIDS, Wood, Set of 10, 10 cm. high, 5 cm. base. Cube, cylinder, sphere, cone with single horizontal section, triangular, rectangular, and hexagonal pyramids, triangular, rectangular and hexagonal prisms, in box .. .. £ s. d. 1 10 0

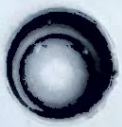
A 14-430. CUBES, Wood, Set of 8, ash, beech, boxwood, ebony, mahogany, oak, poplar and walnut, 2 cm. side, in box 0 12 6



A 14-470—500.



A 14-560.



A 14-585.



A 14-595.

A 14-620—625.



A 14-645.

CUBES, Wood.

	Hardwood.	Ash.	Beech.	Boxwood.	Ebony.	Oak.
A 14-470. Side 1 cm.	*Prices on application.*					
A 14-475. Side 2 cm.	*Prices on application.*					
A 14-480. Side 1 in.	*Prices on application.*					

CUBES, Metal.

	Aluminium.	Brass.	Copper.	Iron.	Lead.	Marble.	Tin.	Zinc.
A 14-490. Side 1 cm. ..	*Prices on application.*							
A 14-495. Side 2 cm. ..	*Prices on application.*							
A 14-500. Side 1 in. ..	*Prices on application.*							

A 14-520. **CUBES, Metal, Set of 7,** 1 cm. side, aluminium, brass, copper, iron, lead, tin and zinc, in card box .. .. *Price on application.*

CYLINDERS, Metal.

	Mild Steel.	Copper.	Brass.	Lead.	Aluminium.	
A 14-540. size $1\frac{1}{4} \times \frac{5}{8}$ in. ($l \times d$)	1/-	1/6	1/-	2/-	1/6	*each*
A 14-545. size 3 × 1 cm. ($l \times d$)	1/-	1/6	1/-	2/-	1/6	*each*

	Hardwood.	Boxwood.	Ebony.	Brass.	
A 14-560. CYLINDERS, 3 × 3 cm. ..	1/9	2/-	3/-	4/6	*each*

SPHERES.

Diam.	$\frac{5}{8}$	$\frac{1}{2}$	$\frac{3}{4}$	1	*in.*
A 14-570. Brass	1/3	2/6	11/-	27/6	*dozen*
A 14-575. Steel, polished	1/3	2/6	8/6	15/-	*dozen*

	Hardwood.	Boxwood.	Ebony.	Brass.	
A 14-585. SPHERES, 3 cm. diam. ..	2/6	3/-	3/6	*Price on application.*	*each*
A 14-595. CONES, 3 × 3 cm.	1/6	1/9	2/-	4/3	*each*

		£	s.	d.
A 14-620. **CYLINDER, SPHERE AND CONE, Hardwood,** of same height, 3 cm., and same diam., 3 cm., for comparison of volumes	*set*	0	5	9
A 14-625. Ditto, **Brass**	*set*	1	5	0
A 14-645. **RIGHT CONE, Hardwood,** 8 in. high, in four sections, showing circle, ellipse, parabola, and hyperbola		2	15	0


A 14-710.


A 14-715.


A 14-740.


A 14-780.


A 14-790.

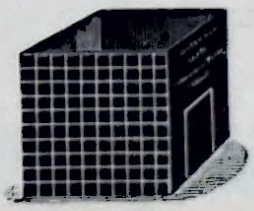
		£	s.	d.
A 14-710.	**PYRAMID, Hardwood, Triangular,** 2 in. high, base 1 in. side	0	2	3
A 14-715.	**Ditto, Rectangular,** 2 in. high, base 2 × 1½ in.	0	2	6
A 14-720.	**Ditto, Hexagonal,** 2 in. high, base 1½ in. diam.	0	2	9
A 14-740.	**PRISM, Hardwood, Triangular,** 2 in. high, base 1½ in. side	0	2	3
A 14-745.	**Ditto, Rectangular,** 2 in. high, base 2 × 1½ in.	0	2	6
A 14-750.	**Ditto, Hexagonal,** 2 in. high, base 1½ in. diam.	0	2	9

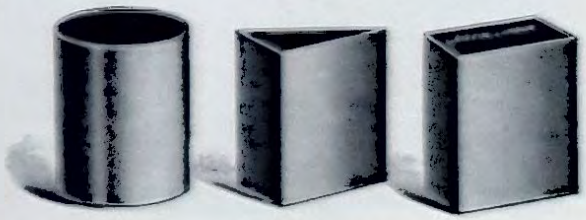
A 14-780. RECTANGULAR BLOCKS, Wood.

Dimensions ..	2 × 2 × 1	2 × 2 × 2	2 × 4 × 3	3 × 3 × ⅜	3 × 3 × 1½	*in.*
p	10/-	15/-	20/-	7/6	15/-	*dozen*
p	11d.	1/5	1/10	9d.	1/5	*each*

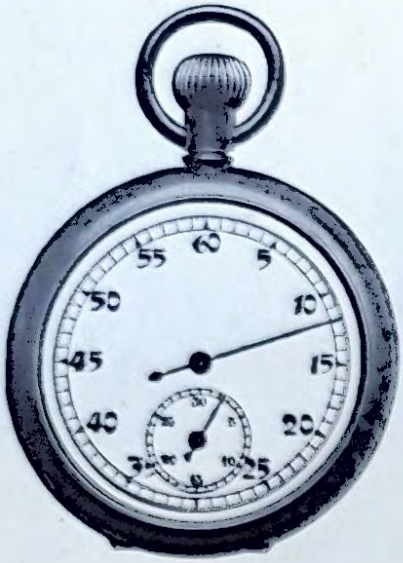
A 14-790. DISCS (Cylinders), Wood, 1 in. thick.

Diam.	2	3	4	6	8	*in.*
p	10/-	15/-	20/-	35/-	40/-	*dozen*
p	11d.	1/5	1/10	3/6	3/9	*each*

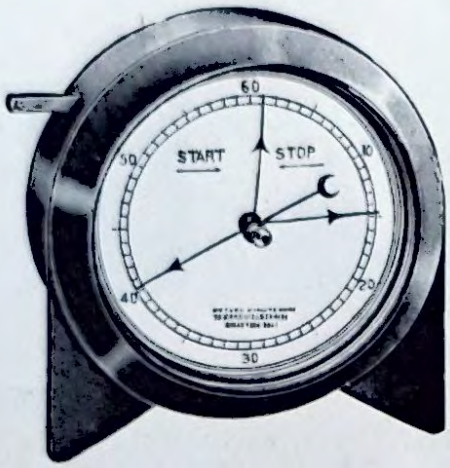

A 14-855.


A 14-875.

		£	s.	d.
A 14-850.	**CUBICAL BOX, Tin,** capacity = 1 litre	0	2	0
A 14-855.	**Ditto,** graduated on one side into square cm.	0	4	6
A 14-860.	**CUBICAL BOX, Tin,** capacity = 1 cc.	0	1	0
A 14-865.	**Ditto,** capacity = 1 cub. in.	0	1	3
A 14-875.	**RIGHT PRISMS, Hollow, Set of 3, Brass,** uniform height 42 mm., having respectively a circular, triangular, and rectangular base for measurement of volumes	*p* 1	5	0
A 14-880.	**CYLINDER, Hollow, Tin,** with one end closed, 1½ in. high, 1½ in. internal diam. To take 1½ in. sphere exactly	0	0	9
A 14-885.	**Ditto,** to take 3 cm. sphere	0	0	9



A 15-240.



A 15-320.

	£	s.	d.
A 15-240. STOP-WATCH, keyless, in nickel case, with jewelled lever movement, dial graduated up to 30 min., with triple action for start, stop and reset. Reading to $\frac{1}{5}$ sec. ..	*t* 4	5	0
A 15-245. Ditto, 15 min., reading to $\frac{1}{10}$ sec.	*t* 4	7	6
A 15-320. STOP-CLOCK, dial 4½ in. diam., 30-hour movement, in black Bakelite dust-proof case. For timing intervals from 1 to 60 sec. and 1 to 60 min. The stop is actuated by a sliding rod which has a very definite action. No damage can be done to the movement however sharply the rod is moved. Fitted with indicator hand to show the point of starting	*t* 2	2	0



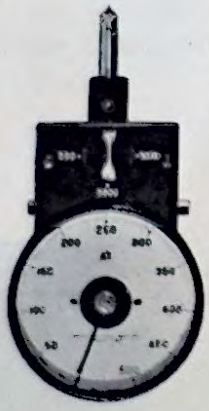
A 15-650.



A 15-655.



A 15-660.



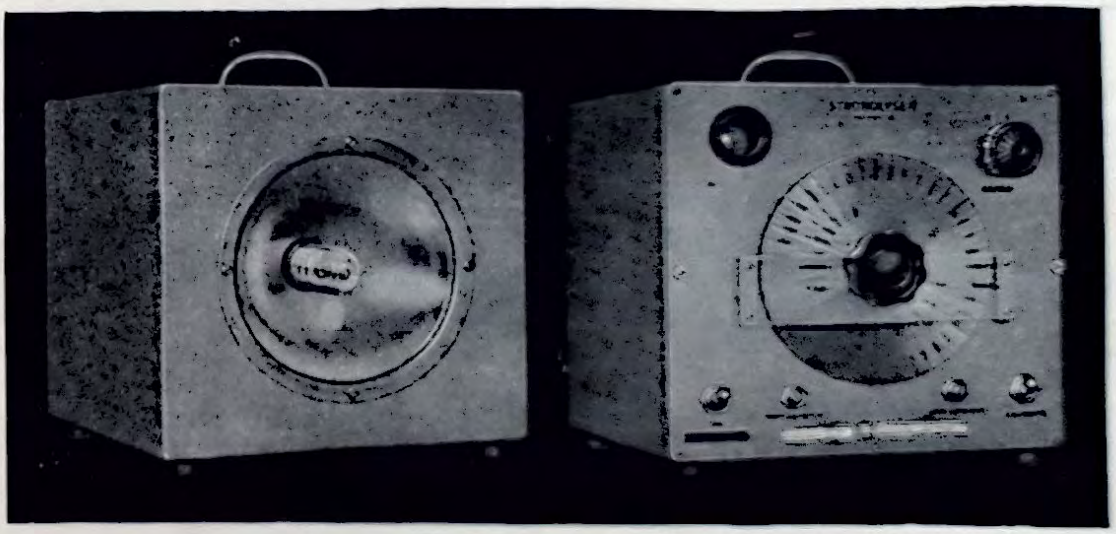
A 15-680

	£	s.	d.
A 15-650. REVOLUTION COUNTER, five figures. Metal case 1 × 1 × ⅞ in., left-hand drive, non-resetting, geared 10–1. Suitable for speeds up to 500 r.p.m.	*t* 2	2	0
A 15-655. Ditto, four figures. Metal case 2⅜ × 1¼ × 1 in., geared 1–1, with resetting device. Suitable for speeds up to 1500 r.p.m. Left- or right-hand drive (*Please state when ordering*)	*t* 2	15	0
A 15-660. Ditto, four figures. Rectangular metal case 2½ × 1¼ × 1 in., left- and right-hand drive, two bits, resetting device. Suitable for speeds up to 6000 r.p.m. In leatherette covered case	*t* 5	15	0
A 15-680. TACHOMETER, based on speedometer principle with mechanical and magnetic coupling. For both left- and right-hand drive, reading 0–500 r.p.m. directly, 0–5,000 r.p.m. (× 10), or 50,000 r.p.m. (× 100), with range selector switch, stop and zero setting buttons. Accuracy ± 0·5 per cent. Temperature compensating device. In snap case with male and female rubber cowlers and disc	*t* 12	12	0



A 15-710.

A 15-710. STROBO-VISOR, a small, portable stroboscope, calibrated to read speeds directly in revs. per min. and for studying the motion of moving mechanisms. Robust construction, will retain its accuracy for an indefinite period. With four discs giving the following speed ranges:— 500–2000 (1 slot), 1000–4000 (2 slots), 4000–16,000 (8 slots), 5000–20,000 (10 slots). In operation the motor is wound during progress of the measurement by trigger action of the first finger. A spring operated governor drives the disc .. £30 0 0



A 15-740 (showing the light projector and the control panel).

A 15-740. STROBOLYSER, an electric "stroboscope" with variable frequency, 700–14,000 cycles/min., for use in the analysis of recurrent motion. In welded steel case, 9 in. cube, crackle finish, with carrying handle. Double range dial 700–3000 and 3000–14,000 cycles/min., range selector switch, "magic-eye" calibration check, drift corrector. In back of case, reflector 5½ in. diam. with neon tube having flash duration of a few microsecs. Complete with all electrical equipment for use on 200–250 volts A.C. 50 cycles £35 0 0

The Strobolyser comprises a relaxation electronic oscillator driving a neon tube with very short flash duration. The flash is directed on to the moving system under examination, which is caused to appear to be stationary when the two are in synchronism. Clockwise or anti-clockwise slip is visible according as the system moves faster or slower than the Strobolyser flash.

Each instrument is individually calibrated. The calibration can be checked against the 50 cycle mains (= 3,000 flashes/min.) and any necessary adjustment made by means of the drift correctors. This may be necessary when replacing a valve. The circuit is designed to be insensitive to mains voltage variations, to ageing and to temperature effects. The oscillator circuit employs tropical grade mica-silver condensers.

SLIDE RULES

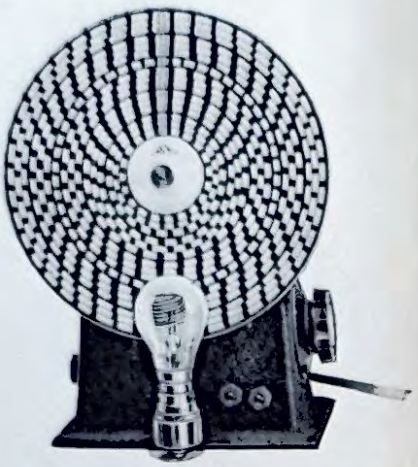
£ s. d.

A 15-780. STROBOSCOPE, light metal disc 10 in. diam. with 16 concentric rings, each with alternate black and white segments ranging from 20 to 44 segments per ring, with a central 50 cycle ring; mounted on spindle, geared to electric motor for use on 50 cycle A.C. supply; in enamelled cast iron casing, with speed control knob and on-and-off switch. Neon lamp with spiral electrode mounted in B.C. holder in front of disc, independent switch for lamp **15 10 0**

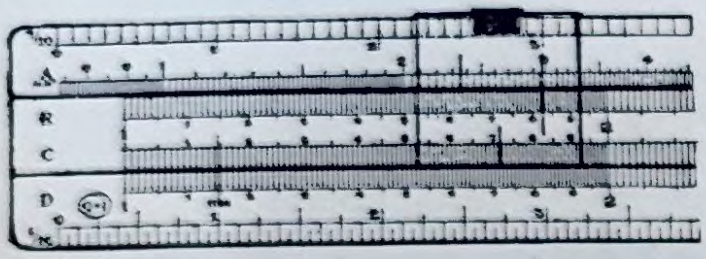
When ordering please state mains voltage.

The speed of the disc should be regulated until the ring marked "50" containing 50 white segments appears stationary in the illumination from the neon lamp. At this speed the adjacent rings appear to be slowly revolving in clockwise or anti-clockwise directions, slight speeding-up or slowing-down of the motor will bring each ring successively into coincidence with the lamp frequency. The apparatus demonstrates important industrial applications of the stroboscope, such as its use as a tachometer, inspection of machine gear wheels whilst in motion, etc.

The apparatus is also useful in the physics laboratory for rotating colour discs, siren discs, etc.



A 15-780.



A 16-230.

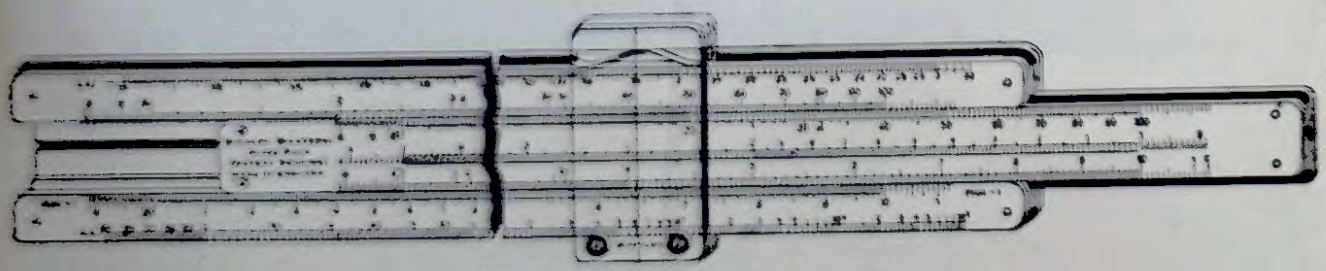
£ s. d.

A 16-230. SLIDE RULE, all metal, 10 in., with two slides and transparent cursor. In addition to ordinary A, B, C, D scales it has sine, tangent, log, log-log, and electrician's scales. In case .. .. *r* **0 4 0**



A 16-240.

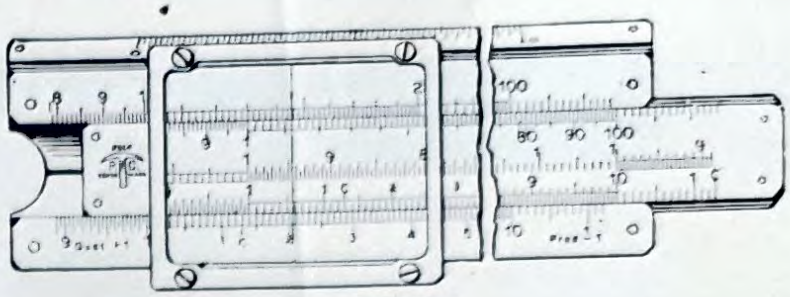
A 16-240. SLIDE RULE, "Unique," 10 in., mahogany body with glass cursor. A, B, C, D and log-log scales. In case, with instructions .. .. *r* **0 7 0**



A 16-250.

£ s. d.

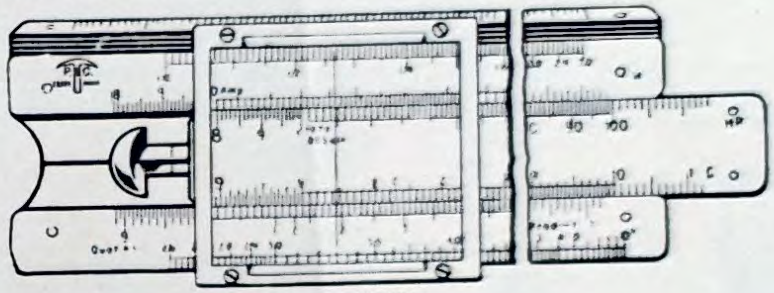
A 16-250. SLIDE RULE, 10 in., two sided with cursor. Mahogany body with celluloid-faced scales reproduced from an engine-divided master rule. Slide properly tongued and grooved and fitted with steel springs to ensure flexibility. In addition to usual A, B, C and D scales the front face has a double range of log-log scales and a reciprocal scale. On the back face sine, log and tan scales are permanently fixed to specially provided A and D scales. In case with instructions .. .. *r* **0 10 0**



A 16-280.

£ s. d.

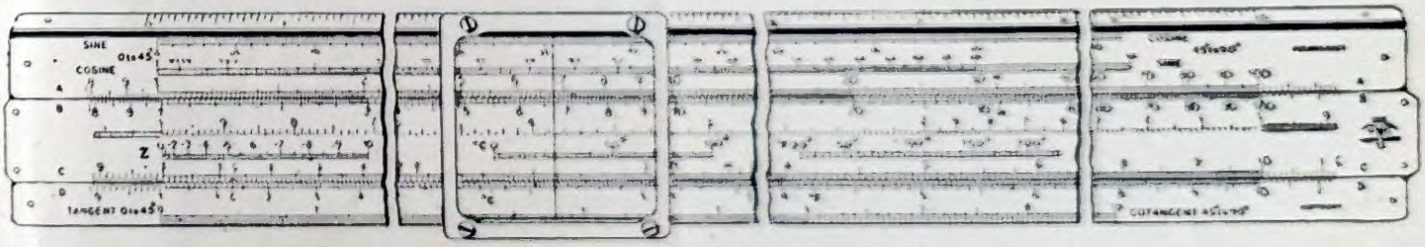
A 16-280. SLIDE RULE, Standard Pattern, white celluloid-faced scale, length 25 cm., glass framed magnifying cursor. Multiplication, division, square and square root scales, known as A, B, C, D and reciprocal scale are on the face ; sine, tangent and logarithm scales on the back of the slide. Edges divided into inches and 32nds and mm. Complete in cloth-covered case with instructions for use .. .. *t* 1 12 6



A 16-290.

A 16-290. SLIDE RULE, Pocket, Electrical and Mechanical Engineers', white celluloid-faced scale, 12·5 cm. long, framed magnifying cursor. A, B, C, D scales, and log-log scale on the face (the latter scale is in two sections, *i.e.*, on the top and bottom edges, range 1·1 to 100,000). Sine, tangent and logarithm scales on the back of the slide. Volt and dynamo scales underneath the slide, with improved index pointer. Edges divided inches in 32nds and mm. Complete in cloth-covered case, with instructions for use .. *t* 1 11 0

A 16-295. Ditto, 25 cm. scale length, with the addition of C° scale (Temp.-resist. scale for a copper circuit) .. .. *t* 2 2 6



A 16-310.

£ s. d.

A 16-310. SLIDE RULE, A.C., Electrical, Model F, scale length 25 cm., A, B, C, D, sine, cosine and tangent (inter-related), Z and reciprocal scales. Logarithm and angle scales (on flat edge). Log-log (1·1 to 100,000). Decimal log-log (0·98 to 0·15) and extra C scale on slide reversed. Made of mahogany, celluloid faced, spring back, machine divided, single line side-cursor, in case with instructions for use .. .. *t* 2 15 0

A 16-315. Ditto, Model E, as Model F, but without log-log and extra C scale graduations on slide reversed .. .. *t* 2 10 0

A 16-320. Cursors, three-line .. .. *extra t* 0 1 6

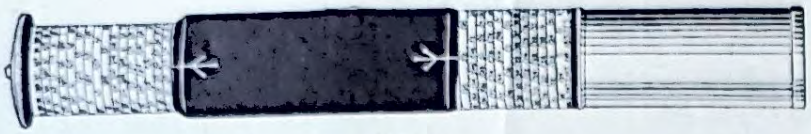
The A.C. Electrical Slide Rule (Model F) is particularly suited to all calculations involving vector quantities, and to alternating current problems. The unique features are :

(1) A special scale—the Z scale—is provided for determining the *square root* of the sum of the squares of two numbers.

(2) The trigonometrical scales are arranged in a new manner so that with a single setting of the cursor, having given θ, sin θ, cos θ or tan θ, the other three can be read off at once.

(3) Two new Temperature Resistance Scales for both °F. and °C, to scale D accuracy.

(4) A decimal log-log scale (additional to the usual log-log scale) reading in conjunction with scale A (range 0·98 to 0·15), is useful in dealing with x^x when x is $\leqslant 1{\cdot}0$), it also serves to extend the normal scales down to 1·02—a great advantage.



A 16-450.

CALCULATORS, **Otis King**, equivalent to a 66 in. slide rule. Improved pattern with scales on unstretchable vellum paper, weatherproofed by a special process, and dead-black cursor. Size fully extended 10¼ × 1¼ in., closed 6 × 1¼ in. Weight 4 oz. With instructions.

	£ s. d.
A 16-450. Model K. For all calculations involving multiplications, division and proportion, including costs, percentages, discounts, brokerage and foreign exchange problems ..	*t* 1 10 0

The Cylinder carries two scales in series, both being identical with the Holder Scale. This double scale, because it ensures that every incoming factor is at a place to which the Cursor can be immediately set, frequently reduces the number of operations involved in a series of calculations. Model K, therefore, is recommended, except where readings of logarithms, roots and powers are regularly required.

A 16-455. Model L. With additional scale for logarithms, powers and roots	*t* 1 10 0

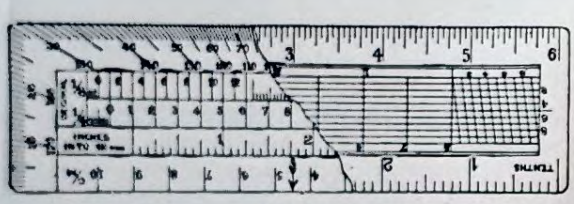
The Cylinder carries two scales, but the upper half only is identical with the Holder Scale. These operate together for multiplication, division, etc. The lower half consists of a scale from 0 to 1, graduated in 2000 equal divisions, and is used in conjunction with the Holder Scale to give direct readings of the logarithms of any number, by means of which roots and powers are obtained.



A 17-350.



A 17-370.



A 17-385.

A 17-350. DRAWING BOARDS, Hardwood, clamped sides.

Dimensions	16 × 11½	23 × 16	31 × 23 *in.*
	p 7/-	12/6	20/- *each*

A 17-370. SET SQUARES, Celluloid, 45° .. .. ..

	6	8	10 *in.*
	1/6	2/-	3/- *each*

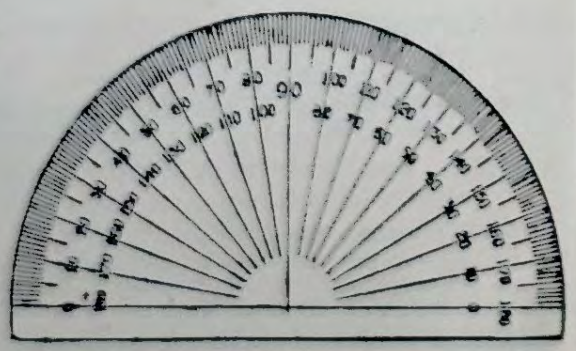
A 17-375. Ditto, 60° .. .. .. 1/- 1/6 2/- *each*

A 17-385. PROTRACTOR, Boxwood, 6 in., with scales in mm., 8ths and 10ths in., diagonal scale, and scale of chords .. .. £ s. d. *each* 1/3 ; *dozen* 0 13 6

A 17-420. PROTRACTORS, Brass, semi-circular, in single degrees, 3½ in. diam. .. .. £ s. d. *each* 8d. ; *dozen* 0 8 6

A 17-425. Ditto, Celluloid, semicircular, in single degrees.

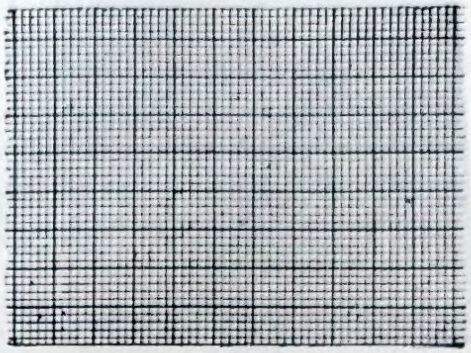
Diam.	4	5	6 *in.*
	6/-	10/6	22/- *dozen*
	7d.	1/-	2/- *each*



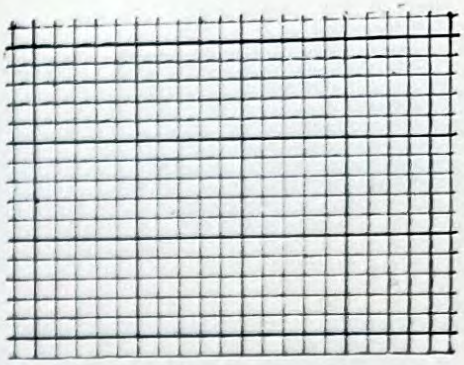
A 17-425.

A 17-440. PROTRACTORS, Celluloid, circular, with two scales 0–360°, clockwise and anticlockwise, reading in ½°.

Diam. ..	3	6 *in.*
	3/6	4/6 *each*

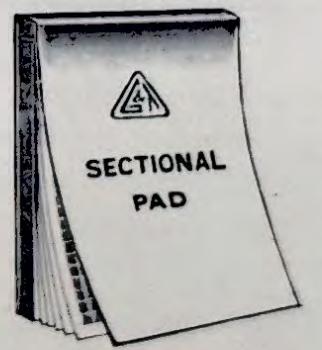


Section of mm. ruling.

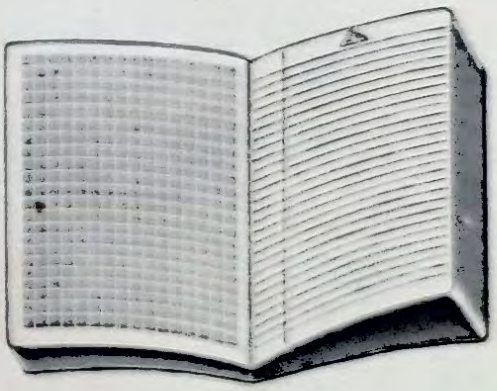


Section of 0·1 in. ruling.

		£	s.	d.
A 17-805. PAPER, Graph, Sheets, divided both sides **in mm.** Size of divided space 30 × 20 cm., with margin all round .. .. *quire p*		0	3	6
A 17-810. Ditto, size of divided space 21 × 17 cm., with margin all round .. .. *quire p*		0	1	6
A 17-815. Ditto, divided both sides **in 0·1 in.** Size of divided space 9 × 7 in. with margin all round .. .. *quire p*		0	1	6
A 17-820. Ditto, divided both sides **in ⅛ in.** .. .. *quire p*		0	1	6
A 17-825. Ditto, divided **in 0·1 in.** Size of sheets, 23 × 18 in. .. .. .. *quire p*		0	4	6
A 17-830. Ditto, divided **in 0·1 in.,** alternate blue and red lines every half-inch. Size of sheets, 23 × 18 in. .. .. *quire p*		0	5	0
A 17-835. Ditto, divided **in 0·1 in.** Size of sheets, 23 × 18 in. Accurately ruled on stout paper .. .. *quire r*		0	6	0
A 17-840. Ditto, divided **in mm.** .. .. *quire r*		0	10	6
A 17-870. PAPER, Graph, Rolls, 11 yds. × 30 in., divided **in mm.** on medium paper ; width of divided portion 70 cm. .. .. *roll p*		0	15	0
A 17-875. Ditto, on stout paper .. .. *roll p*		0	17	0
A 17-880. Ditto, 10 yds. × 26 in., divided **in 0·1 in.,** on stout paper ; width of divided portion 24 in. .. .. *roll p*		0	17	0
A 17-895. PAPER, Graph, Tracing, Rolls, 11 yds. × 29½ in., divided **in mm.** ; width of divided portion 68 cm. .. .. *roll p*		1	0	0

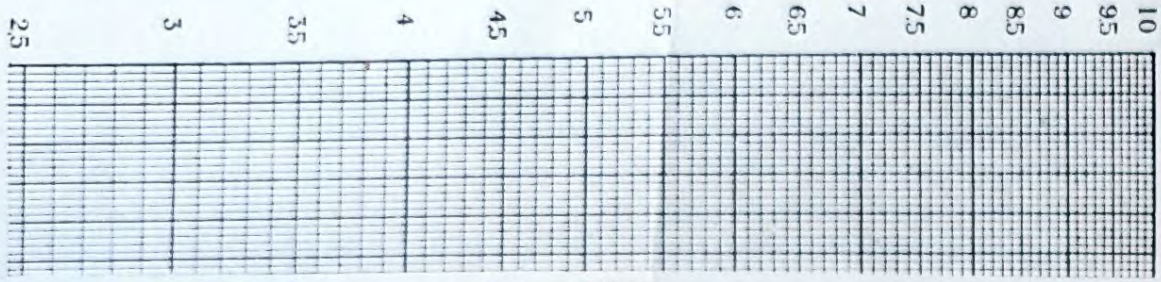


A 17-920—925.



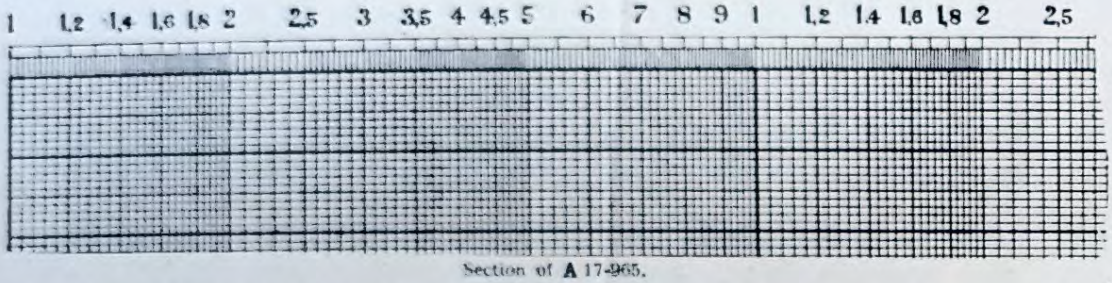
A 17-940—945.

		£	s.	d.
A 17-920. PAPER, Graph, Pads, containing 50 sheets, divided **in 0·1 in.,** size 10½ × 8 in. *each p*		0	2	9
A 17-925. Ditto, containing 50 sheets, divided **in mm.,** size 10½ × 8 in. .. .. *each p*		0	2	9
A 17-940. BOOKS, Graph, Students', 10½ × 8 in., ruled on one side **in mm. and cm.** squares, on the other side lines and margin. 80 pp. in semi-stiff cover *each* (*a*) *p* 3/- ; *dozen*		1	12	0
A 17-945. Ditto, divided **in 0·1 in.** .. .. *each* (*a*) *p* 3/- ; *dozen*		1	12	0



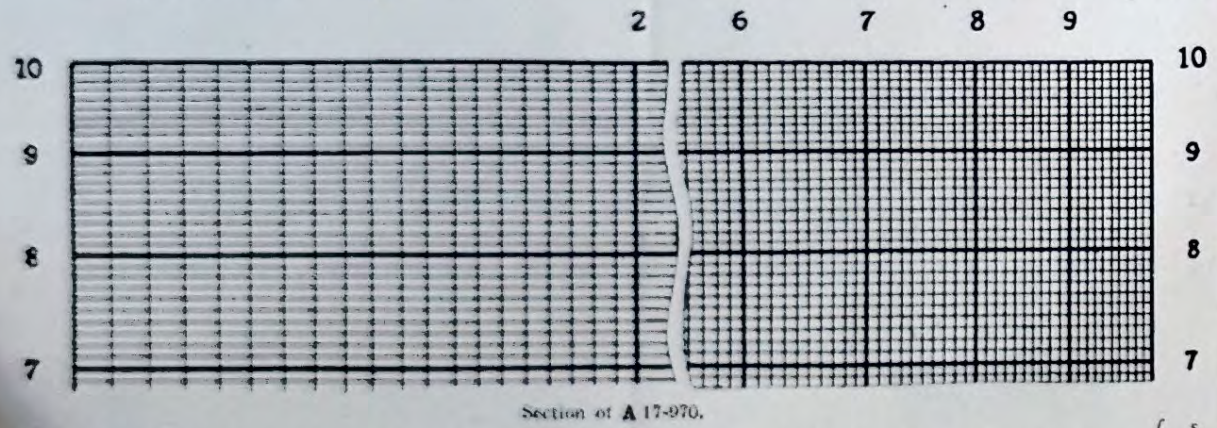
Section of **A** 17-960.

A 17-960. PAPER, Logarithmic, One-way. The vertical lines are equi-distant and the horizontal rulings are logarithmically spaced. Sheets 13½ × 13 in. with ruling 25 cm. square *quire p* £ 0 s. 5 d. 3



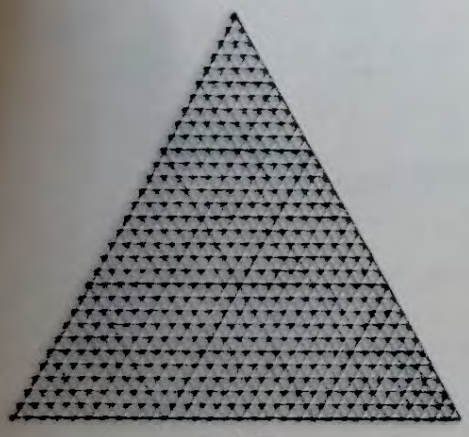
Section of **A** 17-965.

A 17-965. PAPER, Logarithmic, One-way repeated. The vertical lines are equi-distant and the horizontal rulings, logarithmically spaced, are repeated. Sheets 15¾ × 11 in. with ruling 30 × 20 cm. .. .. *quire p* £ 0 s. 5 d. 3



Section of **A** 17-970.

A 17-970. PAPER, Logarithmic, Two-way, both horizontal and vertical rulings being logarithmic. Sheets 13½ × 13 in. with ruling 25 cm. square .. .. *quire p* £ 0 s. 5 d. 3



A 17-975.

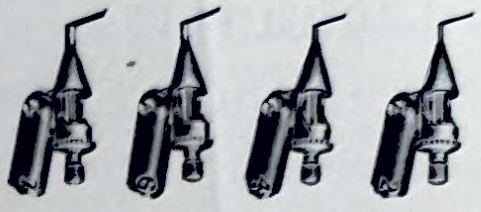
A 17-975. PAPER, Graph, Triple Co-ordinate, for a co-ordinate system of three variables having a constant sum. Triangles 20 cm. side, in 100 parts .. .. *quire p* £ 0 s. 2 d. 6

A 17-980. Ditto, rectangular, 48 × 30 cm., with triangles 5 mm. side .. .. .. *quire p* £ 0 s. 4 d. 6

A 17-985. PAPER, Polar Co-ordinate, radius 15 cm., concentric circles 1 mm. apart, with every tenth circle thickened .. .. *quire p* £ 0 s. 6 d. 0

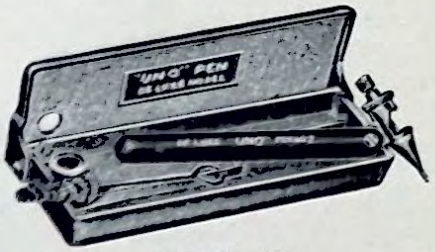


A 18-150—170.



Pen No. 2 4 6 7

A 18-170.



A 18-170—175.

STENCILS, Uno. Provide a simple method of lettering drawings, notices, cards, labels, etc., in either pencil or ink. Made of stout, transparent plastic and so constructed that the stencil can be moved along the straight-edge without smudging the letters already made. Special reservoir pens are used, with waterproof drawing ink (black or colours) which will stand wash colouring or out-door exposure.

Height of letters	¼	⅜	½	1 *in.*
Use Pen No.	2	4	6	7
A 18-150. Capital Letters, A-Z, & ..	*t* 4/-	5/3	7/-	12/- *set*
A 18-155. Figures, 0-9	*t* 3/-	4/-	5/-	7/- *set*

£ s. d.

A 18-170. PENS, Uno, complete in moulded plastic box with cleaning brush. (*When ordering state pen number required*) .. .. *each t* 0 8 3

A 18-175. Plungers, spare, for Uno Pens .. .. *each t* 0 1 0



A 18-230.



A 18-290.

A 18-230. INKS, Waterproof, for general use but specially made for use with Uno Stencils; black, red, blue, orange, green, brown and white.

Bottle	1	5 oz.
	(*a*) *t* 1/8	(*a*) *t* 4/11 *each*

A 18-255. INDIAN INK, Fixed Fluid.

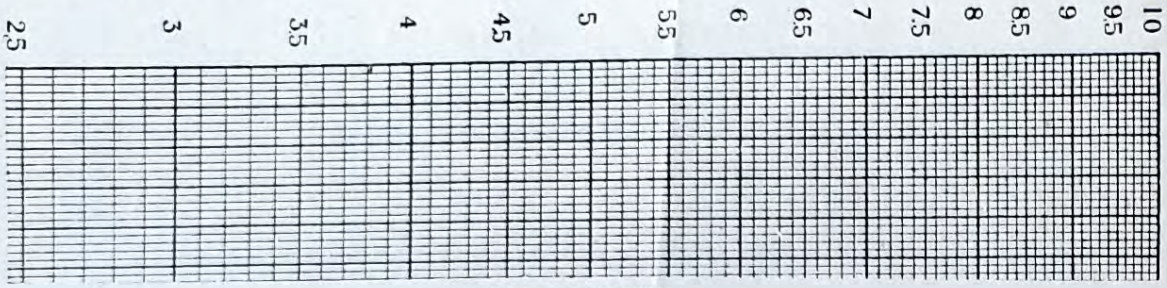
Bottle	*t*	4 oz.
	(*a*) *t* 1/6	5/-

A 18-290. DRAWING PINS, Brass, best bevelled.

Diam. of head	11	12	13 mm.
	9d.	1/-	1/3 *dozen*

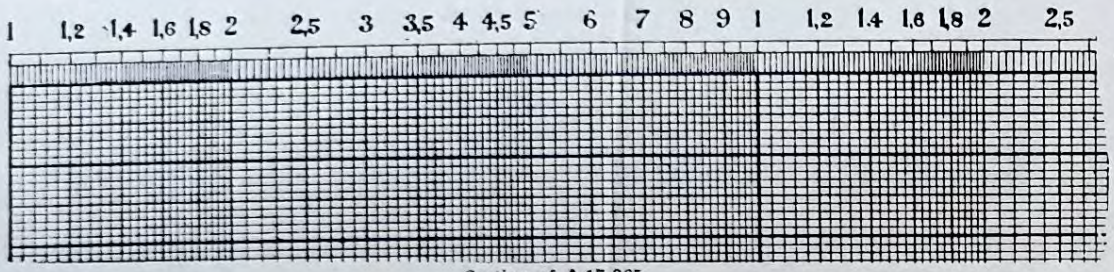
£ s. d.

A 18-295. DRAWING PINS, Steel .. .. *box of* 100 0 2 6



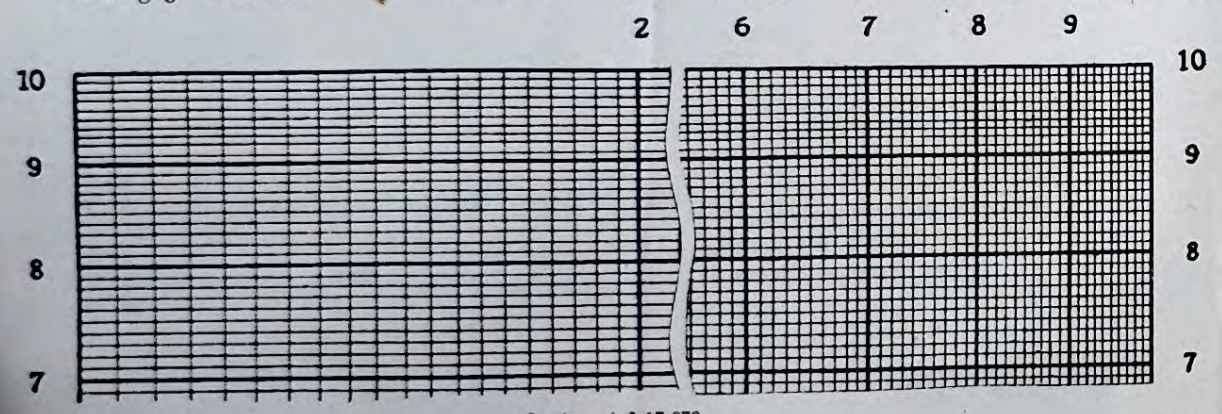
Section of **A** 17-960.

	£	s.	d.
A 17-960. PAPER, Logarithmic, One-way. The vertical lines are equi-distant and the horizontal rulings are logarithmically spaced. Sheets $13\frac{1}{2} \times 13$ in. with ruling 25 cm. square *quire p*	0	5	3



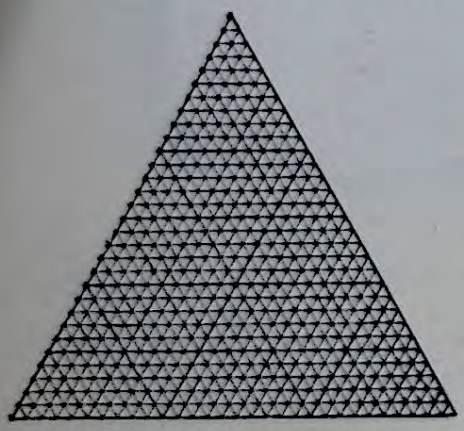
Section of **A** 17-965.

	£	s.	d.
A 17-965. PAPER, Logarithmic, One-way repeated. The vertical lines are equi-distant and the horizontal rulings, logarithmically spaced, are repeated. Sheets $15\frac{3}{4} \times 11$ in. with ruling 30 × 20 cm. .. .. *quire p*	0	5	3



Section of **A** 17-970.

	£	s.	d.
A 17-970. PAPER, Logarithmic, Two-way, both horizontal and vertical rulings being logarithmic. Sheets $13\frac{1}{2} \times 13$ in. with ruling 25 cm. square .. .. *quire p*	0	5	3

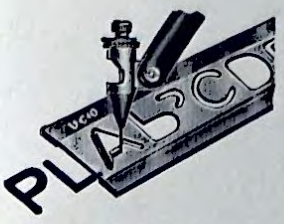


A 17-975.

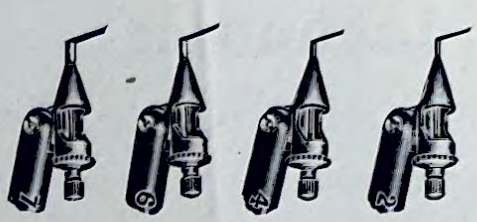
A 17-975. PAPER, Graph, Triple Co-ordinate, for a co-ordinate system of three variables having a constant sum. Triangles 20 cm. side, in 100 parts .. .. *quire p* 0 2 6

A 17-980. Ditto, rectangular, 48 × 30 cm., with triangles 5 mm. side .. .. .. *quire p* 0 4 6

A 17-985. PAPER, Polar Co-ordinate, radius 15 cm., concentric circles 1 mm. apart, with every tenth circle thickened .. .. *quire p* 0 6 0



A 18-150—170.



Pen No. 2 4 6 7

A 18-170.



A 18-170—175.

STENCILS, Uno. Provide a simple method of lettering drawings, notices, cards, labels, etc., in either pencil or ink. Made of stout, transparent plastic and so constructed that the stencil can be moved along the straight-edge without smudging the letters already made. Special reservoir pens are used, with waterproof drawing ink (black or colours) which will stand wash colouring or out-door exposure.

Height of letters	¼	⅜	⅝	1 *in.*
Use Pen No.	2	4	6	7
A 18-150. Capital Letters, A-Z, & ..	*t* 4/-	5/3	7/-	12/- *set*
A 18-155. Figures, 0-9	*t* 3/-	4/-	5/-	7/- *set*

£ s. d.

A 18-170. PENS, Uno, complete in moulded plastic box with cleaning brush. (*When ordering state pen number required*) .. .. *each t* 0 8 3

A 18-175. Plungers, spare, for Uno Pens .. .. *each t* 0 1 0



A 18-230.



A 18-290.

A 18-230. INKS, Waterproof, for general use but specially made for use with Uno Stencils ; black, red, blue, orange, green, brown and white.

Bottle	1	5 *oz.*
	(*a*) *tx* 1/8	(*a*) *tx* 4/11 *each*

A 18-255. INDIAN INK, Fixed Fluid.

Bottle	1	4 *oz.*
	(*a*) *t* 1/6	5/-

A 18-290. DRAWING PINS, Brass, best bevelled.

Diam. of head	11	12	13 *mm.*
	9d.	1/-	1/3 *dozen*

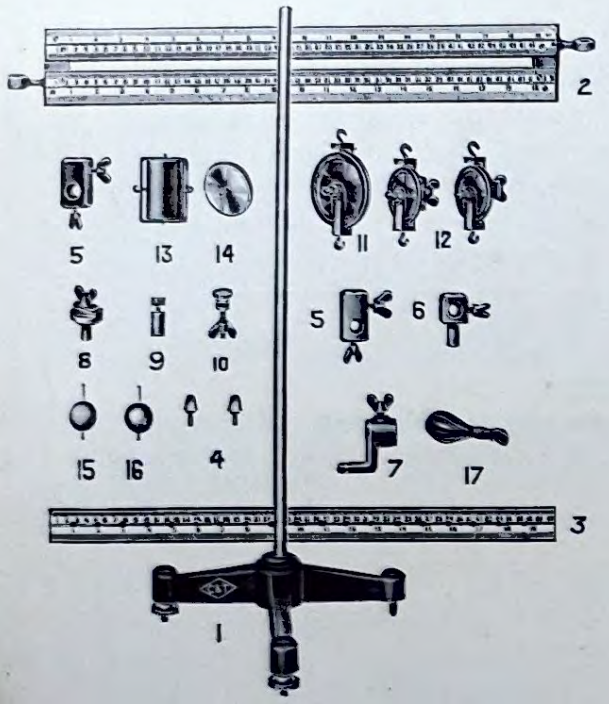
£ s. d.

A 18-295. DRAWING PINS, Steel .. .. *box of* 100 0 2 6

Mechanics

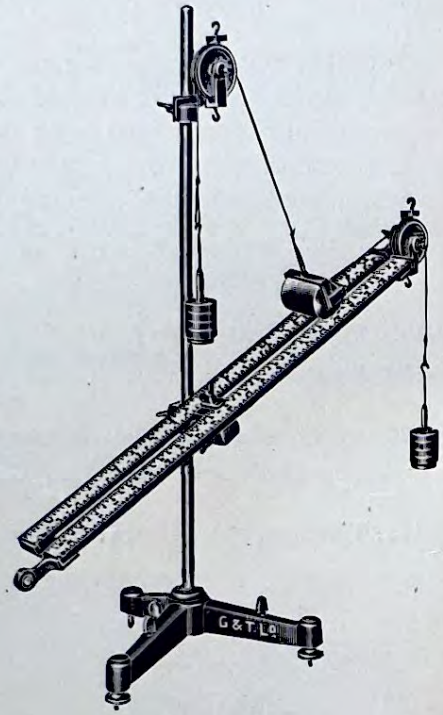
THE MICROID MECHANICS SET MODEL A

A simple comprehensive set of great flexibility.



The Microid Mechanics Set.

A 21-120.



A Typical Set-Up (Expt. No. 3, Components of a Force).

Although the subject of mechanics offers immense opportunities for practical work the scope of a course is often seriously limited by the expensive nature of the apparatus necessary for an adequate treatment.

It is clear that economy will result from the use of a set of which the parts are interchangeable and multi-purposed The mechanics set here offered enables most of the experiments that a student should have done before School Certificate, to be performed with the absolute minimum of parts, and with the exception of, perhaps, a few pieces of demonstration apparatus which most schools possess, the apparatus is all that is required in Mechanics up to this standard.

SPECIFICATION.

The Stand (No. 1) used throughout has a tripod base with a 30 by $\frac{1}{2}$ in. stainless steel rod, and is provided with levelling screws.

The Slide (No. 2) or inclined plane, consists of two, half metre scales $\frac{1}{2}$ in. apart, rigidly clamped at their ends by special L section castings which have extensions for holding pulleys. It can be supported at any height on the stand with its surface either horizontal or vertical and at any angle.

The Lever (No. 3) is a half metre scale with holes drilled at every 2·5 cm. It can be fitted into **Spring Clips** (No. 4) carried in two of the feet of the tripod, for the Ballistic Balance experiment.

A 21-120. The Microid Mechanics Set, Model A—*continued.*

The Clamps (No. 5) fit on the stand and by means of the **adapter** (No. 6) the **right angle support** (No. 7) and the **slide holder** (No. 8) confer universal adjustability on the pulleys and the slide.

The Pivot (No. 9) and the **Screw** (No. 10) are used in conjunction with the lever and the slide respectively

The Pulleys (Nos. 11 and 12) are of aluminium with steel bushes running on steel centres and will be found singularly free from friction. Their sheaves are shaped so as to combine the advantages of the open pulley and the snatch block, making them adaptable to both purposes.

The Roller (No. 13) weighs about 500 grams and is fitted with yokes enabling its reaction at the plane to be investigated.

The Rolling Disc (No. 14) is accurately centred and will be found to give good results for a distance-time graph.

The Pendulum Bobs (Nos. 15 and 16) one of wood and one of metal, are provided with wire pointers for use in the Ballistic Balance experiment.

A length of cord (No. 17) and various hooks and rings are supplied. The use of wing nuts throughout enables the parts to be adjusted with ease and certainty.

	£	s.	d.
A 21-120. MICROID MECHANICS SET, Model A, with stand and levelling screws, two 2 in. and one $2\frac{3}{4}$ in. pulleys, roller fitted with yokes, rolling disc with spindle, metal and wood pendulum bobs fitted with a wire pointer and with a hook, slide and special clamp and slide holder, $\frac{1}{2}$ metre scale with holes spaced 2·5 cm., spring clips on base, with hooks, rings and cord	r 8	10	0
A 21-125. Case, storage, for above	r 2	0	0

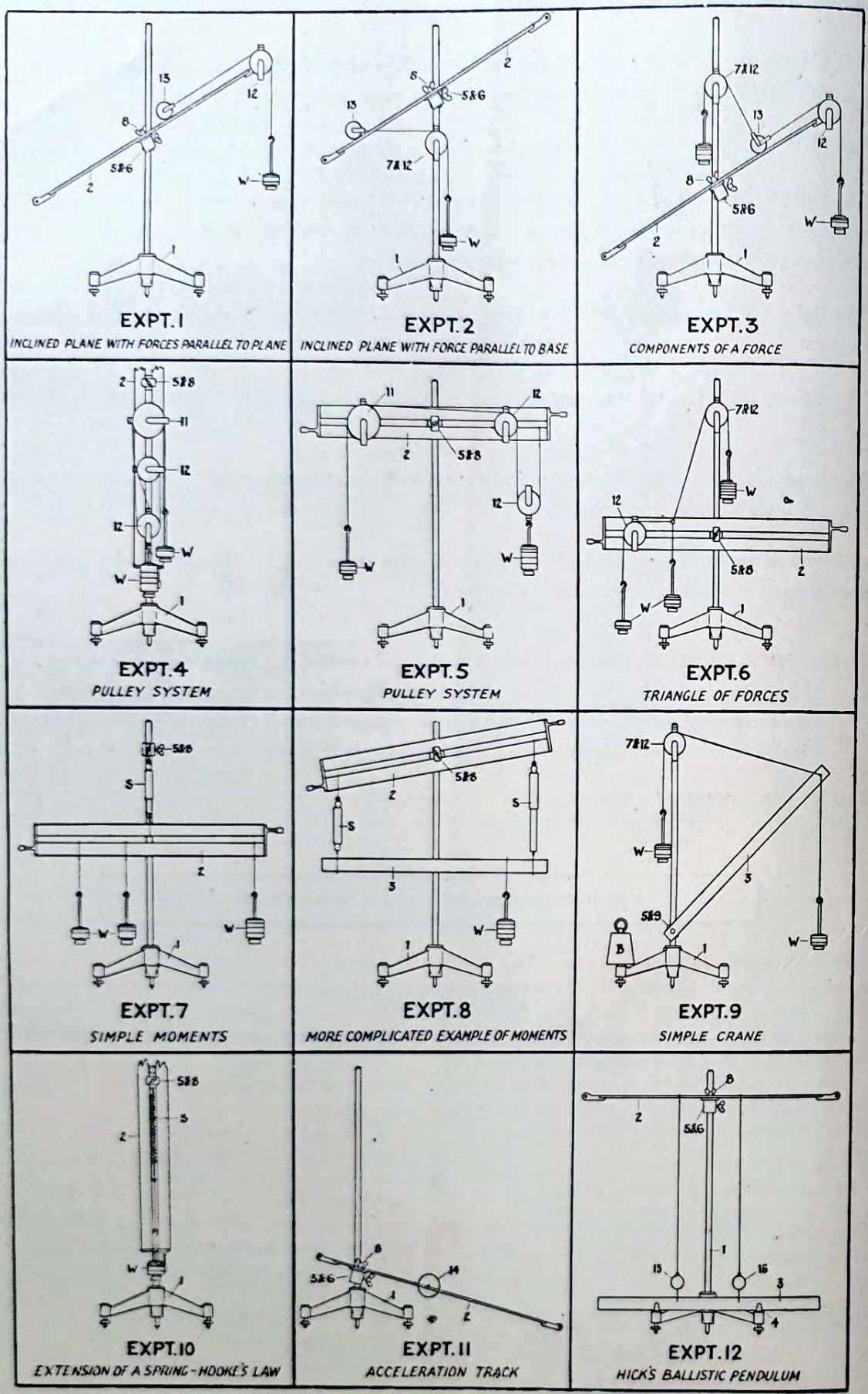
Slotted Weights, see Balances and Weights Section.

EXPERIMENTAL NOTES

The following list of experiments is not exhaustive, but is merely indicative of the scope which the apparatus has been designed to cover. Other experiments will no doubt suggest themselves. Diagrams of the arrangement of the parts in some typical experiments are given, the numbers corresponding with those given in the illustration on p. 26.

1. Inclined Plane with force parallel to the plane.
2. Inclined Plane with force parallel to the base.
3. Components of a force.
4. Pulley systems.
5. Pulley systems.
6. Parallelogram and Triangle of Forces.
7. Simple Moments: Levers: Weight of beam, etc.
8. More complicated examples of moments.
9. Simple Crane.
10. Extension of a Spring. Hooke's Law.
11. Acceleration Track.
12. Hick's Balance experiments.
13. Simple Pendulum.
14. Resultant of two parallel forces.
15. Resultant of several parallel forces.
16. Polygon of Forces.
17. Tangent Law.
18. Centre of Gravity.
19. Blackburn's Pendulum.
20. Resonance in Pendulum.
21. Falling Plate.
22. g by swinging lath.
23. Simple Hoist.
24. Archimedes' Balance: Simple steelyard.

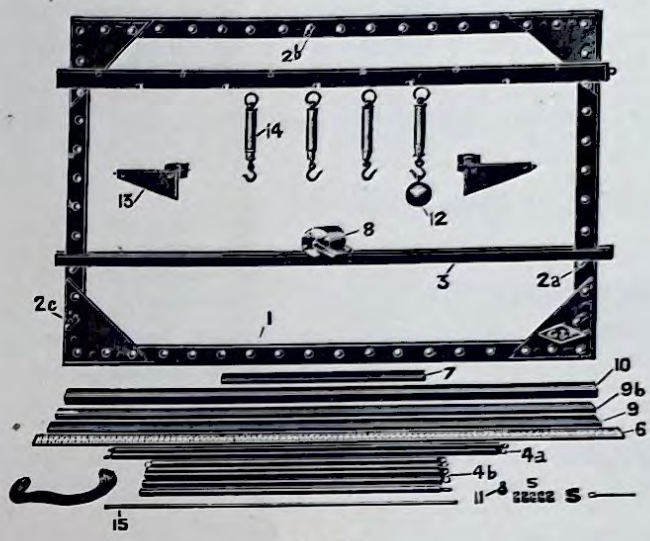
[*continued overleaf*



A 21-120.—Microid Mechanics Set, Model A. Diagrams of selected experiments. (*See page 25.*)

THE MICROID MECHANICS SET MODEL B

A constructional set of apparatus for students' use



A 21-160.

This mechanics set utilises a frame on which many usual, and some unusual, experiments in mechanics may be set up by students with very little trouble and the properties of each combination studied. The apparatus is remarkably adaptable and covers the requirements of students up to the School Certificate stage. Some typical experiments are described and illustrated with assembly diagrams. Having, however, the adaptability associated with apparatus which can be built up, the eighteen experiments described, do not exhaust the possibilities of the apparatus. The apparatus is readily dissembled and takes up little space for storage purposes.

SPECIFICATION

No. 1. Frame is 3 ft. × 2 ft. constructed of 1 in. square section wood, the sides being drilled with holes $\frac{3}{8}$ in. diam. at intervals of 2 in. Rigidity is secured by means of metal plates, approximately triangular in shape, screwed to each corner.

No. 2. Pegs (*a*) 3 × $\frac{3}{8}$ in. are used to insert in the holes in the frame for supporting the accessories for any experiment. Two pegs (*b*) are provided with eyes or hooks and another (*c*) is drilled with two holes $\frac{1}{16}$ in. diam., $\frac{1}{8}$ in. apart.

No. 3. Inclined Plane, 3 ft. × about 3 in. wide, with slots 2 in. deep at one end and 18 in. deep at the other end, the latter enabling forces parallel to the base of the plane to be measured.

No. 4. Rod, $\frac{3}{8}$ in. diam. of two lengths ; (*a*) 2 each of 2 ft. wood and steel and (*b*) 5 of 18 in. wood and 2 of 18 in. steel, each fitted with screw eyes. The wood rods are used for the construction of cranes, etc., and the steel rods for the investigation of resultant forces not in one plane, etc. (*e.g.* Expt. 18).

No. 5. Strainers. Small aluminium plates $\frac{3}{4}$ × $\frac{1}{4}$ in., drilled with two holes and provided with a small central slot. These are convenient for adjusting the length of the strings and the tension in them, in any experiment. Five supplied. To use the strainer, knotted twine is threaded through one of the holes. The free end is passed, from the same side of the strainer, through the other hole. The loop of twine left between the holes is taken over a peg. The kink in the twine, caused by inserting it in the slot of the strainer, adequately prevents slipping, while leaving its length readily adjustable.

No. 6. Metre Rule, graduated along one edge in inches and tenths, and along the other edge in centimetres and millimetres.

[*continued overleaf*

A 21-160. The Microid Mechanics Set, Model B—*continued.*

No. 7. Half-Metre Lath, section 1 × ¼ in., for use in experiments with levers, etc.

No. 8. Roller for inclined plane. A heavy brass cylinder about 2 in. diam. × 3 in. long, weight about 1250 grams. Fitted with a yoke and hook.

No. 9. Laths, 3 ft. × 1 × ¼ in., for use as levers, etc. Two supplied, one of which is notched so that twine will not slip. A third lath has a slot at one end and a hole drilled through at right angles. A small pin is supplied for suspending this lath when finding *g*.

No. 10. Beam, 3 ft. × 1 in. square section. For use as a lever, etc. Made heavy to introduce the weight of the lever.

No. 11. Plumb Bob, about ½ in. diam., fitted with an eye.

No. 12. Pendulum Bob. An iron ball about 1½ in diam., weight about ½ lb. Fitted with hook.

No. 13. Ballistic Balance Platforms. Two wood platforms about 4 × 3 in. fitted with eyes for suspension, an eye for attachment of string for drawing the platforms apart and triangular, sheet-metal pointers. The contact faces of the two platforms are each fitted with cork inserts. On one platform two sharp points project.

No. 14. Spring Balances. Four supplied, of tubular type, with hook and ring. Read to 4 lbs. in steps of 1 oz. The zero of each balance is adjustable by means of a sliding milled sleeve.

No. 15. Iron Rod, 2 ft. × ⅛ in., for use as a pivot for sheer legs.

No. 16. Hank of Twine, S hook, etc.

	£	s.	d.
A 21-160. MICROID MECHANICS SET, Model B, with frame: 8 pegs ; 1 inclined plane ; 7, ⅜ in. diam. rods of two different lengths ; 5 strainers ; 1 metre rule ; 1 half-metre lath ; 1 heavy roller with yoke ; 3 laths ; 1 beam ; 1 each plumb and pendulum bobs ; 2 ballistic balance platforms ; 4 spring balances reading to 4 lbs. × 1 oz. ; 1 iron rod ; 1 hank twine, S hook	6	0	0
A 21-165. Case, Storage, for above	2	0	0

EXPERIMENTAL NOTES

In many of the experiments described, the spring balances used to measure tensions are placed in non-vertical positions. In such cases, in order to minimise errors arising from the use of the balances in these positions, the tensions established should be as large as is convenient.

* **Expt. I.—The Parallelogram of Forces.** The frame is placed flat on the bench and pegs are placed in the holes at A, B and C. Over each peg is placed the ring of a spring balance and three looped strings, each incorporating a strainer, are hooked on to the balances, their free ends being fastened to a central ring. The tension in each string is readily adjusted by means of the strainer and a permanent record can quickly be drawn on a sheet of paper placed beneath. Large numbers of cases may rapidly be taken either by adjustment of the strainers or by movement of the pegs.

Expt. II.—The Triangle of Forces. The apparatus and methods of Expt. I. are used.

Expt. III.—Polygon of Forces. By the insertion of more pegs in the frame and the use of more strings and balances than in Expts. I. and II. this can be shown for any number of forces.

* **Expt. IV.—Resolution of a Force.** The force to be resolved is OA into two directions OB and OC at right angles. Pegs are placed at A, B and C and the rings of the spring balances slipped over them. Three looped cords with strainers are then attached to the hooks of the balances and their free ends joined to a central ring. The strainers in OB and OC are then adjusted until OB and OC are perpendicular. This is best accomplished by making OB and OC respectively coincident with strings taken from B to B^1 and from C to C^1. Alternatively a set square or protractor may be used to test when $B\hat{O}C = 90°$.

It may be noted that in Expts. I.-IV. the final arrangement is rigid and, if used for demonstration purposes, may be held up for observation or may be placed against a blackboard to show how diagrams are drawn.

* **Expt. V.—To Find the Forces acting on a Pendulum.** The frame is clamped near to the edge of the bench, with its plane vertical and either a long or a short side parallel to the edge of the bench. Pegs are placed at B and C and spring balances with strings and strainers attached, the pendulum bob No. 12 being then suspended from the junction of the strings.

* Illustrated on p. 30

A 21-160. The Microid Mechanics Set, Model B—*continued.*

The string attached to balance B is then adjusted until it is horizontal, and readings are taken. The conditions of the experiment may be varied by alteration of the positions of B and C.

* **Expt. VI.—Period of a Pendulum.** The frame is clamped vertically and the short peg containing two small holes is placed in a hole in the top of the frame, another peg being placed in a corresponding hole in the bottom of the frame. The pendulum bob No. 12 is suspended by threading the string through one of the small holes in the peg. A second string may be stretched between the two pegs to act as a reference line to indicate when the pendulum passes through its position of zero displacement.

* **Expt. VII.—Cranes.**

(*a*) **The Jib Crane.** With the frame clamped vertically, pegs are inserted at B, C and D. The eye of a rod No. 4 either 18 in. or 2 ft. long is then pushed over the peg C and spring balances with strings and strainers, connected from A to B and from A to D, the string of which should be vertical. If desired, this latter balance may be replaced by a known weight. The tension in the tie is determined for various inclinations by placing peg C in different holes.

(*b*) **The Wall Crane.** If peg C be raised so that AC is horizontal, the model becomes a wall crane.

* **Expt. VIII.—Sheer Legs.** In this experiment the frame is placed flat on the bench and pegs inserted at A, B and C. Two, 2 ft. rods No. 4 are taken and through the eyes at one end an S-hook is inserted, holding them together. The iron rod No. 15 is then pushed through the eyes at the other ends of the rods and this placed on the frame so that the pegs A and B act as stops. A spring balance with string and strainer is then taken from peg C to the S-hook on which a load also may be suspended. The inclination of the legs is altered by adjustment of the strainer in this back guy.

* **Expt. IX.—The Inclined Plane.** The frame is clamped vertically with the short sides horizontal and pegs placed at A, B and C. The vertical side of the frame at A then fits into the shorter slot in the plane and the side at B, into the longer slot. A spring balance with string, is then attached to the peg C and the roller No. 8 hooked on to the balance. If the peg C be placed below B, the long slot in the plane enables force parallel to the base of the plane to be measured. The inclination may readily be altered and may be measured by means of a protractor and plumb line or, the width of the frame and the distance between pegs being known, the height and length of the plane can be calculated.

* **Expt. X.—Moments.**

* (*a*) **Forces at Right Angles to a Lever.** The frame is clamped vertically, with its long sides horizontal and a peg containing a hook is inserted at A, other pegs being placed at B, C, D and E. A lath No. 9 with central eye is hooked on at A and spring balances with strings and strainers connected as shown, or where desired. The strainers are adjusted until the lath is horizontal.

* (*b*) **Forces Inclined at an Angle.** In this arrangement the frame is clamped with the long sides vertical and pegs inserted at A, B, C and D. In this case the notched lath containing a hook in its end is used and various arrangements built up, with the spring balances hooked on to B, C and D, by adjustment of the pegs and strainers.

* (*c*) **Equilibrant of Parallel Forces.** The frame is clamped with a long side horizontal and pegs placed at A, B and C to which spring balances, strings and strainers are attached. A lath is attached as shown and is held vertical while the strainers are adjusted until the arrangement becomes rigid.

Expt. XI.—Reaction on a Beam. The beam No. 11 is supported by spring balances near each end, the balances being hung from pegs placed in the top of the frame. The beam is then loaded either by means of spring balances or by known weights.

Expt. XII.—Centre of Gravity of Plane Figures. The peg containing two holes is placed in the frame. A plumb bob is suspended from a string threaded through the front hole in the peg and the plane figure is suspended from a line passing through the rear hole in the peg. The plumb line then hangs very close to the figure enabling the line which passes through the C.G. to be marked readily.

* **Expt. XIV.—Acceleration due to Gravity.** The frame is clamped vertically, and at A is placed the peg 2*b* with two eyes which, with the steel pin, are used to support the slotted lath No. 9 as shown in the diagram. A length of cotton is affixed to the lower end of the lath, passes over a peg at B, and thence over the steel pin and supports the small plumb bob No. 11. This is inked or chalked and the cotton burnt in the usual manner.

* **Expt. XV.—The Ballistic Balance.** The frame is clamped with a long side vertical and the two platforms No. 13 are suspended from pegs placed at A, B and C. A metre rule is supported on two pegs at a convenient height behind the triangular front pointers. The platforms are then suitably loaded and the usual method adopted for drawing the platforms apart.

Expt. XVI.—Tension in an Aerial-Pole Guy. The frame is placed flat on the bench and two rods No. 4 inserted in holes in a long side. A peg is placed at a corner and balances and strainers inserted in both the aerial and the stay. A realistic "clothes line" could be similarly constructed.

Expt. XVII.—The Funicular Polygon. The frame is clamped with a long side horizontal and pegs placed in the short sides. Balances and strainers are attached to these and the hooks of the balances joined by a string from which various loads may be suspended. The angles are measured either directly by a protractor or by supporting a sheet of paper on a board behind the strings and drawing in the lines of the strings.

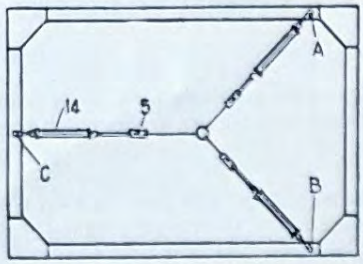
* **Expt. XVIII.—Forces not in one Plane.** The frame is placed flat on the bench and four rods No. 4 of various lengths, inserted in holes either at the corners or along the sides. Strings, strainers and spring balances are attached to the tops of the rods and a load fastened to the junction of the four strings. The equivalent single pull for any pair of forces may then be found either by calculation or experiment and the positions of the rods and the magnitude of the load, varied.

* **Expt. XIX.—Compound Levers.** The frame is clamped vertically, pegs are inserted at A, B and C, or other convenient points and the end eyes of three 18 in. × ⅜ in. rods No. 4 passed over the pegs at A, B and C. Strings and strainers are then attached as shown in the figure. A spring balance should be hooked on to the free end of the lever at A and a load hung on to the lever at C.

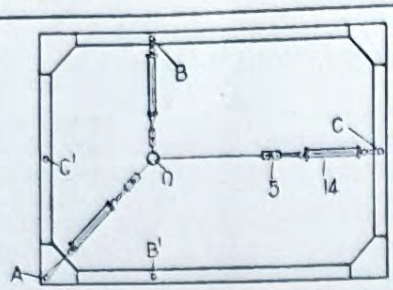
The construction of various combinations is interesting and the resulting small motion of the load with that of the effort, is instructive.

* Illustrated on p. 30

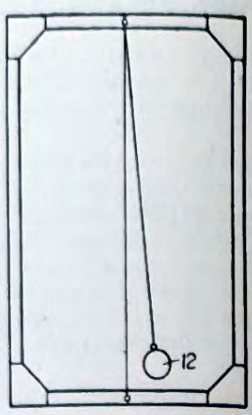
[*continued overleaf*



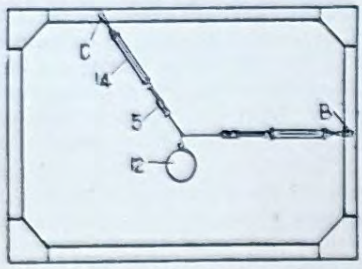
EXPT. 1. PARALLELOGRAM OF FORCES



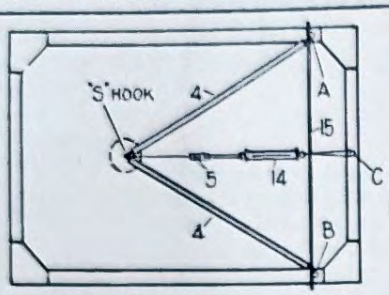
EXPT. 4. RESOLUTION OF A FORCE



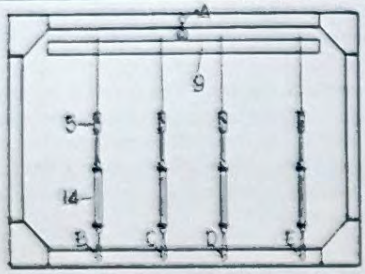
EXPT. 6.
PERIOD OF A PENDULUM



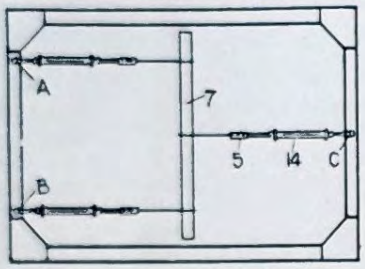
EXPT. 5. FORCES ON PENDULUM



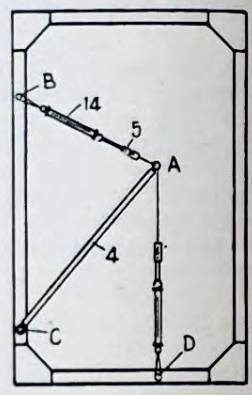
EXPT. 8. SHEER LEGS



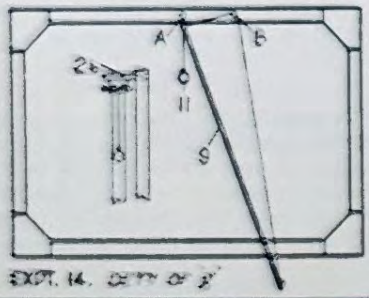
EXPT. 10A. FORCES ∥ TO A LEVER



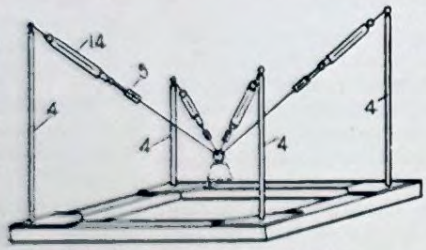
EXPT. 10C. EQUILIBRANT ≠ FORCES



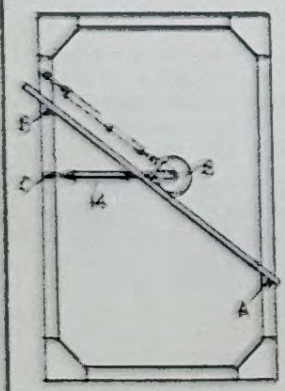
EXPT. 7A.
JIB CRANE



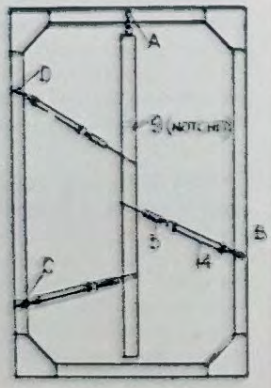
EXPT. 14. CENTRE OF [illegible]



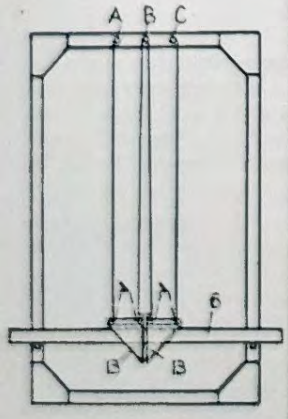
EXPT. 18. MULTI PLANAR FORCES



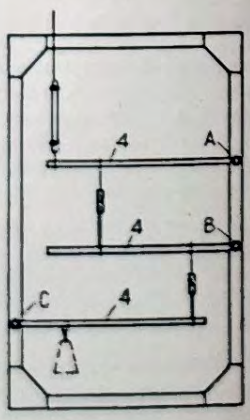
EXPT. 9.
INCLINED PLANE



EXPT. 10B.
FORCES INCLINED AT AN ANGLE

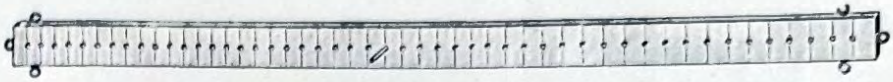


EXPT. 15.
BALLISTIC BALANCE



EXPT. 19.
COMPOUND LEVERS

A 21-160. The Microid Mechanics Set, Model B. Diagrams of selected Experiments.



A 21-240.



A 21-260.

£ s. d.

A 21-240. LEVER, Suspension, wood, 3 ft. long, having 49 holes drilled in and eyes fastened on for suspending weights **0 8 6**

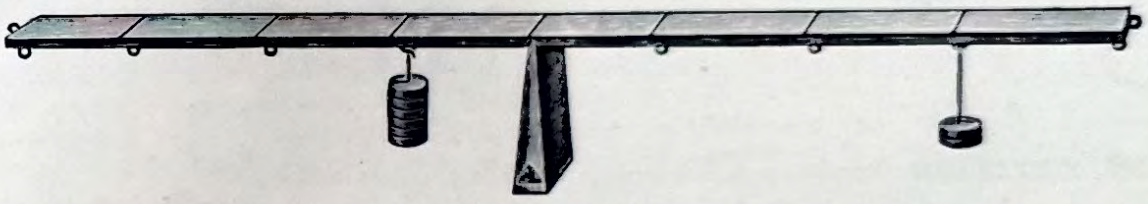
This lever, with a set of weights and two single-sheave pulleys, is sufficient to demonstrate the three types of levers.

A 21-250. LEVER, Boxwood rule, 1 metre long, divided in mm. and 10ths inches; bored every 10 cm. for use as lever **0 6 6**

A 21-255. PINS, Brass, for above .. .. *dozen* **0 1 6**

A 21-260. S-HOOKS, Iron.

Length	1	1½ *in.*
	1/6	**2/-** *dozen*

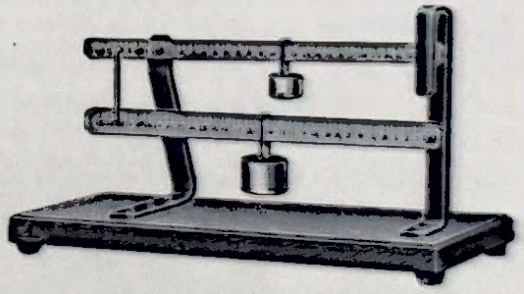


A 21-290—295.

£ s. d.

A 21-290. LEVER, Hardwood, 4 ft. long, with brass eyes and wedge-shaped fulcrum. **Without** weights **0 17 6**

A 21-295. WEDGE, Hardwood, for use as fulcrum, height 6 in., base 2 × 1⅜ in. **0 4 6**



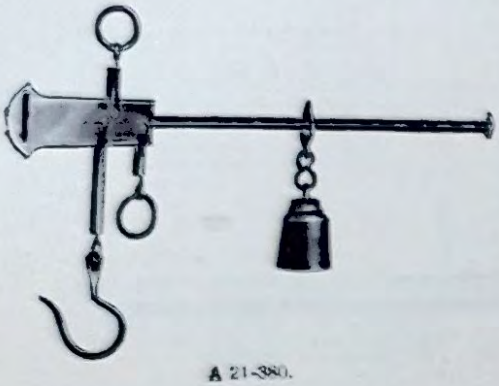
A 21-310.

A 21-310. LEVER, Compound, two levers 30 cm. long, marked every cm., the lower lever pivoted at one end on a support, the other end linked to the upper lever, which is pivoted at one-fifth of its length; the connecting link can be placed in any of three positions. Each lever is provided with a sliding weight, 50 and 400 grams, respectively. Mounted on wood base 14 × 6 in. **5 5 0**

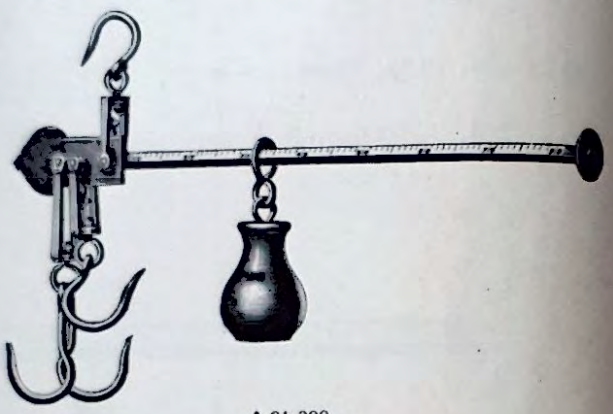


A 21-370.

A 21-370. STEELYARD, Danish, with sliding hook and pan .. .. *Price on application.*



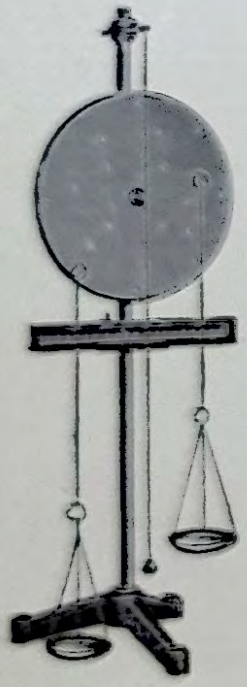
A 21-380.



A 21-390.

A 21-380. STEELYARD, **Roman**, notched arm with sliding weight and hook
Price on application.

	£	s.	d.
A 21-390. **Ditto.** Iron lever supported on knife edge, arm divided to 56 lb. .. .. *p*	2	5	0



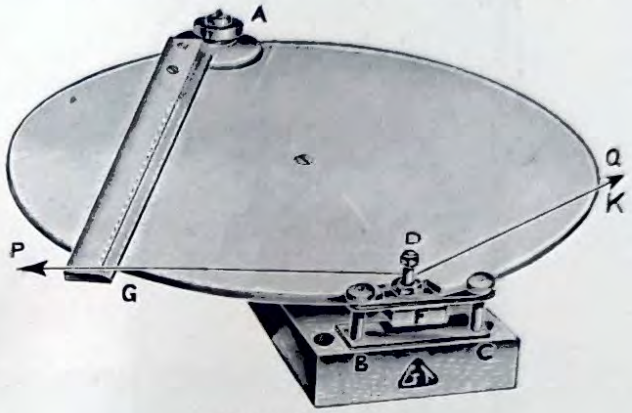
A 21-415.

A 21-415. MOMENTS APPARATUS. A stout hardwood disc 8 in. diam., clamped to a stand, rotatable and adjustable for height. The disc is drilled with a number of holes into which pegs are inserted from which two scale pans are suspended. Below the disc an adjustable carrier holds a silvered glass scale graduated 10–0–10 cm. divided in mm. and figured every cm. A plumb-line can be set so that when the disc is viewed normally the line is coplanar with the vertical diameter of the disc. The glass scale can be displaced laterally so that the plumb-line and its image coincide with the scale zero and its image **3 10 0**

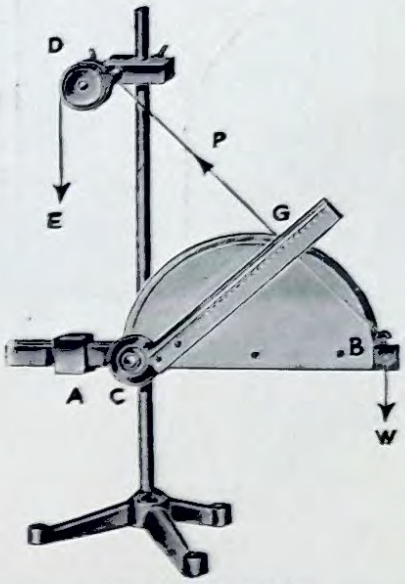
For the verification of the law of moments the perpendicular distance of the force from the fixed point of the body (the centre of the disc) may be read directly from the glass scale. Conditions of stable equilibrium may be demonstrated when the line joining the pegs is below the centre of the disc; unstable equilibrium when the line is above the centre; neutral when the pans, equally loaded, are on a diameter and are equidistant from the centre.

THE MICROID MOMENTS APPARATUS

A new design utilising a property of the semicircle to facilitate measuring the arms of non-parallel forces.



Model A (Full Circle).
A 21-450.



Model B (Semicircle).
A 21-455.

The experimental measurement of the arm of a force, as commonly carried out, is seldom easy unless the force acts at right angles to a graduated rod. The object of the apparatus here described is to facilitate the exact measurement of the arm of a force, by using the property of a semicircle, and to determine the conditions of equilibrium of non-parallel forces. The apparatus is made in two forms:—Model A may be used with any convenient number of forces while Model B should be restricted to two. Model B substitutes actual weights for spring balances, and therefore measures the forces in operation more accurately than Model A.

SPECIFICATION

Model A. Full Circle.—A hardwood base approx. 14 × 4 in., which can be screwed to the bench, is provided at one end with a spindle A, acting as a pivot for a metal disc 12 in. diam., which is reinforced with a beaded edge. The disc is free to swivel about A in a horizontal plane. The extent of movement is limited by two short pillars B and C, between which there projects a tongue F attached to the disc. A peg D is provided on the disc for attachment of two or more cords by which the non-parallel forces are applied to the disc. One rule 29 cm. long, graduated in cm. and mm. is fitted, to pivot on A, the zero being coincident with the pivot centre.

Model B. Semicircle.—A reinforced metal semicircle 12 in. diam. is pivoted at C and is weighted at A so as to remain at rest when the diameter is horizontal. A graduated rule is provided. The apparatus is mounted on a retort stand, with tripod foot. A pulley D is adjustable along the rod so that the angle of the force may be varied.

PRICES

	£	s.	d.
A 21-450. MICROID MOMENTS APPARATUS, Model A, full circle, (*Science Masters' Book*, Ser. II. Pt. I, 41) as described above	4	15	0
A 21-455. Ditto, Model B, semicircle, on retort stand, with adjustable pulley	4	15	0

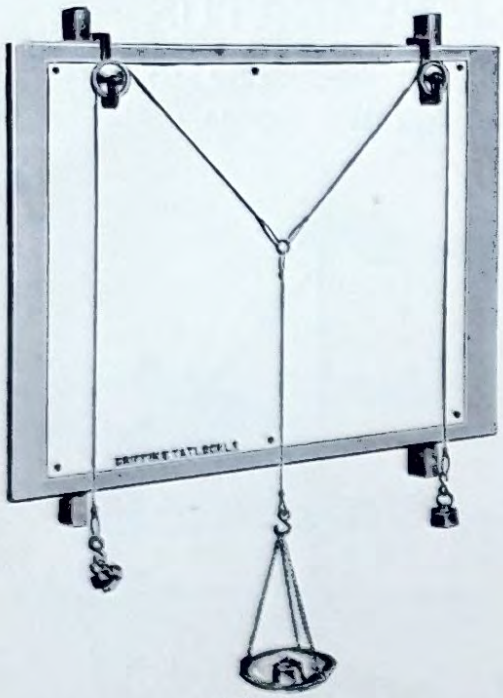
EXPERIMENTAL NOTES

Model A.—Attach cords to the pillar D and to accurate spring balances adjusted to read zero when unloaded in the horizontal position. It may be convenient to slip the ring of the spring balances on the rods of weighted retort stands. Forces P and Q are then applied, by moving the retort stands such that pillar D remains in equilibrium midway between B and C. (The weight of the disc is supported by a ball bearing running on a metal plate on the wood base.) The readings of the spring balances are now taken and the arms of the forces are measured by the rule provided.

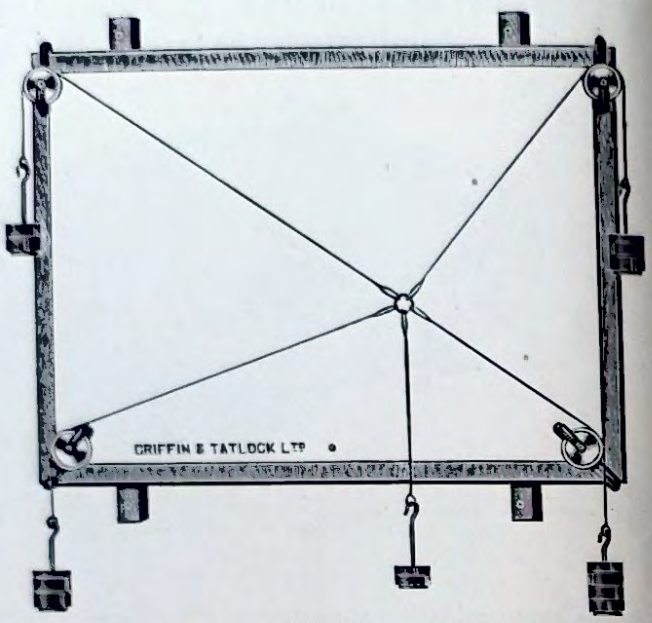
The moments P × AG and Q × AK are now evaluated and their algebraic sum should be zero. The experiment may be repeated with other positions of the retort stands and other values of P and Q. Any desired number of spring balances may be employed to provide a corresponding number of forces. A series of experiments, using forces ranging from 23 to 83 ounces weight gave the following results:— + 538, − 541; + 848, − 854; + 1610, − 1619; + 1484, − 1511; + 984, − 978; + 1642, − 1631.

Model B.—Assemble the apparatus on the retort stand and adjust the position of weight A so that BC is horizontal. Tie a cord at B pass it over pulley D and attach weights E and W. Adjust the arm of force D, by sliding pulley D up or down or laterally until BC is restored to the horizontal. Measure the arm CG. Then (P × CG) − (W × BC) = 0.

The experiment should be repeated using other values at E and W.

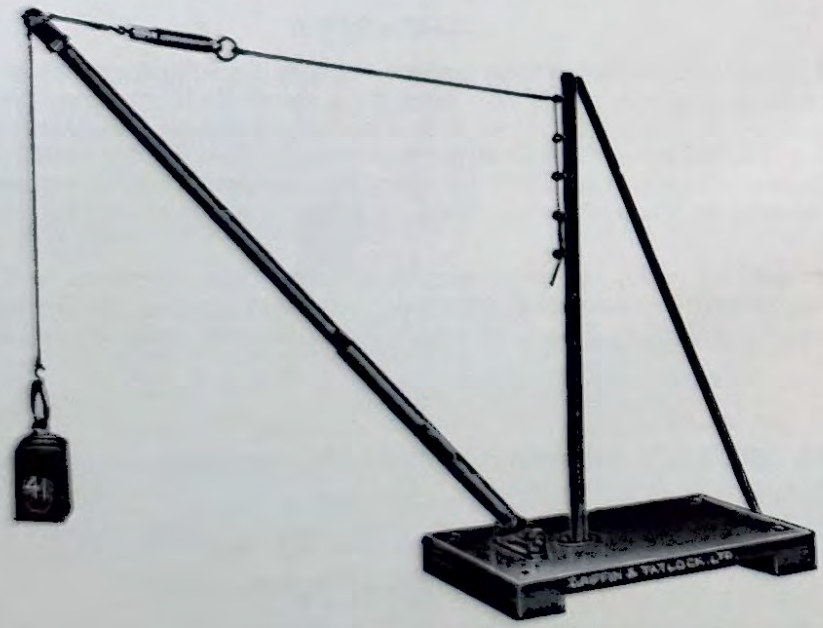


A 21-520.



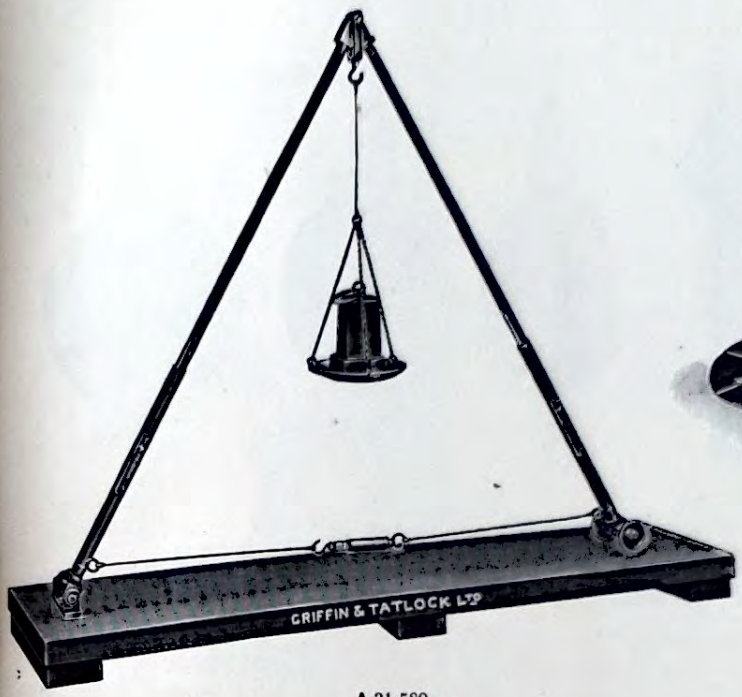
A 21-530.

	£	s.	d.
A 21-520. PARALLELOGRAM OF FORCES APPARATUS, drawing board 31 × 23 in. with two aluminium pulleys which can be fixed in any position, cords and scale-pan. **Without** weights	4	5	0
A 21-530. POLYGON OF FORCES APPARATUS, additional items to enable polygon of forces experiment to be carried out with **A 21-520**:—2 extra pulleys, centre ring and 5 cords. **Without** slotted weights and hangers	1	2	6

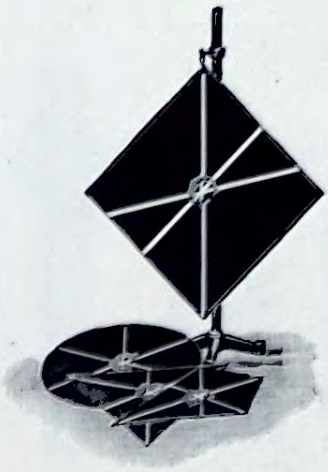


A 21-560.

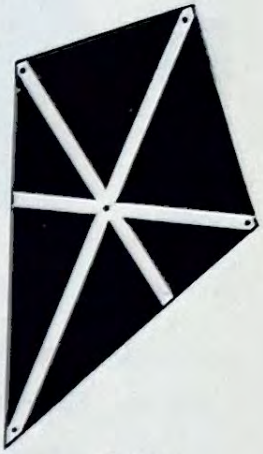
A 21-560. MODEL CRANE. The jib is a tubular compression balance reading to 20 lb. by 4 oz. and pivots about a spindle attached to the base. The tension in the tie is given by a spring balance reading to 16 lb. by 4 oz., and the angle which the tie makes with the jib can be altered by passing the cord through different eyes fixed in the king post, which is firmly secured to the base and strengthened by a metal tie. The base is of polished hardwood 24 × 10 in., with countersunk ferruled holes for screwing down. **Without** weights .. .. r 6 0 0



A 21-580.

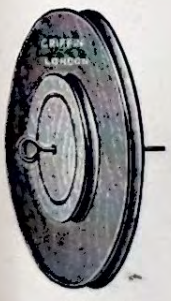


A 21-650.

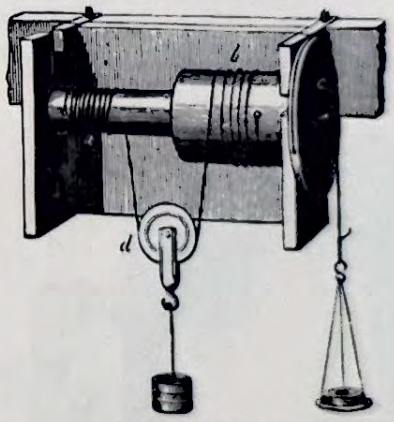


A 21-660.

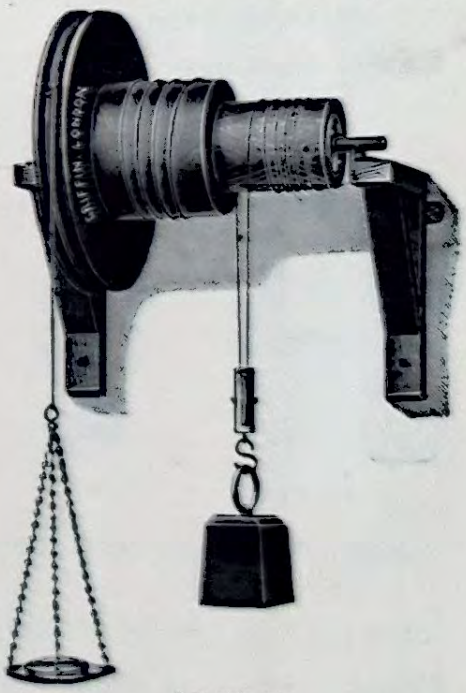
	£	s.	d.
A 21-580. ROOF TRUSS, with extension spring balance in the tie and two compression balances for measuring thrust on the supports. Supports 3 ft. long, one hinged, the other on wheels	7	8	5	0
A 21-650. CENTRE OF GRAVITY APPARATUS, with 4 plane figures, japanned metal, and stand		3	10	0
A 21-660. IRREGULAR QUADRILATERAL, japanned metal, with holes and white lines		0	10	0



A 21-805.

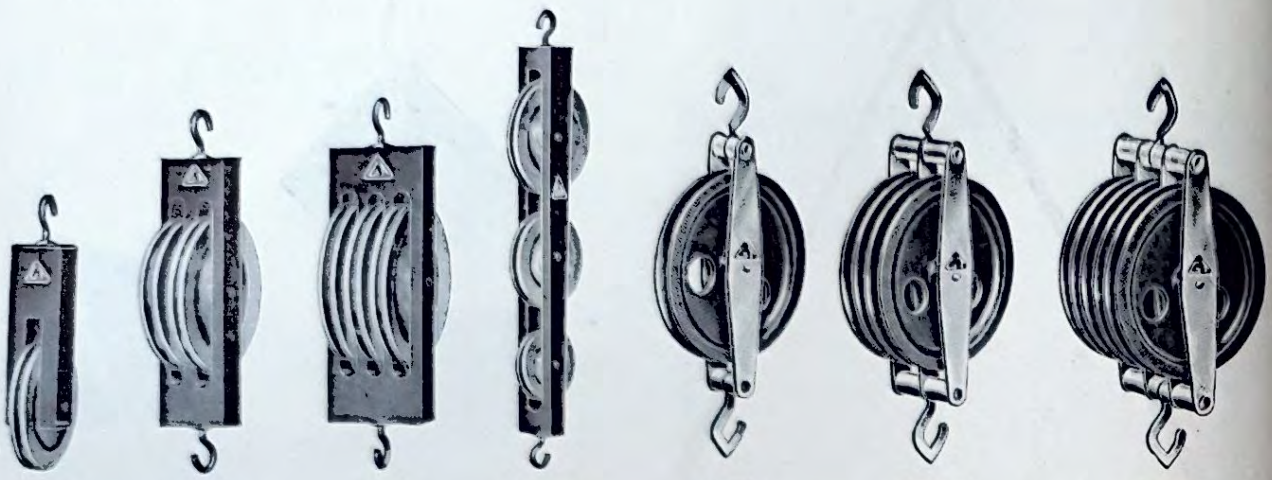


A 21-810—815.



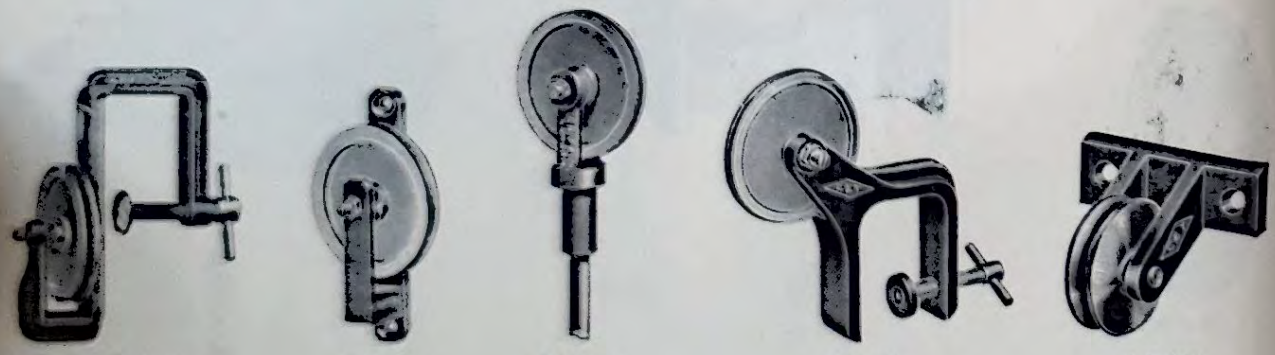
A 21-825—830.

	£	s.	d.
A 21-805. WHEEL and AXLE, hardwood, wheels 6 in. and 3 in. diam., with brass pin		0	6	6
A 21-810. WHEEL AND AXLE, Compound, in bracket, with 1½, 3, and 6 in. wheels. *(Illustration shews wheel and axle mounted on rail on wall)*		2	5	0
A 21-815. Ditto, with pulley, scale-pan, and cord, **without** weights		3	2	6
A 21-825. WHEEL AND AXLE, Compound, wood, with brackets. Wheel 12 in. diam × 1½ in. wide, axles 3⅞ in. and 5⅞ in. diam., × 5 in. long. **Without** cord, pulley block, scale-pan and weights		4	5	0
A 21-830. Ditto, with Cord, Pulley Block, and Scale-pan		5	0	0



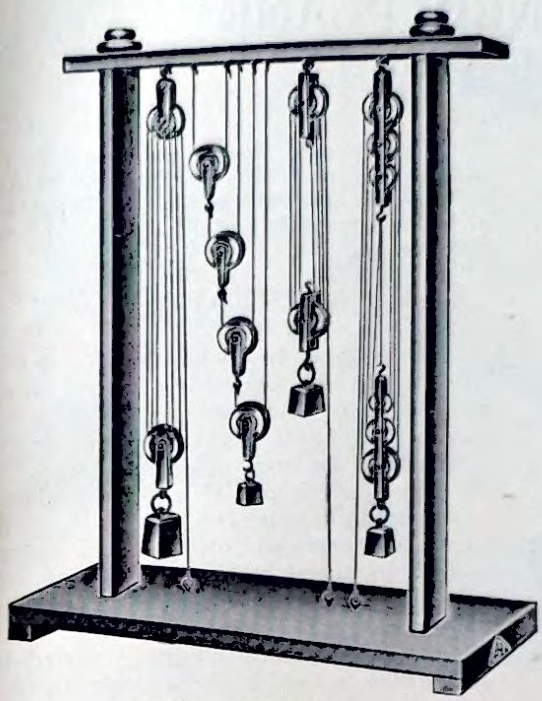
A 21-850. A 21-855. A 21-860. A 21-865. A 21-885. A 21-890. A 21-895.

	£	s.	d.
PULLEYS, Boxwood, wood frames, with hooks.			
A 21-850. Single Sheave, pulley approx. 2 in. diam. .. .. .. *each* 2/6 ; *dozen*	1	7	0
A 21-855. Double Sheave, „ „ 2½ in. „ .. .. .. *each* 3/6 ; *dozen*	1	18	0
A 21-860. Triple Sheave, „ „ 2½ in. „ .. .. .. *each* 4/6 ; *dozen*	2	9	0
A 21-865. Triple Sheave, vertical pattern, with pulleys 1½, 2, 2½ in. diam. *each* 4/6 ; *dozen*	2	9	0
PULLEYS, Bakelite, nickel plated metal frames, with hooks.			
A 21-885. Single Sheave, pulley approx. 2 in. diam. .. .. .. *each* 4/6 ; *dozen*	2	9	0
A 21-890. Double Sheave, „ „ 2 in. „ .. .. .. *each* 7/6 ; *dozen*	4	2	0
A 21-895. Triple Sheave, „ „ 2 in. „ .. .. .. *each* 12/6 ; *dozen*	6	15	0



A 21-910. A 21-915. A 21-920. A 21-925. A 21-930.

	£	s.	d.
A 21-910. **PULLEY, Aluminium,** 2 in. diam., mounted in malleable iron S-frame for clamping to a board	0	10	6
A 21-915. **Ditto,** mounted in frame for screwing to a board	0	10	0
A 21-920. **Ditto,** mounted in line with ¼ in. steel rod 6 in. long, for fixing by means of a bosshead to a rod	0	8	0
A 21-925. **Ditto,** mounted in frame for clamping to bench or board	0	10	6
A 21-930. **Ditto, Brass,** ¾ in. diam., in bracket as fitted to Inclined Planes	0	5	0



A 21-940.



A-21-965.—Single Arm.



A 21-965.—Double Arm.

		£	s.	d.
A 21-940. PULLEY FRAME, Hardwood, 30 in. high, 20 in. wide, can be dismantled for convenience in storage. **Without** pulleys		2	15	0
A 21-950. SILK CORD, 1 mm. diam., hanks about 16 yds.	*hank (a)*	0	3	9
A 21-952. WHIP CORD, about 1½ mm. diam., hanks about 18 yds.	*hank*	0	2	3
A 21-955. SASH CORD, 4 mm. diam., hanks about 12 yds., suitable for **A 21-980—990**	*hank*	0	6	6

A 21-965. RODS, Bosshead, 6 in. steel rods with bosshead, for supporting pulley systems from retort stands, etc.

Single Arm	Double Arm
4/-	**6/6** *each*

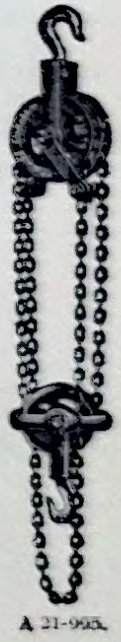
PULLEY BLOCKS, Wrought Iron, with turned shafts and bright pulleys, cross-heads of wrought iron.

Diam. of Pulley ..	2½	3½	4	*in.*
Width of Groove ..	⅜	½	⅝	*in.*
Weight (single sheave)	1½	3	5	*lb.*
A 21-980. Single Sheave	**9/6**	**11/-**	**14/6**	*each*
A 21-985. Two Sheaves	**13/6**	**16/-**	**17/6**	*each*
A 21-990. Three Sheaves	**16/-**	**17/6**	**24/6**	*each*



A 21-980.

A 21-995. PULLEY BLOCK, Weston Differential, tested to ½ ton, for 2½ cwt. lift. With chain guides and 20 feet of chain, for 5 ft. height of lift, with test certificate .. .. £ 2 17 6



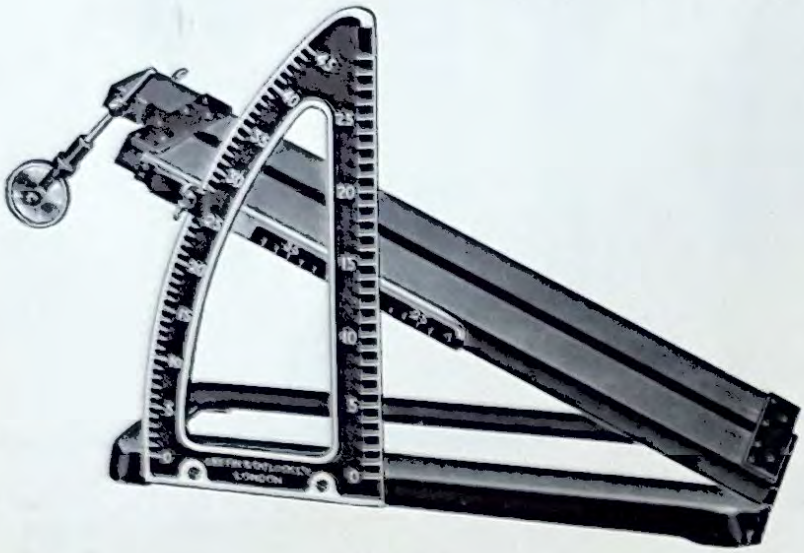
A 21-995.

Orders for Export are handled in a department organised for the purpose and are packed with special care by an expert staff.

THE MICROID INCLINED PLANE

An improved demonstration model

Regd. Design No. 777878



A 22-115.

The improved design and sound construction of the Microid Inclined Plane provides teachers with an apparatus capable of giving consistently accurate and convincing results.

SPECIFICATION

The base is a heavy casting 18 × 6 in. The hardwood plane is of the same dimensions as the base, to which it is attached by a substantial hinge firmly screwed to the ends of each member.

The plane is made up of two strips, separated by a gap about ¾ in. wide, tied together at top and bottom on the upper surface by metal crosspieces. These act as stops for the carriage used in composition of forces experiments and also as holders for the various materials which may be used in friction experiments, *e.g.*, plates of glass, wood, ebonite, etc., may be placed on the plane between the stops and by these prevented from sliding off when the plane is inclined.

An aluminium pulley, 2 in. diam., well balanced and freely running on steel pivots, is attached to a clamp passing through an extension of one side of the plane. The pulley is adjustable for angle and is in line with the centre of the gap dividing the parts of the plane, so that with a string attached to one end of the carriage, passing through this space and then horizontally over the pulley, the horizontal component of the force exerted by the carriage may be measured.

The plane is provided with a cast aluminium centimetre scale having bright raised divisions and figures, standing up in bold relief against a dull background. A combined angular and linear scale similarly graduated is screwed to the base. A positive clamp, which serves as an index also, holds the plane at any angle between zero and 45°. Thus the angle of the plane and its height and length may be seen directly without recourse to other measuring apparatus.

With the plane horizontal and the pulley extending over the edge of the table, the ordinary friction experiments may be performed. The coefficients of friction so obtained may then rapidly be checked by the angle of friction method. In addition, the plane is suitable for all experiments on the composition and resolution of the forces exerted by a body at rest on an incline.

	£	s.	d.
A 22-115. MICROID INCLINED PLANE, with heavy metal base, slotted wood plane, adjustable pulley 2 in. diam., and bold linear and angular scales .. .. *r*	3	15	0



A 22-130.

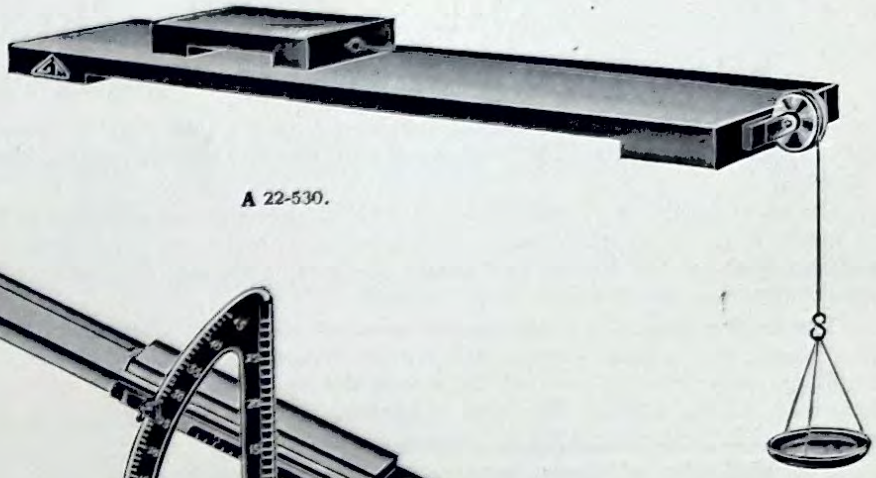


A 22-140.



A 22-150.

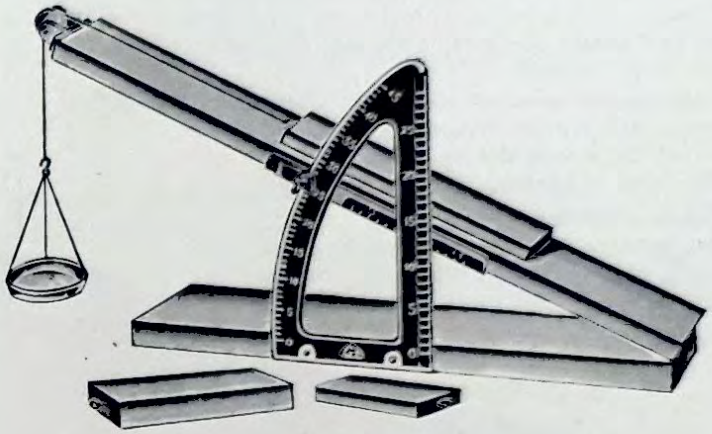
	£	s.	d.
A 22-130. INCLINED PLANE, Simple form, whitewood 24 × 3 in., with 1 lb. metal roller. A wire frame is provided so that the force can also be measured horizontally. With scale-pan, **without** weights	1	17	6
A 22-140. ROLLER, Metal, for use on inclined planes, weight 1 lb.	0	8	6
A 22-150. TRUCK, Metal, 6 × 2½ in. wide overall, with metal wheels, for use on inclined planes	0	13	6



A 22-530.



A 22-420.



A 22-550.

	£	s.	d.
A 22-420. SCREW JACK. Heavy iron base with handle, fitted with ½ in. pitch screw and hard-wood pulley 6½ in. diam. A rotatable collar and arm carrying a pulley can be locked in position on the base. The pulley is adjustable for height and can be turned so that its plane is tangential to the load platform. With scale-pan but **without** weights ..	5	15	0

A 22-530. FRICTION BOARD, for experiments on sliding friction. Heavy wood board, 30 in. long and 7 in. wide, with top surface planed smooth and level, fitted at one end with pulley. Reversible slider, machined from same wood as the board, one face being planed like the board and the other undercut. With scale-pan but **without** weights 2 15 0

An interesting method of using this apparatus is described in *Amer. J. Physics*, 1945, **13**, 43. Let the mass of the slider m_1, connected to a driving mass m_2, be allowed to fall a distance h before striking the floor. Let d be the distance travelled by the slider after m_2 has struck the floor. By making $m_1 = m_2$ the method of treatment is as follows :—

$m_2 g = \mu m_1 g + (m_1 + m_2) a$ where μ is coefft. of sliding friction.

$$\therefore a = \frac{m_2 - \mu m_1}{m_1 + m_2} g \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

The energy equation is

$$m_2 gh = \mu m_1 g (h + d) + m_2 ah \quad . \quad . \quad (2)$$

Eliminating a between (1) and (2) and solving for μ, we have

$$\mu = \frac{m_2 h}{m_1 h + (m_1 + m_2) d} \quad . \quad . \quad . \quad (3)$$

If $m_1 = m_2$ the formula becomes

$$\mu = h/(h + 2d) \quad . \quad . \quad . \quad (4)$$

Thus determination of the coefficient of sliding friction involves only a knowledge of m_1, m_2, h and d.

	£	s.	d.
A 22-550. FRICTION APPARATUS, inclined plane 24 in. long, with divided quadrant, two wood blocks 8 × 3 in. and 4 × 3 in., and one metal block 4 × 3 in.	4	0	0
A 22-552. Zinc Plate, 4 × 3 × ⅛ in.	0	4	6
A 22-554. Plate Glass Strip, 30 × 7 × ¼ in., polished edges	0	15	6

SLOTTED WEIGHTS, See Balance and Weights Section.

THE MICROID TROLLEY

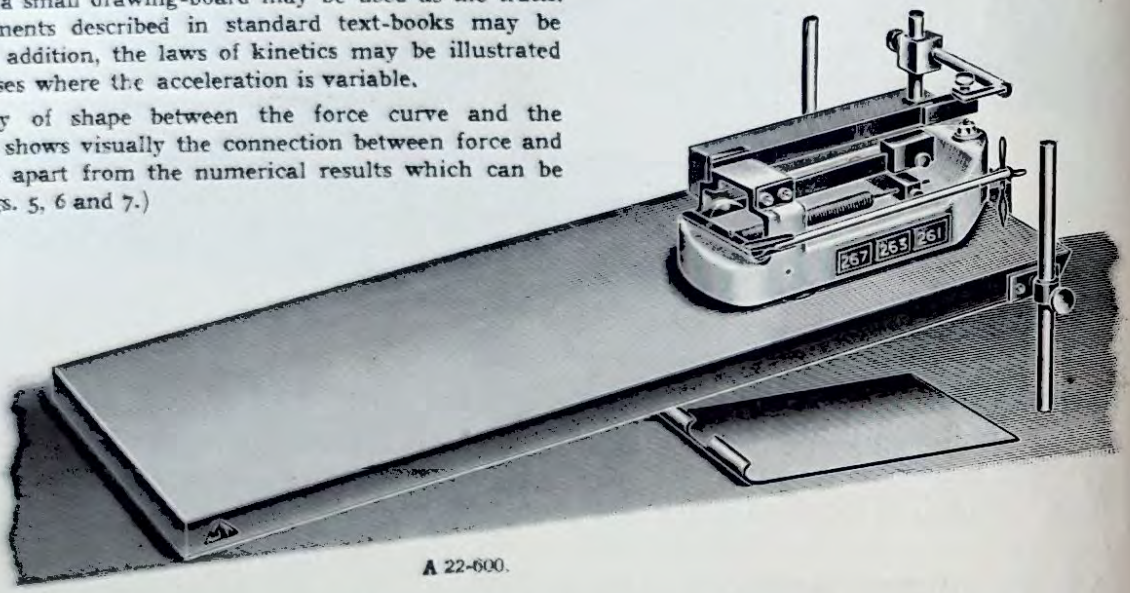
A New Form of Trolley with Self-Registering Dynamometer

This simple apparatus is a radical departure from the traditional Fletcher's trolley. It is small and compact. The range of experiments covered is much more extensive and a more realistic treatment of the principles involved is made possible.

The chief difference between this and other similar types of apparatus is that the vibrator is attached to the trolley and marks the usual type of distance-time trace on a fixed sheet. A spring-controlled dynamometer fitted with an ink-brush is fixed to the trolley and marks a curve, alongside the distance-time trace, of which the ordinates are approximately proportional to draw-bar pull.

The trolley, with the dynamometer removed, is suitable for class use with the simpler experiments and is so proportioned that a small drawing-board may be used as the track. The usual experiments described in standard text-books may be performed, and in addition, the laws of kinetics may be illustrated and verified in cases where the acceleration is variable.

The similarity of shape between the force curve and the acceleration curve shows visually the connection between force and acceleration, quite apart from the numerical results which can be obtained. (See Figs. 5, 6 and 7.)



A 22-600.

SPECIFICATION

The trolley, about 8 in. long, is fitted with two vibrators—one of which carries the ink-brush and is of frequency approximately 10 d.v.s., the other acting as a balancer to prevent oscillation of the trolley itself. The mass of the trolley can be varied by the use of lead blocks of specified weight, which are inserted in a rectangular aperture in the trolley base. The trolley is supported on three smoothly-running wheels.

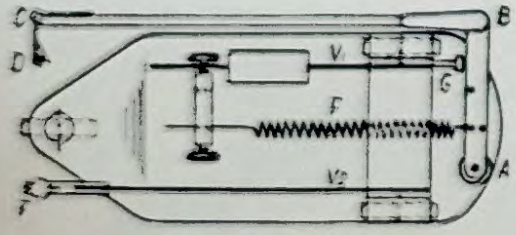
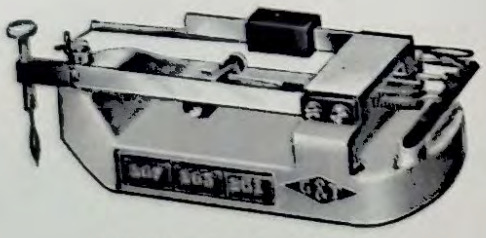


FIG. 1.—Plan of Trolley.

V_1—Dummy Vibrator.
V_2—Vibrator with ink-brush at E.
ABCD—Pull-Recorder with ink-brush at D.
F—Spring. G—Adjustable stop. A—Pivot.



A 22-600.—Showing Vibrators.

The pull-recorder, which is easily removable, has only one moving part. It is sufficiently accurate for class use in those experiments for which a record of the draw-bar pull is required, and is constructed as follows:—

A short pivoted lever A B (Fig. 1), moving in a horizontal plane, is fitted with a light rigid arm B C D carrying an ink-brush at its free end. The lever A B is pierced with two holes; a light spring is hooked in one of the holes, the other end of the spring being adjustably fixed to the body of the trolley. A coupling hook is provided near the centre of A B, by means of which the draw-bar pull can be exerted. With such an arrangement the transverse displacement of the ink-brush at the end of the arm B C D is very nearly proportional

[continued overleaf

A 22-600. The Microid Trolley—*continued.*

to the pull, provided the latter be not too great. (The pull for a given displacement of the brush can be approximately ascertained, when the trolley is stationary by means of a spring balance attached to the coupling hook.)

Owing to the risk of damage to the arm B C D, it is important that it should be instantly replaceable ; this is attained by making the portion B C from a drinking-straw. A spring clip soldered to A B holds the straw at one end ; at the other end a piece of stiff wire, bent to carry the ink-brush, is a push-fit in the straw and forms the portion C D.

A simple form of automatic release is available, enabling measurements near the starting point of the trace to be made with greater accuracy.

PRICES

	£	s.	d.
A 22-600. MICROID TROLLEY, complete set comprising:—Microid Trolley, wood track 24 × 8 in., adjustable for inclination, pulley to clamp to end of bench and adjustable for height, spring balance 100 gm., automatic release for trolley, skid for brake tests, packet of 80 spare pull recorder arms, spring 35 cm. long extending 25 cm./100 gms., 50 sheets paper 24 × 8 in.	6	10	0

Component and Spare Parts for A 22-600

A 22-600 a.	**Microid Trolley,** complete with double vibrator, dynamometer and three lead blocks	3	15	0
„ „ b.	**Track, wood,** with adjustable metal rods for varying inclination	0	11	6
„ „ c.	**Pulley,** adjustable for height, to clamp to end of bench	0	11	6
„ „ d.	**Spring balance,** 100 gm. × 1 gm.	0	6	0
„ „ e.	**Automatic Release,** weighted wood " T-square " with hook to engage screw on flexed vibrator spring	1	0	0
„ „ f.	**Skid,** for brake tests. Light metal sheet 7½ × 4 in. with upturned end to catch trolley. Useful also as a stop for trolley	0	2	6
„ „ g.	**Pull Recorder Arms** .. .. *packet of* 80	0	1	6
„ „ h.	**Spring, steel,** extending 25 cm./100 gms.	0	2	0
„ „ k.	**Paper,** for traces, sheets 24 × 8 in. .. .. *packet of* 50 *sheets*	0	3	6

EXPERIMENTAL NOTES

The trolley is fitted with a vibrator carrying a brush which, as the trolley moves, marks a wave-trace on a sheet of paper placed beneath it. Distances and times are thus automatically registered.

Examination and measurement of the wave-trace enable the following to be determined, (1) Distance travelled in a given time, (2) Velocity at a given instant, (3) Acceleration at a given instant.

In addition a simple, removable, self-registering dynamometer or pull-recorder is provided, which marks on the paper a trace giving a visual idea of the way in which the force (draw-bar pull) varies. This second trace may also be used to give **approximate** quantitative measurements of force, the deflections of the pull-recorder being nearly proportional to the pull. An approximate value of the work done may also be obtained from the area under the force-curve.

The trolley, with pull-recorder removed, may be used in the same way as the Fletcher trolley for experiments involving constant acceleration. Such experiments are fully described in standard text-books, and usually involve determinations of (*a*) acceleration of a trolley on an inclined plane, (*b*) acceleration of a trolley acted on by the pull of a falling weight.

The Microid trolley can also be used for a further range of experiments involving variable acceleration, such as are described in *School Sci. Rev.*, 1932, **54**, 176. Some details of these are given below.

Precautions to be observed in using trolley.

(1) Lubricate wheels lightly with thin (clock) oil.

(2) Before use, turn trolley on its back, clean wheel rims to remove any matter picked up. See that track and paper are free from dust, paper uncreased.

(3) Adjust sliding weight until dummy vibrator synchronises with the vibrator.

(4) Adjust brushes to touch paper as lightly as possible, consistent with giving a continuous trace. A little preliminary practice is advisable. Brushes may conveniently be inked by allowing trolley to overhang edge of track.

(5) Always pick trolley up by bridge to avoid damage to pull-recorder arm.

(6) To start vibrators, pinch together with thumb and fore-finger. Alternatively, tie with cotton, and burn ; or use automatic release.

(7) Adjust pull-recorder spring in its clamp so that the cross-bar is normally just in contact with the adjustable stop.

(8) Adjust position of pull-recorder brush so that, when under no pull, it is as nearly as possible opposite to the vibrator brush (on a line transverse to the trolley). This is effected by cutting the pull-recorder arm to the correct length. Rigidity, at the spring clip, may be increased by the insertion of two half match stalks into the end of the hollow arm.

(9) Owing to the fact that the pull-recorder brush moves in an arc, there is a slight lead of the force reading. This may be neglected in most cases. If desired, a corrected force curve can quickly be plotted with the aid of a piece of tracing paper marked with the arc and a tangent at right angles to the direction of motion.

(10) The Automatic Release though not essential, allows measurements close to the starting point to be made with greater accuracy. To use, see that the arm of release is adjusted by means of the set-screw so that when the base of release is resting on track

[*continued overleaf*

DYNAMICS

A 22-600. The Microid Trolley—*continued.*

In the manner of a T-square, the arm is at right angles to length of track, and at such a height that the hook can engage the screw of vibrator brush, just below the milled head. Place trolley (on sheet of paper) in the required starting position on track. Ink brushes. Arrange release so that the mark on arm is opposite vibration brush. Pinch vibrators with finger and thumb, and allow trolley to run forward slightly, till hook of release engages screw of vibrator brush. On letting go vibrators, trolley is released.

PERIOD OF VIBRATOR.—For many experiments it is unnecessary to know the exact period of the vibrator; but where an actual value of acceleration or velocity is to be obtained, as in experiments involving force and kinetic energy, it is essential that this period be known as accurately as possible. A usual method of determining this is to time the trolley, with a stopwatch, over as long a run as possible, finding from the trace, number of complete waves or fractions of a wave executed in a given time. The following modification has advantages, in the absence of more elaborate methods; it may be carried out by a senior student :—

Clamp to the trolley a small electro-magnet, arranged to operate an armature which gives a small " kick " to the cross-bar of the pull-recorder. Connect magnet by means of long flexible leads to a battery and switch. Arrange a stopwatch (preferably reading to 1/10 sec.) so that the action of starting or stopping the watch operates the switch. (Alternatively, use a pendulum operating an electric contact.) Arrange trolley to give a trace on a sheet of paper at least 2 ft. long, set at a slight gradient. Ink both brushes, set vibrators in motion, start trolley. Quickly press switch momentarily, starting stopwatch. Again press switch, stopping watch, when trolley is near end of run. Read stopwatch: carefully count the number of complete waves and fractions between the two marks registered by the kick of the pull-recorder brush. Enter time and number of waves on the trace. Repeat several times, and work out the mean time of one complete vibration of brush.

VELOCITY AND ACCELERATION AT THE MID-INTERVAL.—In computing a trace, a " wave-length " is the distance travelled by the trolley during one complete movement of the vibrator. If the wave-length is divided by the period of the vibrator, the **average** velocity during the interval is obtained. In cases where acceleration is constant, this is equal to the actual velocity at the middle of the time-interval. In experiments where the acceleration is not constant, this is not exactly true. It can be shown that, in the case of a trolley pulled by a stretched spring (acceleration proportional to distance), the error introduced by assuming :—average velocity during interval = velocity at mid-interval is negligibly small under the conditions of the experiment.*

In other cases of variable acceleration, a greater error may be caused by the assumption, but with a time-interval of 1/10 sec. this error is usually not large.

Similar remarks apply to average acceleration.

---

* If acceleration be proportional to, and oppositely directed to displacement, then with the usual notation

$$s = a \cos \omega t, \quad v = -a\omega \sin \omega t.$$

Let interval be t^1, mid-interval t_1 then :—

$$\text{average velocity} = a\left(\cos \omega\left(t_1 + \frac{t^1}{2}\right) - \cos \omega\left(t_1 - \frac{t^1}{2}\right)\right) \Big/ t^1$$

$$= -2a \left(\sin \omega t_1 \sin \frac{\omega t^1}{2}\right) \Big/ t^1$$

$$= -a\omega \sin \omega t_1 \times \sin \frac{\omega t^1}{2} \Big/ \frac{\omega t^1}{2}$$

In a given case $T = 2{\cdot}5$ sec., $t^1 = 0{\cdot}1$ sec.

$$\omega = \frac{2\pi}{T} = 2{\cdot}51 \text{ rads./sec.}$$

hence " " " $\omega t^1/2 = 0{\cdot}126$ radians

thus average velocity = velocity at mid-interval within about 3 in 1000. A similar result is obtained for acceleration.

METHODS OF COMPUTING WAVE-TRACE.

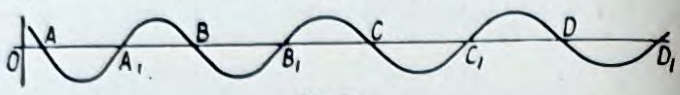


Fig. 2

First Method.—This is the usual method, described in standard text-books. Briefly it is as follows :—

Draw as carefully as possible the centre line of the wave-trace. Measure with a scale, and write on the trace, opposite the points A, B, C, etc., the distances OA, OB, OC, etc., from the start. (If start is not clearly marked, an arbitrary point O must be taken.) Tabulate these, entering each against time measured from the start (*e.g.*, if vibrator has a period 1/10 sec., the times are 0·025, 0·125, 0·225 sec., etc.). Subtract to give " first differences " AB, BC, CD, etc. Enter these in the table opposite the mid-intervals 0·075, 0·175, 0·275 sec. Divide each by the time-interval (1/10 sec.), enter in a fresh column under the heading " velocity." Then *either* :—plot a velocity-time graph, and find acceleration from slope of graph, *or* :—subtract again to give " second differences " $(BC - AB)$, $(CD - BC)$, etc. Enter in table opposite times 0·125, 0·225 sec., etc. Divide by (time interval)^2, enter in table in fresh column under heading " acceleration." (*NOTE.*—If desired, additional values of velocity and acceleration may be found (*e.g.*, 1st differences A^1B^1, B^1C^1, etc.), and 2nd differences $(B^1C^1 - A^1B^1)$, $(C^1D^1 - B^1C^1)$, etc.)

Second Method.—Greater accuracy in practice is attained by reducing the number of readings on a scale to as few as possible. Thus to make a velocity-time table, measure AB, BC, etc. with dividers, and write distances on the trace. Enter in table opposite the mid-intervals 0·075, 0·175 sec., etc. Divide by time-interval to give velocities (*i.e.*, $10AB$, $10BC$, etc., if interval = 1/10 sec.). Enter in table. Then *either* :—plot velocity-time graph, and find acceleration from slope, *or* :—make an acceleration-time table as follows :—set dividers to AB, lay off on BC, then set dividers to the difference $(BC - AB)$. Read off on scale, enter in table opposite time 0·125 sec. Divide by (time-interval)^2 to give acceleration [*i.e.*, $100\,(BC - AB)$]. Repeat for $(CD - BC)$, etc., and enter in table. Additional values may be obtained from $(B^1C^1 - A^1B^1)$, $(C^1D^1 - B^1C^1)$, etc.

N.B.—Errors in individual values obtained from a difference of two quantities are to be expected. In no circumstances should half wave-lengths be used as a basis for calculations. Measurements between crests, however, do not cause serious error and are often convenient, though not theoretically as sound as those made along the centre line.

The following experiments are suggested as useful additions to those generally described in text-books. Expts. I. and II. may be found suitable for a Lower or Upper Fifth form, Expt. III. for an Upper Fifth or Lower Sixth, and Expt. IV. for an Upper Sixth. (Though it is not claimed that the same order of accuracy is obtainable, the results are reasonably convincing.)

Expt. I.—To measure the acceleration of a trolley on an inclined plane, and to find how the acceleration depends on the inclination.

Set up the trolley track. Pin sheet of paper on track. Remove pull-recorder arm of trolley; place one of the removable masses in the slot. Ink brushes, place trolley at top of slope, start vibrators, and allow trolley to run down plane. Enter the height and length of slope on the trace, also the time-interval. Repeat for various heights, over a range of about 1 cm. to 6 cm. (**N.B.**—To save time in working out, traces for different heights may be distributed among groups or individual members of the class.)

Measure the wave-lengths with dividers (in cm.), multiply by 10 to give velocities at the mid-intervals. Make a velocity-time table (for each trace) and plot a velocity-time graph. Enter on graph the height and length of plane. Determine the slope of the straight line which passes most nearly through the points plotted. This is

A 22-600. The Microid Trolley—*continued.*

the value of the (constant) acceleration for the corresponding inclination of plane.

Now collect results to make a table of "height of plane" and corresponding "acceleration"; record length of plane above the table. Plot acceleration against height of plane: draw the "mean straight line." (This does not pass through the origin, owing to friction.) From a study of the graph, find and write down the relation between acceleration and height of plane.

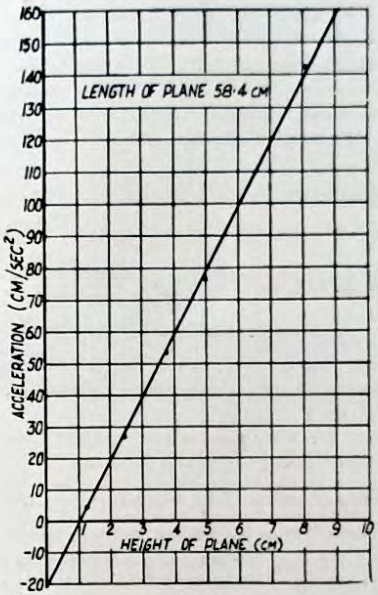


Fig. 3.

Again from the graph, write down (i) the retardation due to friction, (ii) the height of plane for which the acceleration is zero (check (ii) by testing that trolley just rolls freely on the plane when raised to this height). From slope of graph, find (iii) the acceleration produced by each centimetre increase in height, hence calculate (iv) what the acceleration would be, if there were no friction and if the plane were raised to a height equal to its **length** (*i.e.*, if it were vertical, so that trolley fell freely).

N.B.—If the exact time-interval of the vibrator is known, correct the result (iv) by multiplying by 100/(time-interval)^2.

NOTE.—In the above, the effect of the small *variation* of friction with inclination of plane is found to be negligible over the range of inclinations used. The experiment may also be used to test the law $a = g \sin\theta$, $\sin\theta$ being found from the "corrected height" divided by the length of plane.

Expt. II.—Brake tests on a moving trolley. To find how the stopping distance depends on the speed. In this experiment the brake skid **A 22-600 f** is used. When trolley has fully entered skid, all three wheels are locked. Remove pull-recorder arm; place one of the removable masses in slot. Set up at the foot of the inclined track a horizontal drawing board arranged so that the trolley runs from the sloping track on to the level board. In consecutive experiments choose two inclinations such that the speed of the trolley, on entering the level stretch, is doubled. (**Note.**—To do this approximately, for a board 50 cm. long, raise the end until trolley just runs with constant velocity; then raise it an additional 1 cm.; this gives the first inclination. To obtain the second inclination, raise board 4 cm. + friction height.)

Arrange sheet of paper on horizontal board, ink brush, start trolley at top of slope. Find speed of trolley (by measurement of wave-length) for each inclination, at the instant when trolley has completely entered the level board. Enter results in a table.

Now arrange the skid at beginning of horizontal board so that the trolley, after entering the level board completely, has its wheels locked. To ensure even friction, rub skid to-and-fro several times on surface. Mark position of skid. Screw back ink-brush. Allow trolley to run the full length of slope, entering the skid symmetrically. Measure distance travelled by skid. Take mean of several readings. Enter in table. Repeat for second inclination.

The approximate stopping distances for a car with 4-wheel brakes have been stated as follows:—

Speed	10 m.p.h.	15 m.p.h.	20 m.p.h.	40 m.p.h.
Stopping Distance (average)	6 ft.	13 ft. 4 in.	23 ft. 3 in.	96 ft. (approx.

This would presumably be for limiting friction (wheels on the point of locking, but not locked).

Trolley Brake Test. Record total mass of trolley.

	Distance between crests (cm.)	Speed (cm./sec.)	Stopping Distance (cm.)
1st inclination	4·15	41·5	2·7, 2·6, 2·2 } mean 2·5
2nd inclination	8·35, 8·0 } 8·18	81·8	10·0, 9·2, 10·5 } 9·9

It can be seen from the table that doubling the speed requires approximately four times the stopping distance. Repeat with a different mass on the trolley. (**Note.**—This experiment, if extended, can be used as an introduction to Kinetic Energy.)

Expt. III.—Study of motion produced by a Stretched Spring. Place one of the removable masses in the slot of trolley. Attach one end of spring **A 22-600 h** to the hook on dynamometer cross-bar, and fix the other end to a clamp in such a way that when the spring contracts the trolley is pulled forward, (see that connection to cross-bar swivels freely). The tension of the spring should be such that the dynamometer brush is deflected not more than 5 cm. in the rear position (pull about 100 grm. wt.) the deflection falling to zero just before the trolley reaches the end of the paper.

Test this by a few trial runs before inking the brushes, altering the distance of the fixed end of the spring accordingly. Unhook the spring and adjust the brushes so that they press lightly on the paper.

Push trolley back so that the brushes overhang the edge of the board. Ink both brushes, using a camel-hair paint brush to transfer the ink. (**N.B.**—Wash all brushes after use.) Move trolley forward about half an inch, so that the brushes, in their zero positions, just mark the paper, thereby registering the zero positions. Push trolley back, and arrange a 1 kg. flat weight on the board to hold trolley stationary.

Hook spring on to dynamometer hook, keeping trolley stationary. Allow brush to deflect. The trolley is now ready for release. Pinch together the vibrators between a finger and thumb (or use automatic release). Let go, and instantly withdraw the flat weight, allowing the trolley to be pulled forward, making traces with both dynamometer and vibrator brushes. Take several traces, and choose the best for subsequent investigation. Record on each trace the total mass of the trolley and the period of the vibrator.

To find Dynamometer Constant Approximately. Screw back vibrator brush so that it does not touch paper. Place trolley on a (small) sheet of paper, move it along a few inches so that the dynamometer brush marks a zero line. Move trolley back along the same track; hold it in position by a flat weight. Connect one end of a thread to the dynamometer, the other end passing over a pulley and carrying a 100 gm. weight.

Tap bench, move trolley slightly forward so that brush makes a mark. Remove trolley, measure the perpendicular distance between

[*continued overleaf*

A 22-600. The Microid Trolley—*continued.*

the mark and the zero line. Enter result on trace in gm. wt. per cm. deflection. (N.B.—A good 0-100 gm. spring balance can be used instead of the 100 gm. weight and pulley; zero error must be taken into account.)

To Plot Acceleration-Distance Curve. (See Fig. 4.) Draw the line $O\,O^1$ on trace, joining the zero marks of the force trace. Rule in, as accurately as possible, the centre line of the wave-trace. Letter alternate intersections A, B, C, D, and A^1, B^1, C^1, D^1 as shown (A being next to the zero position).

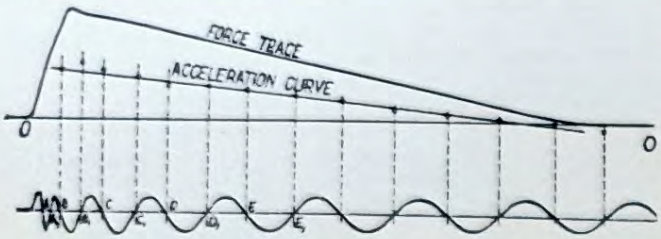


Fig. 4.

Through B, C, etc., draw lines across the paper at right angles to $O\,O^1$. With dividers, lay off the length AB on the line BC, then set the dividers to the distance $BC - AB$. This represents the acceleration at the point B, very nearly. Transfer this length (doubled, for convenience of scale) as the ordinate at the point B, using $O\,O^1$ as zero line. Repeat with other "differences," *e.g.*, $CD - BC$, $B^1C^1 - A^1B^1$ etc., in each case marking the points by small crosses. Draw the straight line most nearly passing through the points.

To plot velocity-distance curve. Transfer with dividers the length AB, BC, etc. (doubled for convenience of scale) as ordinates of velocity at A^1, B^1, etc., using $O\,O^1$ as zero line. Mark the points with small circles. Repeat with A^1B^1, B^1C^1, etc. Draw a curve passing as nearly as possible through the points.

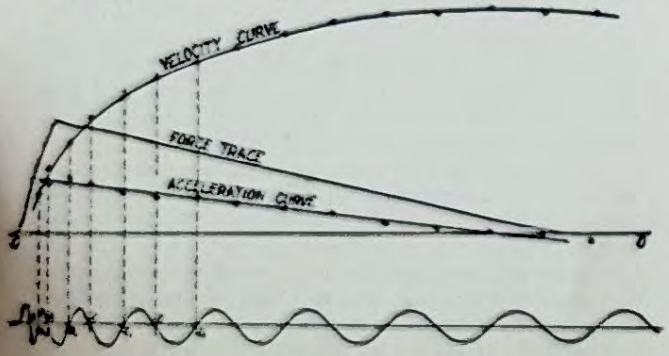


Fig. 5.

To find an approximate value for the work done. Find the area under the force-curve (which represents the work done) by multiplying length of base (in cm.) by half the height. Multiply this result by the dynamometer constant (previously obtained in gm. wt. per cm. deflection) and by 980. The result is the work done in ERGS.

To find an approximate value for the Kinetic Energy gained. Find from the wave-trace, as nearly as possible, the maximum wave-length. Divide by the time-interval of the vibrator, square, and multiply by half the total mass of trolley. The result is the K.E. gained in ERGS. The difference of these two results is the work lost in friction.

Rough check.—Divide by distance run and by 980, this gives average force of friction in gm. wt. Check as nearly as possible with spring balance. (Take zero error of balance into account.)

It may be of interest to investigate other forms of motion, such as are produced by pulling trolley by hand or by a toy clockwork engine (see Figs. 6 and 7). A spring or rubber band should connect trolley with tractive force. Estimates of, and comparisons between the following may be made:—

Work done (from area under force curve; compare with K.E. gained).
Horse-Power (from work done in a given time).
Impulse (Plot a force-time curve; determine area).

Change of momentum (compare with Impulse).
Loss of energy
Loss of momentum } due to friction (allow trolley to "coast").
Average Retardation

Expt. IV.—To illustrate the laws of Simple Harmonic Motion. Remove pull-recorder arm, set track to "friction gradient," and obtain a trace with a stretched spring as in Expt. III. The motion of the trolley may be regarded as a S.H.M. of which a quarter-period is shown on the trace. Assume time-interval of vibrator to be 1/10 sec. Plot acceleration-distance and velocity distance curves as in Expt. III.

Note the straight-line and elliptic forms. The equations are $\frac{d^2x}{dt^2} = -\omega^2 x$ and $v^2 = \omega^2(a^2 - x^2)$ where $\omega = \frac{2\pi}{T}$. Calculate the period T of the S.H.M. from $T = 2\pi\sqrt{\frac{\text{displacement}}{\text{acceleration}}}$, finding the value of $\frac{\text{displacement}}{\text{acceleration}}$ from the reciprocal of the slope of acceleration-distance line. (Remember that, in carrying out the instructions of Expt. III, the 2nd difference was doubled, and that the slope must be multiplied by 100.)

Check the result for T by comparison with the time (T/4) taken to reach maximum velocity as shown by trace.

Now find a series of values of ωt where $\omega = \frac{2\pi}{T}$ and $t = 0{\cdot}1, 0{\cdot}2,$ 0·3 sec., etc. Convert from radians to degrees, and find values of cos ωt. Tabulate the corresponding displacements (x) measured on the trace from the point of maximum velocity (if this point cannot be exactly determined, measure from an arbitrary point).

Make a plot of x against cos ωt. The equation of the straight line obtained is $x = a \cos \omega t$ where a is the amplitude.

Determine a from slope of line. Compare with value given by measurement of trace.

Note.—Other straight line plots may be made, viz.:—
v against sin ωt, slope $= a\omega$
v^2 against x^2, slope $= \omega^2$.
Expt. IV. may be modified by using two opposed springs arranged to give half a complete oscillation of the trolley.

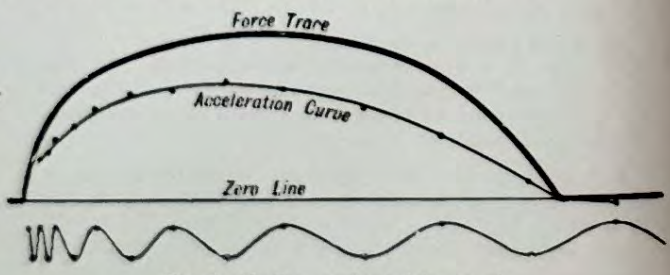


Fig. 6.—Trolley accelerated by Hand.

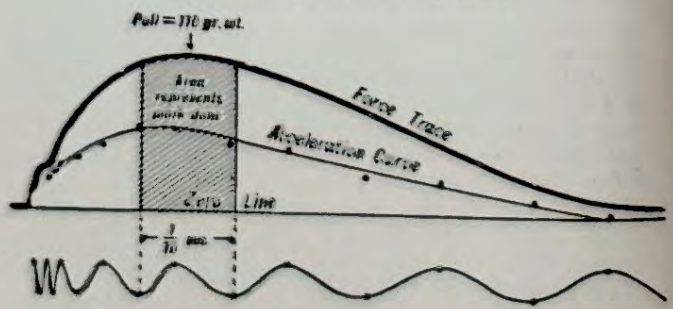


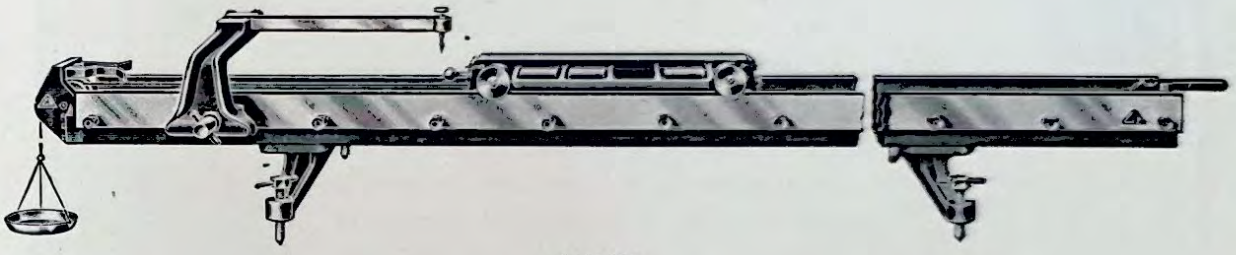
Fig. 7.—Trolley accelerated by Caterpillar Tractor.



A 22-650.

	£	s.	d.
A 22-650. TROLLEY APPARATUS, Fletcher, for experiments on acceleration. Wood plane 6 ft. long with vibrating spring, trolley 30 in. long with set of weights, and ink brush	*t* 7	10	0
A 22-655. Paper for above, cut to size .. .. 100 *sheets*	*t* 0	4	6

The trolley, 30 in. long, is provided with three smooth-running aluminium wheels and carries on its top surface a strip of paper on which a vibrating spring is made to record equal time intervals. The mass of the trolley can be varied by inserting weights in the holes shown in the illustration. The plane, 6 ft. long, is made of carefully selected wood.



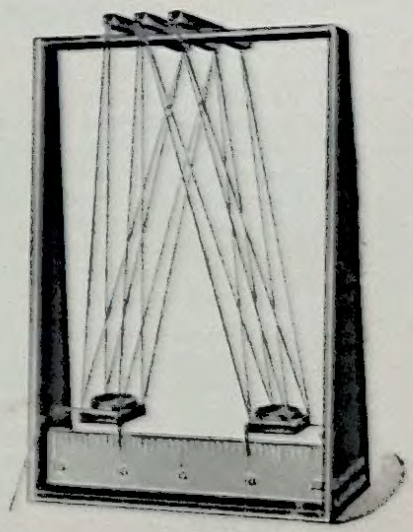
A 22-680.

	£	s.	d.
A 22-680. TROLLEY APPARATUS, Fletcher, improved all-metal construction. Metal trolley 18 in. long, running on three ball-bearing aluminium wheels, with set of 8 cylindrical weights to vary the mass of the trolley ; metal rails 6 ft. long. Vibrator and fine-pointed brush, end pulley with ball-bearings, cord and scale pan	*r* 32	10	0
A 22-685. Paper for above, size 22 × 2 ins. .. .. 100 *sheets*	0	4	6

The metal trolley is mounted on three smooth-running, ball-bearing aluminium wheels ; the two wheels on one side being grooved, the single wheel on the other side having a convex face. Along each side of the trolley are four compartments designed so that the cylindrical weights, of equal mass, can be dropped in and taken out easily, to vary the mass of the trolley. A spring clamp at either end enables lengths of paper strip to be easily and quickly placed in position and held firmly.

The plane comprises two machined parallel steel rails 6 ft. long bolted to a bed-plate and supported on four levelling screws. The vibrator, 14½ in. long, is marked with two lines for clamping to give 5 and 8 vibs./sec. It is held in a bracket which can be attached to the plane at various points along its length. A trigger device to release the trolley is fitted at one end of the plane, and at the other a rubber buffer and spring clip which engages with a ball-fitting on the trolley to prevent rebound.

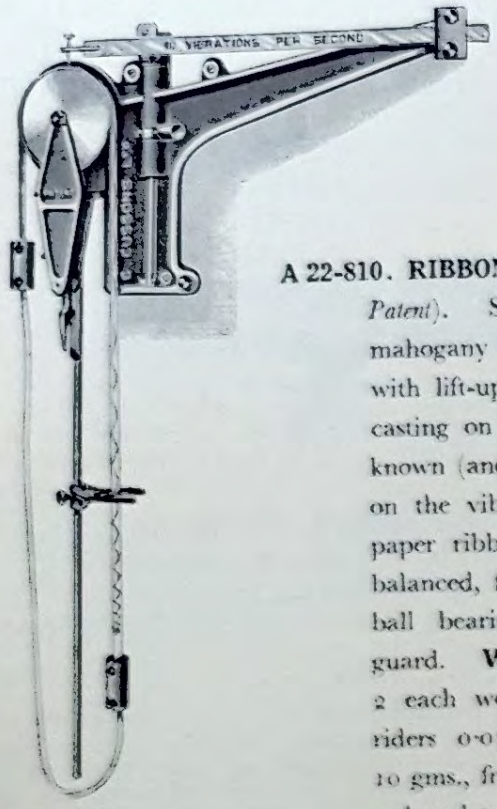
	£	s.	d.
A 22-750. BALLISTIC PENDULUM, Hicks's, well made, rigid wood frame, 42 in. high, on baseboard 24 × 7 in. ; two suspended wood platforms with pointers indicating on divided scale with centre zero ; cords for releasing platforms simultaneously ..	*p* 5	10	0



A 22-750.

£ s. d.

A 22-805. ATWOOD MACHINE, steel pillar 6 ft. × 1¼ in. diam. on heavy tripod base with levelling screws. Accurately turned aluminium pulley 4 in. diam., running on adjustable steel pivots. Three sliding platforms can be locked in position on the pillar by thumb screws. The mass can be started instantaneously by pulling a cord, the rider is retained by a ring on the second platform and the weight is arrested by the lowest platform. With cord, weights and riders .. .. *r* 12 10 0



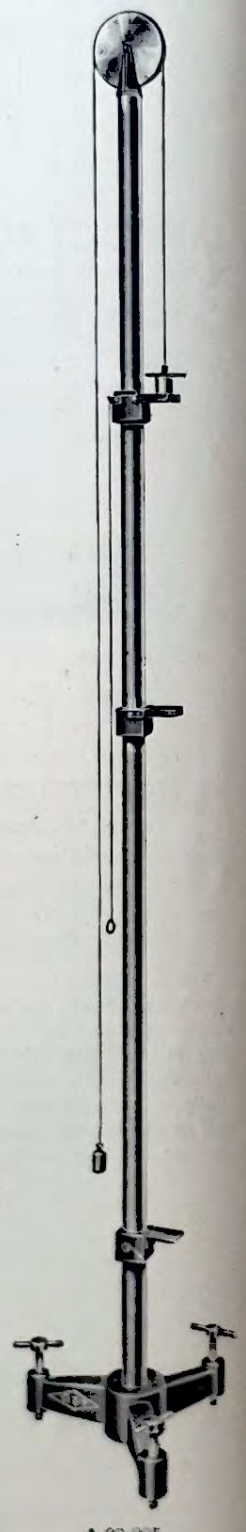
A 22-810.

A 22-810. RIBBON ATWOOD MACHINE (*Cussons' Patent*). Self-contained in wall-mounting mahogany case approx. 24 × 13½ × 6 in., with lift-up front, lock and key, housing a casting on which is mounted a vibrator of known (and adjustable) frequency. A brush on the vibrator is arranged to bear on a paper ribbon on the periphery of a well-balanced, freely-running wheel, mounted in ball bearings and fitted with protective guard. **With double set of accessories,** 2 each weights 0·75 lb. and 375 grams., riders 0·01, 0·015, 0·02 lb., 5, 7·5 and 10 gms., friction rider 0·0012 lb., arrestment rod and two platforms (R. and L.), weight holder for use while attaching tapes, 2 rolls paper ribbon, ink, brushes ands intructions .. *t* 25 0 0

A 22-820. Paper Strip .. .. .. *reel* *t* 0 4 0

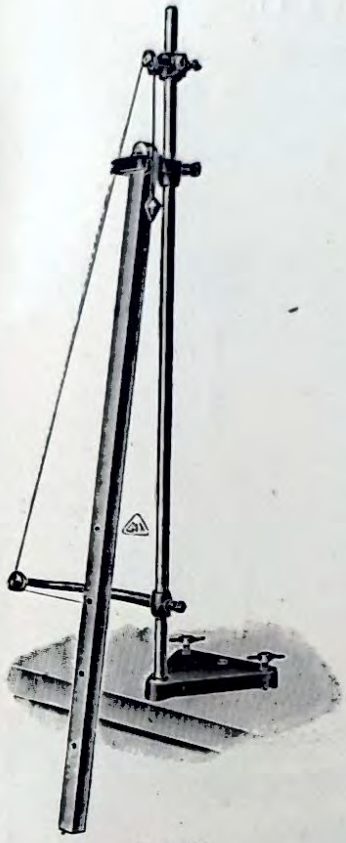
All working parts being mounted on the same bracket, complete rigidity is ensured. On the periphery of the wheel runs a paper ribbon to which two equal weights can be simply attached. By placing the oblong rider on one of the weights, which is supported by the starting platform, the apparatus is ready for use. A steel vibrator of known frequency, clamped at one end and carrying a fine brush charged with ink at the other, is set in motion. The brush is adjusted to be in contact with the tape. As it moves the acceleration trace is described upon the paper. The release is simple, mechanical, and positive, and both vibrator and tape are started simultaneously.

The friction of the wheel is exceedingly low, but a small rider is supplied with each machine, weighing about 0·0012 lb., to overcome the friction and is just sufficient to give motion to the tape without acceleration.



A 22-805.

Particular attention is given to the production of apparatus designed for special purposes by our customers.



A 22-860.

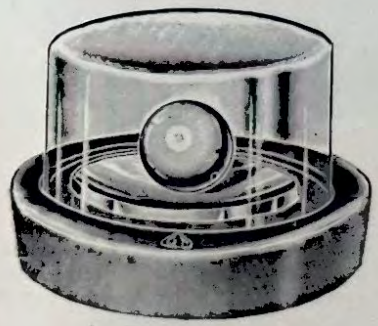
£ s. d.

A 22-860. DETERMINATION OF "g" APPARATUS (Gregory and Simmons: *Exercises in Practical Physics*, Pt. 1, p. 163; Threlfall: *Laboratory Experiments for the Engineering Student*, Pt. 1, p. 96). Wood pendulum 120 cm. long, having a number of holes at intervals in its lower half into which lead weights can be inserted, supported at its upper end on steel knife-edges. Double cone-shaped weight suspended from a thread which is attached to the pendulum at a point in its lower half and which passes over two pulleys and is brought over the top of the pendulum as shown. Metal stand with levelling screws and necessary clamps 3 15 0

The pendulum is used as a time measurer, the lead weights in the holes adjusting its period. To set up the apparatus hang the double cone-shaped weight over the top pulley so that its periphery just touches the pendulum, when the latter is hanging freely. Pass the free end of the thread round the pulleys and tie to the eyelet on the pendulum. The weight will now settle into its position of rest. Rub it with chalk and mark the pendulum at the point where, on swinging forward, it would meet the weight if that remained stationary; this gives the zero.

To operate, burn through the thread. When the pendulum has reached the vertical, *i.e.*, has swung for time t, $\frac{1}{4}$ of its period, it will hit the falling weight. The position will be given by the chalk mark made on impact. Distance s between the two marks is distance traversed by weight. Then

$$s = \tfrac{1}{2}gt^2 \text{ or } g = \frac{2s}{t^2}.$$



A 22-880.

A 22-880. DETERMINATION OF "g" by oscillations of a sphere (Allen and Moore: *Text-Book of Practical Physics*, 165). A bi-concave lens, 7·5 cm. diam. with two spherical faces of different radii of curvature, rests on a wood base, provided with a glass draught shield. Two steel balls about 25 and 38 mm. diam. are supplied 1 15 0

Method of use.—The diameter of the spheres of radius r are measured. The radii of curvature a of the lens are measured. The spheres and lens are carefully cleaned from grease and dust (alcohol) and are not thereafter touched by hand. The time of 50 oscillations of small amplitude is measured. Oscillations are started by tilting the base. With two values of r and of a four sets of observations are recorded.

For small oscillations of the sphere about its mean position:—

$$= 2\pi\sqrt{\frac{7(a-r)}{5g}} \text{ whence } g = \frac{4\pi^2}{t^2} \cdot \frac{7}{5}(a-r).$$

Typical results:—g = 984 995 979 974, cm./sec.^{2} Mean = 983.

The Microid Series is a range of distinctive designs in Scientific Apparatus for the demonstration of physical principles. These special models have been developed in our own Technical Department and in collaboration with independent authorities expert in their various subjects.

THE MICROID "g" APPARATUS

A simple quantitative demonstration type

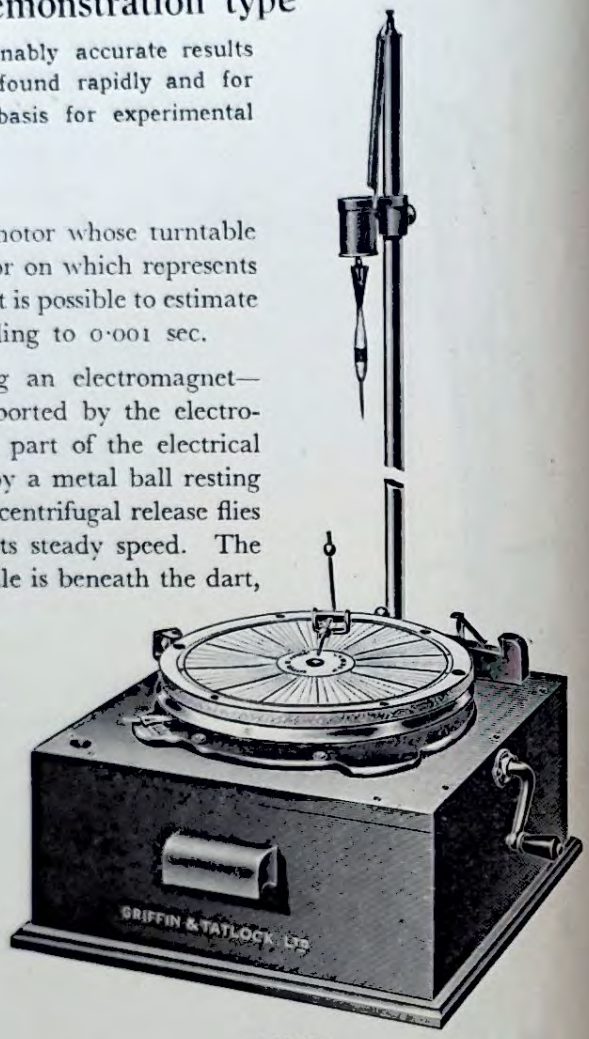
An apparatus designed to give, by a direct method, reasonably accurate results (± 1 %) during a class demonstration. The constant can be found rapidly and for **various heights.** The method can therefore be made the basis for experimental work on accelerated motion.

SPECIFICATION

The apparatus consists of an 80 r.p.m. gramophone motor whose turntable is fitted with a cork mat carrying a circular scale, each sector on which represents 0·01 sec. The arc of each sector is 1 cm. long approx. Since it is possible to estimate to 1/10 of a sector, the apparatus is virtually a clock reading to 0·001 sec.

Fixed to the base is a pillar, 4 ft. 6 in. high, carrying an electromagnet—adjustable for height. A specially constructed dart is supported by the electromagnet. Two metal plates separated by an air gap form part of the electrical circuit. The gap is closed, when the apparatus is in use, by a metal ball resting in a countersunk hole and the circuit is thus completed. A centrifugal release flies over and displaces the ball when the motor has reached its steady speed. The electrical circuit is thus broken and when the zero of the scale is beneath the dart, the latter is released. The point of the dart penetrates the cork mat, by which it is then held, and the time taken is read directly from the divided scale. A device is incorporated for trapping the ball after its release.

	£	s.	d.
A 22-900. MICROID "g" APPARATUS, complete with motor, divided disc, electromagnet and dart. **Without** batteries	12	0	0
A 22-905. Scales, Circular, Divided, spare, for use with above *each*	0	2	0



A 22-900.

EXPERIMENTAL NOTES

To set up the apparatus the pillar is fixed into two holes on the side of the box, care being taken to see that the central portion goes inside the brass contact arm so that the latter makes good electrical connection. The single lead from the electromagnet is fixed to the terminal at the top of the pillar. A four volt accumulator is connected to the two large terminals on the case.

The current taken by the circuit is low (¼ amp. approximately) so that dry cells may be used.

The ball is placed in the countersunk hole and gently rotated to displace any dust particles and thus to make good contact, and the dart suspended. To test the alignment of the solenoid with the zero of the scale, the centrifugal release is put into the "out" position so that it projects over the edge of the cork mat. The disc is rotated very slowly by hand until the centrifugal projection comes in contact with the ball. The rotary disc is then held practically stationary and the dart should fall on the zero on the slightest displacement of the ball. If not, the magnet should be adjusted or the zero error noted.

The ball and dart are then replaced, the centrifugal release thrown over to the "in" position and the motor started. The counter weights on the release should be so fixed that the latter throws over after two or three revolutions, as the motor reaches its steady speed after about 1½ revolutions.

After the dart has entered the cork mat the motor is stopped and the experiment repeated a number of times for the same height. The "bull's eye" of the resultant target is unmistakable and the time corresponding to this is used for the calculations.

SPECIMEN RESULT

The following were obtained under demonstration conditions:—

Expt. No.	Scale Divisions (1/1000th. secs.)	Mean Divisions.	Time (Seconds)	Distance (Inches).	"g" (ft. sec.$^{-2}$).
I.	44·7 45·0 45·3 45·3 45·0 45·3	45·1	0·451	39·5	32·4
II.	39·8 39·8 40·0 39·8 39·6 39·7	39·8	0·398	30·25	31·8
III.	36·7 36·8 36·7 36·6 36·8 36·5	36·7	0·367	25·7	31·8
IV.	32·9 32·6 32·8 32·9 32·9 32·6	32·8	0·328	20·5	31·8
V.	28·8 28·8 28·8 28·9 28·9 28·9	28·9	0·288	15·75	31·5

Mean "g" = 31·9 ft. sec.$^{-2}$ = 972·3 cm. sec.$^{-2}$.



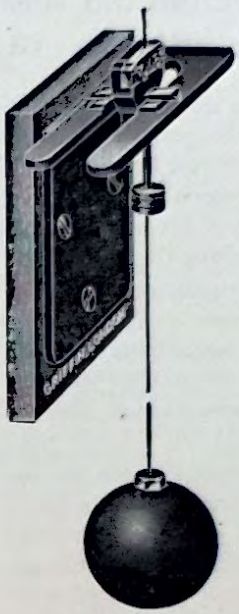
A 23-120.



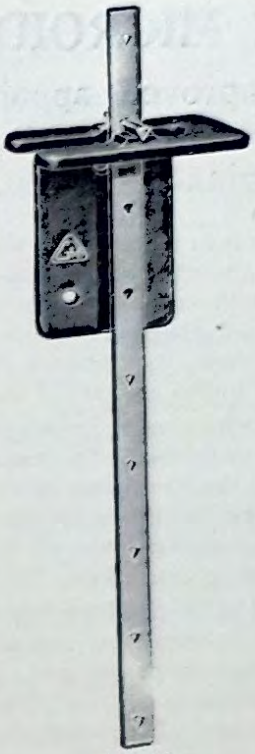
A 23-125.



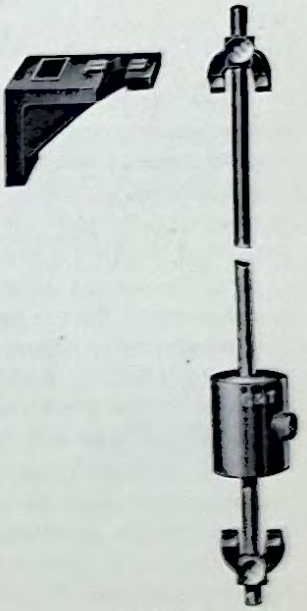
A 23-130.



A 23-150.



A 23-170.



A 23-180.

A 23-120. BALLS, Lead, each with eye, for making simple pendulums.

Diam.	⅝	¾	1	1¼	*in.*
	4/-	4/6	5/6	8/-	*dozen*

A 23-125. BALLS, Brass, with holes drilled through for pendulum experiments.

Diam.	⅜	½	¾	1	*in.*
	5/-	6/6	7/6	12/-	*dozen*

A 23-130. PENDULUM BOBS, Brass, steel tipped.

Weight	1	1½	2½	4½	*oz.*
	t 3/-	3/-	3/-	4/6	*each*

	£	s.	d.
A 23-150. PENDULUM, Simple. Heavy iron ball about 8 cm. diam., wire suspension of adjustable length, knife-edge and bracket support .. .. *p*	3	10	0
A 23-170. PENDULUM, Compound (Allen & Moore: *Text Book of Practical Physics*, p. 170; Worsnop & Flint: *Advanced Practical Physics for Students*, p. 70). Steel bar drilled at equal intervals and removable knife edge. With bracket support	2	0	0
A 23-180. PENDULUM, Compound, Kater type, reversible, with ungraduated stainless steel rod, 48 in. long, heavy adjustable plated cylindrical weight with set screw and steel knife edges set in adjustable metal holders; with bracket support	3	15	0

WHIP CORD AND SILK for suspending pendulums, see A 21-950—952, page 17.

THE MICROID BAR PENDULUM

An improved apparatus for the experimental study of the compound pendulum and for the determination of *g*, the intensity of gravity

The Bar Pendulum has long been recognised as affording a simple introduction to the experimental study of the properties of the compound pendulum. In its usual form it consists of a uniform bar about a metre long, drilled at equal intervals with holes serving as pivots on a fixed knife-edge. Such a bearing is obviously unsatisfactory owing to its short length, the accuracy of timing of the vibrations is poor, and the theory is confused by the presence of the holes along the bar.

In the present apparatus the knife-edge, in two parts, is rigidly attached to a carriage which fits the bar, and can be clamped to it at any position along its length. The pendulum is supported with the two halves of its knife-edge resting on glass plates mounted on a rigid bracket which can be fixed to a wall. The plane of vibration of the pendulum is thus made definite, the friction is very small, and the period of vibration can be accurately determined.

The carriage is so designed as to eliminate the disadvantages which its use might at first sight be expected to introduce: namely, the addition of an extra term (1) to the gravitational deflecting couple, and (2) to the moment of inertia. The first term is eliminated by adjusting the line of the knife-edge to pass through the centre of gravity of the carriage. The second effect is rendered negligible by reducing the moment of inertia of the carriage to a value well below 1 part in 10,000 of that of the bar for any position of the carriage, whilst retaining ample mechanical strength.

By the aid of a stop-watch with dial divided to tenths of a second a very close experimental verification of the theory of the bar pendulum may be obtained and the value of *g* found to within a few parts in 10,000. It is believed that the graphs reproduced in Figs. 2 and 3 are the most accurate that have ever been drawn from observations on the bar pendulum.

Reference.—Owen, *Proc. Phys. Soc.*, 1939, **51**, 456.

SPECIFICATION

A uniform bar of pendulum brass, 1 metre long and about 2·5 × 0·47 cm. cross-section, is engraved near each end with a bold black-filled line by which observations are accurately carried out when it is oscillating. A line CG is engraved on the bar to indicate the cross-sectional plane containing the centre of gravity of the bar. To the carriage, illustrated in Fig. 1, is rigidly attached in two parts a hardened steel knife-edge so adjusted that its bearing edge passes through the centre of gravity of the carriage, which may be clamped in any position along the bar by the manipulation of one screw only. The second screw is introduced to balance the clamping screw. A rigid bracket is supplied to attach to a wall, for use in supporting the pendulum. It is fitted with plane glass bearing surfaces to reduce friction to a minimum.

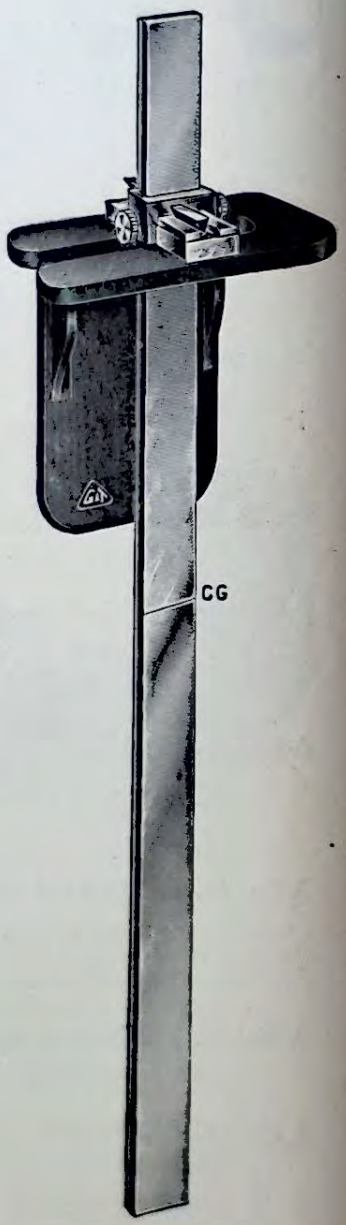


Fig. 1.—A 23-200.

	£	s.	d.
A 23-200. MICROID BAR PENDULUM, brass bar 1 metre long, with specially adjusted knife-edge carriage and with bracket for fixing to a wall	4	0	0

STOPWATCHES, see page 16.

A 23-200. The Microid Bar Pendulum—*continued.*

THEORY

The period of vibration of a compound pendulum is in general expressed by the formula :—

$$T = 2\pi\sqrt{\frac{I}{Mgh}} \quad . \quad . \quad . \quad . \quad (1)$$

where I denotes Moment of Inertia of pendulum about the axis of oscillation,

M the mass of the pendulum, and

h the distance from the axis of oscillation to the centre of gravity.

This reduces to $$T = 2\pi\sqrt{\frac{k^2 + h^2}{gh}} \quad . \quad . \quad . \quad . \quad (2)$$

where k is the radius of gyration of the pendulum about a parallel axis through the centre of gravity.

This formula may be verified by making observations of the period T for a set of varying values of h. A plot of the character indicated in Fig. 2 may be drawn, the branches to right and left of the y axis representing sets of observations taken with the knife-edge first on one side, then on the other side of the centre of the bar. The two branches will in practice be found to be almost exact mirror-images one of the other, and it will be found sufficient to take a set of observations on one side only. As the graph of Fig. 2 indicates, the period becomes a minimum for a certain value of h. Equation (2) shows that the condition for a minimum is $h = k$. In the case of a uniform bar of length L and breadth B it can be shown that $k^2 = (L^2 + B^2)/12$, so that k may be calculated in terms of L and B.

The use of a curved graph, however, has disadvantages, and it is advisable to supplement the simple h, T plot by a rectilinear one. Equation (2) may be written

$$hT^2 = \frac{4\pi^2}{g} \cdot k^2 + \frac{4\pi^2}{g} \cdot h^2 \quad . \quad . \quad (2')$$

which is of the form $y = mx + c$, the equation of a straight line. The truth of (2′) may thus be investigated experimentally by plotting a graph in which the ordinates are values of hT^2, and the abscissae the corresponding values of h^2. A straight line should be obtained passing through the points plotted the slope of which is $\frac{4\pi^2}{g}$, and the intercept on the y axis $\frac{4\pi^2}{g} \cdot k^2$. The measurement of the slope thus enables g to be determined, and the length of the intercept then permits k to be determined.

The existence of a minimum in the h, T curve indicates that the most accurate determination of g, the intensity of gravity, can be made from observations at the setting $h = k$, for in this case a small, first-order error in the measurement of h produces only a second-order error in the value of T. At this setting the accuracy with which g can be determined depends essentially on two measurements only, namely, the total length of the bar and the period of vibration of the pendulum at that setting.

EXPERIMENTAL NOTES

Adjustment of the Pendulum.—Mount the rigid bracket on the wall at a height of about 6 ft. from the floor. Adjust its position so that the plate glass bearing surfaces are level. This may conveniently be done with the aid of a plumb-line suspended from the knife-edge, when the pendulum is in position. The introduction of thin shims of packing between the wall and the bracket may be required to obtain exact levelling.

To set the carriage for any required value of h.—The position of that cross-section containing the centre of gravity of the bar has been ascertained by balancing the bar alone on a horizontal knife-edge, and a fine line (CG of Fig. 1) has been engraved on the bar to indicate this position (it is usually found to be indistinguishable from the geometrical centre-line of the bar). First measure the fixed distance d from the knife-edge to the face of the carriage next to it. Slide the carriage on to the bar, and set it so that the face indicated is at the desired distance from the central line CG. It is most convenient if the values of h are made an exact number of centimetres, so that the face of the carriage should be adjusted to the requisite distance $(h - d)$ from CG, and the carriage then clamped by its set-screw. Distances should in every case be measured to the nearest tenth of a millimetre, using an ordinary centimetre rule. A hand lens may be found helpful.

To measure the period of oscillation T.—The carriage having been adjusted along the bar and clamped at any required position, the pendulum is suspended with its knife-edge resting on the glass bearing surfaces of the wall-bracket, care being taken to ensure that the mounting is central, and that there is satisfactory clearance.

For the determination of the period of oscillation a stopwatch with dial divided into tenth-seconds is strongly recommended. By this means the duration of an experiment for a given accuracy of determination can be very materially reduced.

To observe transits of the pendulum a telescope should be used, at a distance of, say, 6 ft. from the pendulum. The telescope is focussed on the black line marked on the bar at either end, so that when the pendulum is at rest the image of the line coincides with the vertical cross-wire in the eyepiece. The extremity of the pendulum having been displaced laterally about an inch and released, observations may at any time be commenced. The stop-watch is started at the instant of a transit of the pendulum across its rest position, and stopped at the end of 50 complete vibrations. The total time will vary from about 70 seconds upwards, according to the value of h, and should be observed with an error not exceeding 1/20 sec., which gives ample accuracy in a series of observations for studying the law of the pendulum.

To investigate the formula.—In order to verify the truth of formula (2), a set of observations of T is carried out for values of h = 5, 10, 15, 20, 25, 30, 35, 40 and 45 cm. If desired a similar set of observations may be made with the carriage and knife-edge on the other side of the centre of gravity of the bar.

Table I contains a specimen set of observations d = 0·90 cm. :—

TABLE I

h (in cm.)	Time of 50 oscillations (in seconds)	T (sec.)	T^2	hT^2	h^2
5	131·45	2·629	6·912	34·56	25
10	97·07	1·941	3·771	37·71	100
15	84·30	1·686	2·842	42·63	225
20	78·83	1·577	2·484	49·68	400
25	76·65	1·533	2·350	58·75	625
30	76·19	1·524	2·322	69·66	900
35	76·90	1·538	2·365	82·79	1225
40	78·18	1·564	2·446	97·84	1600
45	79·95	1·599	2·557	115·06	2025

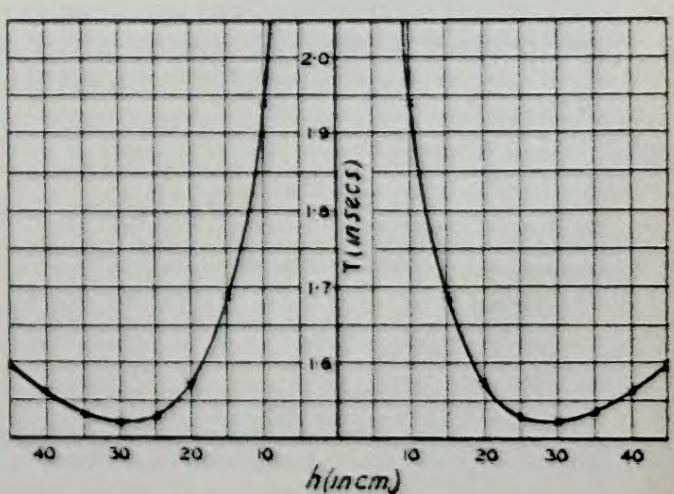


Fig. 2.—Graph of T against h.

The graph of h against T is shown in Fig. 2, indicating how T passes through a minimum.

[*continued overleaf*

DYNAMICS

A 23-200 The Microid Bar Pendulum—*continued.*

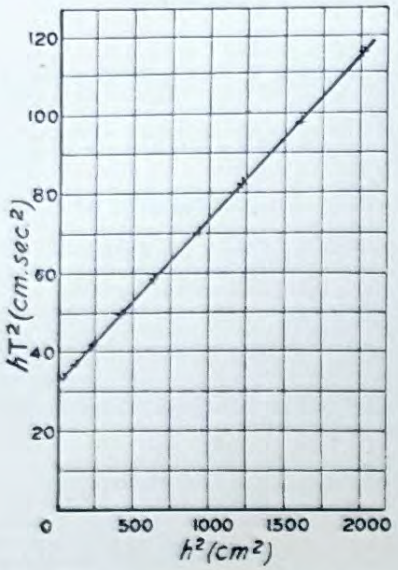


Fig. 3.—Graph of hT^2 against h^2.

The graph of hT^2 against h^2 is shown in Fig. 3. This rectilinear graph is obviously of more value for the accurate deduction of g and of k. From it we obtain for the slope $\frac{114{\cdot}0 - 33{\cdot}5}{2000} = 0{\cdot}04025$; equating this to $\frac{4\pi^2}{g}$ we deduce the value $g = \mathbf{980{\cdot}8}$ **cm./sec.²**

The intercept on the y axis is 33·5, and equating this to $\frac{4\pi^2k^2}{g}$, and using the above value for g, we deduce that $k = 28{\cdot}85$ cm. By calculation from the dimensions of the bar, for which the length L is 100·00 cm. and the breadth 2·54 cm., we obtain for k the theoretical value $\sqrt{(100^2 + 2{\cdot}54^2)/12} = 28{\cdot}876$ cm. The rectilinearity of the graph, and the values of g and k deduced from it, afford a very close verification of the theory of the bar pendulum.

Accurate determination of g.—As already pointed out, the value $k = \sqrt{(L^2 + B^2)/12}$ should be used in order to obtain the highest accuracy possible in the determination of g. It can be shown that for a bar 1 metre in length a departure of 1 mm. from this setting affects the value of T by only 3 parts in 1 million. The accuracy of the value of k to be substituted in the formula thus depends essentially on the accurate measurement of L, the length of the pendulum, which can be made to within one or two tenths of a millimetre. Equation (2) now reduces to

$$T = 2\pi\sqrt{2k/g}.$$

It is, of course, necessary to realise the same degree of accuracy (1 part in 10,000) in the determination of T as in the calculation of k. This requires the observation of a larger number of vibrations than that used in the preceding observations, but it will be found sufficient to extend the total duration of the timing to about 10 minutes. The well-known procedure can be followed which reduces the observer's task to one of starting the watch at a transit across zero, and stopping it about 10 minutes later, without counting the oscillations or giving close attention in the meantime. A correction for the inaccuracy of the watch is also made.

The procedure therefore consists in accurately measuring L and B, thence calculating the value of k and setting the carriage so that the knife-edge is at this distance on either side of the line CG.

A preliminary estimate of the period should be made by timing 50 counted oscillations, repeating the determination, and taking the mean.

For the accurate timing of the pendulum, set the bar swinging and commence the timed interval of about 10 minutes at the instant when the datum line coincides with the vertical crosswire in the eyepiece of the telescope. Allow the pendulum to continue to oscillate freely for about 10 minutes and stop the watch at the instant of another transit in the same direction. The method is made clear in the following example of a set of observations :—

Specimen Result.

Length L of bar = $(99{\cdot}99 + 100{\cdot}00)/2 = 99{\cdot}99_5$ cm.
Breadth B of bar .. .. .. = 2·54 cm.

$\therefore\ k = \sqrt{(L^2 + B^2)/12} = \sqrt{(99{\cdot}99_5^2 + 2{\cdot}54^2)/12} = 28\ 876$ cm.

The preliminary determination of T by timing 50 oscillations in duplicate gives an approximate period

$$\frac{76{\cdot}18 + 76{\cdot}22}{2 \times 50} = 1{\cdot}524 \text{ secs.}$$

For the accurate determination of T (oscillations not counted),

timed interval = 594·46 secs.

If n denote the number of oscillations in this interval,

$$n \times 1{\cdot}524 \doteqdot 594{\cdot}46;$$
$$\text{or, } n \doteqdot 594{\cdot}46/1{\cdot}524 \doteqdot 390{\cdot}07.$$

Taking n as exactly 390, we have, omitting corrections for any inaccuracy of the stopwatch,

$$T = 594{\cdot}46/390 = 1{\cdot}5243 \text{ secs. (by watch).}$$

The watch was checked over a run of 10 minutes against a standard clock (whose rate was known to be from 2 to 3 seconds' gain per day), and found to be slow by 2·5 parts in 10,000. The final corrected value of the period of oscillation is

$$T = 1{\cdot}5247 \text{ seconds.}$$

Thus $g = 8\pi^2k/T^2 = 8\pi^2 \times 28{\cdot}876/1{\cdot}5247 = 980{\cdot}8$ cm./sec.²

$$g = \mathbf{980{\cdot}8} \text{ cm./sec.}^2$$

No correction has been made for the buoyancy of the air, the effect of which is virtually to reduce the value of g by about 1·5 parts in 10,000.

NOTE.—The following observations and calculations demonstrate the negligible effect of the mass of the carriage on the accuracy of the above determination :—

M, the mass of the bar . . .	= 1024 gm.
m', the mass of carriage . . .	= 68·5 gm.
I, the moment of inertia of bar about the axis of minimum period .	= $1{\cdot}7 \times 10^6$ gm. cm.²
I', the moment of inertia of carriage alone about its knife-edge .	= 98 gm. cm.²
T', the period of oscillation of the carriage alone about its knife-edge	= 3·7 sec.

Applying the formula $T = 2\pi\sqrt{I'/m'gh'}$ the distance h' between the knife-edge and the centre of gravity of the carriage = 0·004 cm. Thus $m'h'/Mk \doteqdot 10^{-3}$, showing that the deflecting couple due to the carriage is utterly negligible compared with that due to the bar. Also it is seen that $I'/I < 10^{-4}$, so that the second theoretical source of error is likewise too small to affect the result.

Customers abroad may be assured that their orders will receive particular and individual attention. Orders for Export are handled in a department organised for the purpose, and packing is carried out with special care. Orders for goods other than our own may be included and will be charged at makers' prices.

THE MICROID ROTATING PLATFORM

An apparatus for demonstrating spectacularly and by personal sensation the consequences of the conservation of angular momentum



A 23-410.—Rotating Table.



A 23-415.—Chair.

The difficulties found by students in grasping the characteristics of momentum and gyroscopic phenomena are well known to teachers. Methods and apparatus for their clearer appreciation have recently been described by Pohl. The consequences of the phenomena are brought vividly before the student by sensations experienced personally. The present apparatus is one of the simplest and most effective of these devices.



A 23-420.—Fly-wheel.

SPECIFICATION.

A hardwood table 18 in. diam. and 1 in. thick is fitted so that it may rotate on a heavy tripod foot which has a radius of 12 in. The table is screwed securely to a flange carried on a vertical shaft which rotates on ball bearings and which is mounted in a heavy boss at the centre of the tripod foot. The whole apparatus is supported on stout levelling screws and is strong and durable. A metal chair of a standard type may be mounted on the table, and is located and secured in a central position by a simple angle-iron fitting.

[continued overleaf

DYNAMICS

A 23-410. The Microid Rotating Platform—*continued.*

	£	s.	d.
A 23-410. MICROID ROTATING PLATFORM, with heavy tripod base on levelling screws and circular table running on ball bearings .. .. *r*	9	0	0
A 23-415. Chair, all metal, for use with above platform .. .. *r*	4	0	0
A 23-420. Fly-Wheel, 26 in. diam., on ball bearings, with extended spindle to form handles, and with heavily loaded rim .. .. *r*	2	5	0
A 23-425. Heavy Iron Balls, about 3 in. diam. .. .. *pair r*	0	18	6

EXPERIMENTAL NOTES

Angular momentum G is defined as the product of the moment of inertia I and the angular velocity ω of a body, *i.e.*, $G = I\omega$. For any given system, therefore, G must remain constant with variations in I and ω. Or otherwise expressed, I and ω are dependent variables. The rotating table may be used to illustrate this law in ways of which the student will retain a lasting impression, relating, as they do, to facts of everyday experience and common, though intuitive, knowledge. It may here be pointed out that the chair listed above (**A 23-415**) is not absolutely necessary for these demonstrations, but will be found valuable for those students who, unless they obtain considerable practice in balancing on the table are likely to fall when the table is in rotation. The experiments can be carried out with perfect safety when the student is seated on the chair and will be described as though the chair were being used. The technique is exactly the same when standing.

Expt. I.—Place a spirit level on the table and level carefully. Sit on the chair with the table at rest and hold in either hand equal, fairly heavy (say 2 kilo) weights. The heavy iron balls **A 23-425** are convenient. Raise the arms to a horizontal position and get an assistant to spin the table at a low speed. Drop the arms suddenly to the sides and observe the increase in angular velocity. Raising the arms reduces the velocity to its initial value. The moment of inertia has been varied and the angular velocity has dependently varied so that the angular momentum has remained constant. Points worth emphasis in the classroom are the dependence of moment of inertia not solely on mass but also on configuration and the application of this experiment to the governor in engineering.

If the pupil cannot support heavy weights at arms' length, it is a good plan to fix them to the ends of a pole say 4 ft. long. This can be moved from a horizontal to a vertical position to produce the necessary changes in the moment of inertia.

Expt. II.—Seated on the chair raise one arm sideways until it is horizontal and then swing it smartly round in a horizontal plane until the hand touches the other shoulder. During the swinging of the arm the body and table move also, but in the opposite sense. When the arm is stationary, the body is stationary. It is quite possible by this method to obtain continuous rotation. But if the arm retrace its path so also will the body. To obtain progressive rotation, therefore, the arm should be returned to zero position in a vertical plane when, since the body is free to rotate about a vertical axis only, it does not respond to the angular momentum of this motion.

This experiment forms an illustration of what a cat does in falling in order that it may land on its feet. In its fall its free axis of least moment of inertia, normally, its horizontal axis, is used as an axis of rotation and its tail and hinder parts are swung round, instead of, as above, the arm.

Expt. III.—(*a*) With the fly wheel in the left hand and its axis vertical, sit on the chair. With the right hand grip the spokes and set the wheel rotating. Result: the body and table rotate in an opposite sense.

Explanation: The wheel receives a certain angular momentum $I_1\omega_1$. By the principle of the conservation of momentum the body and table must acquire an angular momentum $I_2\omega_2$ in an opposite sense. The angular velocity ω_2 of the body and table is less than that of the wheel because their moment of inertia I_2 is greater.

(*b*) Bring the wheel to rest by pressing its rim against the chest. Both wheel and table come simultaneously to rest since both angular momenta are then again zero.

Expt. IV.—(*a*) Sit on the chair holding the wheel with its axis horizontal and one spindle extension in each hand. Get a second person to spin the wheel. No rotation of the table takes place since it does not react to an angular momentum about a horizontal axis.

(*b*) Tilt the axis of the wheel, while it is spinning, in a vertical plane. Rotation of the table and body results. Tilting in the reverse direction produces rotation in the opposite direction. The angular velocity acquired may be varied by tilting through 30°, 60°, etc. The explanation is similar to that for III (*a*).

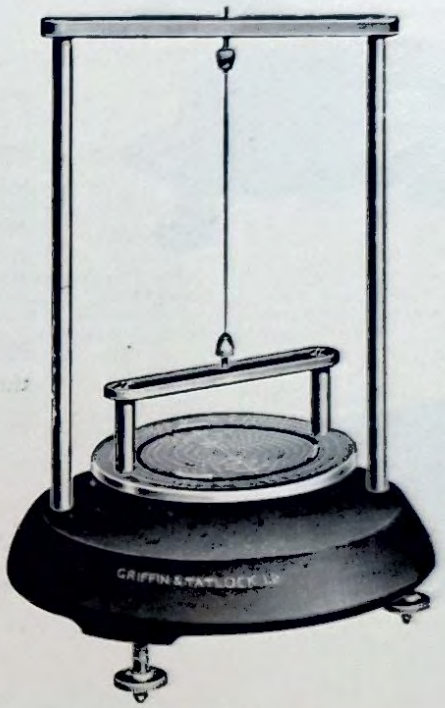
Expt. V.—Hand the rotating wheel to a person seated on the chair. The axis of the wheel may be at any angle to the vertical but the subsequent operations can most readily be carried out if it be vertical. Turn the axis through 180° and rotation of the table follows. Turn the wheel back through 180° and rotation of the chair and body ceases. Hand the rotating wheel back again.

Explanation: By turning the fly wheel through 180° the angular momentum has been altered from + G to − G, *i.e.*, by 2 G, and thus the body and table acquire angular momentum equal to 2 G. Turning the wheel back through 180° restores the system to its original condition and rotation of the table ceases. Momentum has been transferred from one body to another, used, and given back again. So far as we are able experimentally to realise the theoretical conditions this forms a striking demonstration of the conservation of momentum.

Please look under MICROID in the General Index at the end of this Catalogue, to find whether your requirements are met by one of the distinctive designs in the MICROID PHYSICAL SERIES.

THE MICROID MOMENT OF INERTIA TABLE

With rotating table



A 23-470.

The construction is such that a simple harmonic rotational movement of sufficient regularity for experimental purposes is readily obtained.

SPECIFICATION

Two pillars are carried on a heavy iron base with levelling screws. A cross-bar between them is fitted with a chuck for gripping a wire, on which is suspended by two pillars and a chuck, a circular aluminium table 6½ in. diam. On the upper face of table concentric circles are described and a concentric groove is cut, in which three balancing weights may be placed.

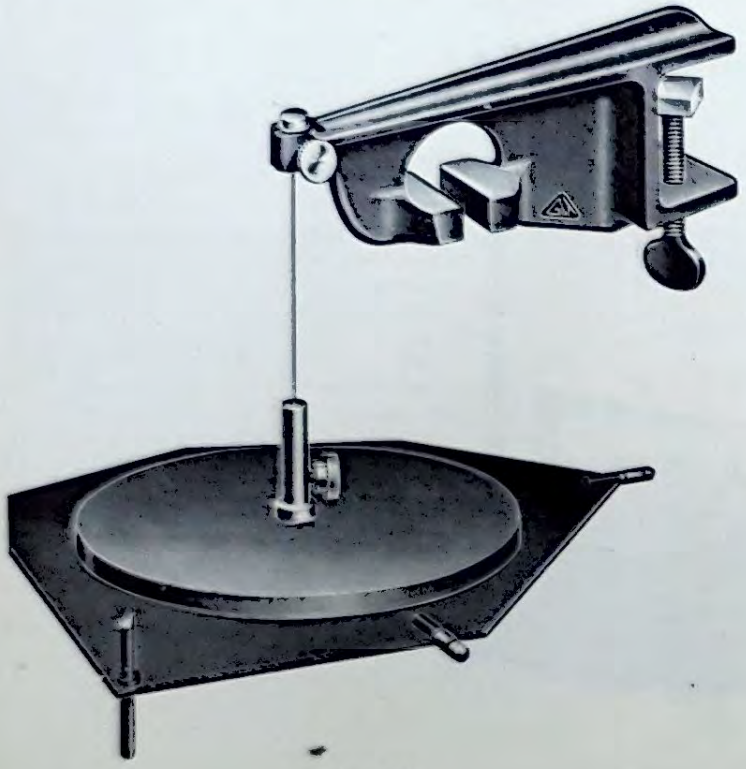
	£	s.	d.
A 23-470. MICROID MOMENT OF INERTIA TABLE, on iron base with levelling screws, complete with three weights	3	0	0

EXPERIMENTAL NOTES

The design follows closely that described in Worsnop and Flint, *Advanced Practical Physics*. With this class of apparatus it has sometimes been found difficult to secure a pure rotational movement. In the type here described a sufficiently pure movement is readily obtained by steadying the hands against the pillars on the table while imparting the initial movement to the table. The three weights provided can be placed in any position in the groove and are used for balancing the table. The concentric circles will be found useful in placing bodies centrally. The whole design will be found simple and effective.

MICROID MOMENT OF INERTIA APPARATUS

A set of apparatus to illustrate the fundamental principles of moments of inertia



A 23-320.

This apparatus is for use in experiments which illustrate a number of fundamental principles underlying the determination of moments of inertia.

An irregularly-shaped lamina can be suspended for rotation about any of three axes, it can be used as a compound pendulum, and it can have added to it, as shown in the illustration, a body of simple geometrical form and of calculable moment of inertia. A well-designed table clamp is provided for use in these experiments.

SPECIFICATION

The apparatus consists of the following parts:—

(*a*) A heavy clamp, which can be rigidly attached to the edge of a laboratory bench for use in supporting the parts in the various experiments. The clamp is provided with two plane surfaces on which the lamina can be swung in the pendulum experiment.

(*b*) A steel torsion wire soldered to brass end pieces. The top fitting can be fastened to the clamp. The bottom fitting is provided with a clamping screw so that to it there can be attached either of the components (*c*) or (*d*).

(*c*) A solid brass rod about 11½ × ½ in. diam., which can perform torsional oscillations in a horizontal plane when attached to the wire by means of a projecting pin at its midpoint.

(*d*) An irregularly-shaped plane brass plate approx. 9½ × 8 in., which can be attached to the torsion wire by any one of three pins. The position of the edge pins is such that the axes of suspension pass through the centre of gravity of the plate and are at right angles. The third pin is placed at the centre of gravity and is at right angles to the plane of the plate. When suspended by the torsion wire from this pin the plane of the lamina is horizontal. The plate is also provided with a knife edge to enable it to swing as a compound pendulum from the two plane surfaces provided for the purpose on the clamp.

(*e*) A circular steel disc, 6 in. diam. × ¼ in. thick, having a central hole which slips over the central pin on the lamina, as shown in the illustration.

PRICES

	£	s.	d.
A 23-320. MICROID MOMENT OF INERTIA APPARATUS, table clamp, torsion wire, brass rod, brass plate and steel disc, as described above	5	5	0

A 23-520. Microid Moment of Inertia Apparatus—*continued.*

EXPERIMENTAL NOTES

Expt. I.—Let GA and GB be any two mutually perpendicular axes of the lamina passing through G, the centre of gravity, and lying in the plane of the lamina. Let I_1 and I_2 be the moments of inertia of the plate about these two axes respectively. If, now, the plate be suspended by a vertical wire, of torsional constant μ lying along AG, the period T_1 of torsional oscillations will be

$T_1 = 2\pi\sqrt{\frac{I_1}{\mu}}$. Similarly for axis BG, $T_2 = 2\pi\sqrt{\frac{I_2}{\mu}}$.

Finally, if the plate be suspended from G so that it lies in a horizontal plane, the period T_3 of torsional oscillations will be $T_3 = 2\pi\sqrt{\frac{I_3}{\mu}}$, where I_3 is the moment of inertia of the plate about an axis through G perpendicular to the plane of the plate.

By a well-known theorem $I_3 = I_1 + I_2$.

Thus $T_3^2 = T_1^2 + T_2^2$.

Readings.

$T_3 = 5{\cdot}30$ secs. $\qquad T_3^2 = \mathbf{28{\cdot}11}$

$T_1 = 3{\cdot}60$ secs.

$T_2 = 3{\cdot}91$ secs. $\qquad T_1^2 + T_2^2 = \mathbf{28{\cdot}27}$

Expt. II.—Determination of I_3 by direct comparison with an inertia bar. The plate of moment of inertia I_3 is attached to the torsion wire by means of the central pin, and the period of oscillation T_3 is determined. The cylindrical bar, of moment of inertia I_4 is then substituted and its time of oscillation T_4 is measured.

Then $\frac{I_3}{I_4} = \frac{T_3^2}{T_4^2}$ and $I_4 = \left(\frac{l^2}{12} + \frac{a^2}{4}\right)M$

where l and a are the length and radius respectively of the bar, and M is its mass.

Readings.

$I_4 = 2{\cdot}30 \times 10^4$ gm. cm.^{2}

$T_3 = 5{\cdot}30$ secs.

$T_4 = 4.68$ secs. whence $I_3 = \mathbf{2{\cdot}95 \times 10^4}$ gm. cm.^{2}

Expt. III.—Determination of I_3 by addition of a body of known moment of inertia. In this method the period T_3 is determined by suspending the plate from the central pin. The heavy circular steel disc of moment of inertia $I_5 = [\text{mass} \times \frac{1}{2}(R^2 + r^2)]$ is then placed on top of the plate and a new value for the combined period T_5 found. This period is given by $T_5 = 2\pi\sqrt{\frac{I_3 + I_5}{\mu}}$. Also $T_3 = 2\pi\sqrt{\frac{I_3}{\mu}}$ whence $\frac{T_5^2}{T_3^2} = \frac{I_3 + I_5}{I_3}$.

Readings.

$T_3 = 5{\cdot}30$ secs.

$T_5 = 7{\cdot}34$ secs.

$I_5 = 2{\cdot}73 \times 10^4$ gm. cm.^{2} whence $I_3 = \mathbf{2{\cdot}98 \times 10^4}$ gm. cm.^{2}

Expt. IV.—Determination of I_3 by using the plate as a compound pendulum. The plate is allowed to swing in a vertical plane about the knife edge, which rests on the planes provided in the table clamp, and its period T_6 is determined. The mass M of the plate is also determined. The distance s from the knife edge to the centre of gravity of the plate is measured. This is conveniently done with vernier callipers by finding the distance from the **back** of the knife edge to the outside of the central pin and then subtracting from this value, the radius of the pin and the distance from back to front of the knife edge.

If now $I_3 = Mk^2$, where k is the radius of gyration of the plate about the appropriate axis, then $T_6 = 2\pi\sqrt{\frac{k^2 + s^2}{gs}}$.

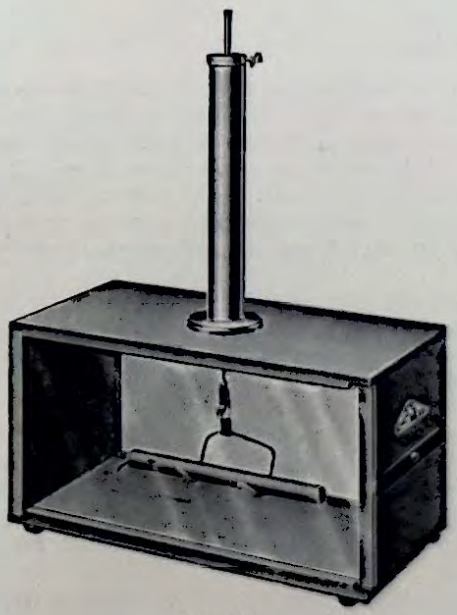
Readings.

$T_6 = 0{\cdot}822$ secs.

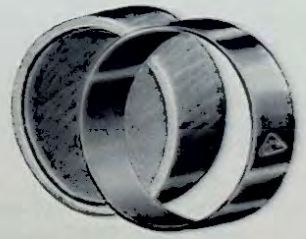
$s = 12{\cdot}02$ cms.

$M = 519{\cdot}5$ gms.

whence $k^2 = 57{\cdot}3$ cm.^{2} and $I_3 = \mathbf{2{\cdot}98 \times 10^4}$ gm. cm.^{2}



A 23-560.



A 23-580.

£ s. d.

A 23-560. MOMENT OF INERTIA APPARATUS. A light wire cradle fitted with a small plane mirror is suspended by means of unspun silk within a draught-excluding wood case, approx. 12 × 6 × 6 in., having removable glass front and back, and brass suspension tube; the length of the suspension being adjustable. Having determined the period of the cradle without load, the comparative times of oscillation of the cradle carrying successively a brass cylinder and brass block of regular geometrical shape are then found and from these times the moment of inertia can be determined. **1 15 0**

A 23-580. MOMENT OF INERTIA, Metal Ring and Wood Disc, both 15 cm. diam. and of same width and mass **0 15 0**

If both discs are released simultaneously on an inclined plane, the wood disc will reach the end of the inclined plane first by reason of its smaller moment of inertia. If given an equal impulse on a level plane, however, the metal ring will travel further than the wood disc owing to its greater moment of inertia.

MICROID ROTATIONAL INERTIA APPARATUS

A new design of wide application in the determination of Moments of Inertia and other experiments

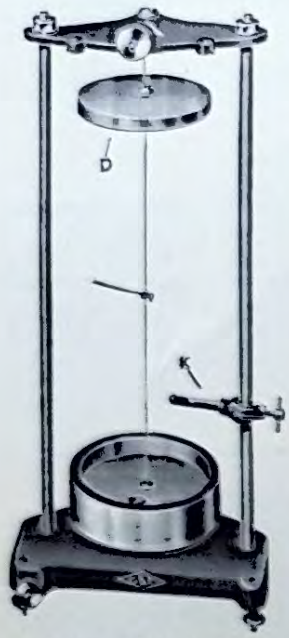


Fig. 1.—A 23-620—625.

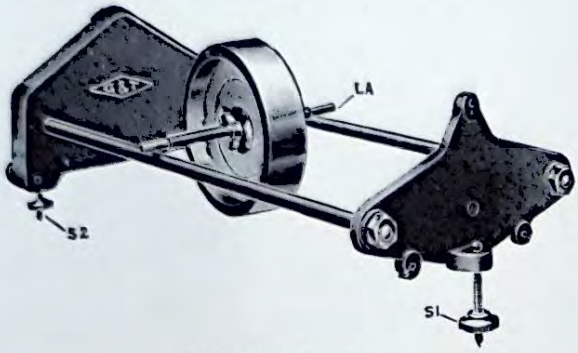


Fig. 2.—A 23-620.

There are a number of different ways of determining the Moment of Inertia of a flywheel, and it is usual to have a different piece of apparatus for each method. In this apparatus a wheel has been so designed that its moment of inertia may be experimentally determined in five distinct ways. It is thus possible to gain an insight into their relative convenience and accuracy. In addition it is also possible to perform experiments investigating the characteristics of the compound pendulum, the trifilar pendulum, and the torsional oscillation of wires. A feature of the apparatus is that the stand may be turned on its side, the pillars then forming inclined rails down which the wheel may be rolled.

SPECIFICATION

The apparatus consists of a stand fitted with levelling screws and having a heavy cast base about 12 × 8 in. from which project two rustless steel vertical pillars P (Fig. 4) about 24 in. long supporting a specially designed top plate. This plate is fitted with a central chuck in which a torsion wire may be gripped, and has three holes H (Fig. 4) for supporting, by means of special nipples, the three wires of a trifilar pendulum. The chuck has a specially large knurled disc attached, to ensure good tightening by hand. When the stand is placed on its side the pillars form rails whose inclination may be both altered and measured by means of the large screw S_1 (Fig. 2). The rails are levelled by the screw S_2. Fine scratches on the pillars mark the starting and finishing positions of the rolling wheel and axle.

The wheel (Fig. 3) is of good grade cast iron, 7 in. diam., weight about 8 lbs., is statically balanced, and has in the web two holes which make it possible for it to be hung (in two positions) as a compound pendulum by means of the knife edge K (Fig. 1). Three screwed holes in the rim of the wheel are provided so that it may be hung as a trifilar pendulum (as in Fig. 4) or may be attached to an aluminium spider (Fig. 3) for suspension from a torsion wire, and then used as an inertia table.

Concentric grooves on the web enable an object, whose moment of inertia is to be found, to be placed centrally in the wheel. A plain disc D (Fig. 1), about 6 in. diam. and weight about 5 lbs., fits inside the wheel, and is used as an object of standard moment of inertia, which may be readily calculated from its diameter and mass. The spider, Fig. 3, is an aluminium casting which is designed to be strong and yet to have a negligible moment of inertia. It is fitted with a special chuck, having a large diameter knurled head, for gripping the torsion wire.

A long axle LA (Fig. 2) may be fitted to the wheel for the experiment where the wheel is rolled down the inclined rails. It is clamped to the wheel by a wing nut.

For the trifilar pendulum (which is identical, theoretically, with the bifilar pendulum, being merely a more convenient practical form) three suspension wires are provided. At the upper end they terminate in steel nipples which drop into the slotted holes H (Fig. 4) in the top plate ; at the lower end they are fitted with caps which screw over the spider screws S_3 (Fig. 3). Thus by unscrewing one or more of the caps a little, adjustment for levelling the wheel is provided.

Two auxiliary items are available. The first consists of a steel wire fitted with screwed steel plugs at each end, and a pointer. By means of this the moment of inertia of the disc and wheel may be compared by the method described by Searle, *Experimental Harmonic Motion*, Expt. 7, where torsional oscillations are set up in the wire, and the pointer used to determine the neutral point. The second consists of a rectangular steel bar **A23-630**, about 30 in. long and 1 in. × ⅛ in. cross section. By clamping the wheel to the laboratory bench with its axis horizontal and allowing the bar to oscillate as a "see-saw" the value of "g" may be found as described in Searle, *Experimental Harmonic Motion*, Expt. 15.

A 23-620. Microid Rotational Inertia Apparatus—*continued.*

£ s. d.

A 23-620. MICROID ROTATIONAL INERTIA APPARATUS. (*School Sci. Rev.*, 1933, **58**, 189).
Stand with levelling screws, cast iron wheel (Fig. 3), axle LA and wing nut, spider (Fig. 3) and three screws, 3 trifilar suspension wires (Fig. 4), knife edge K, plain steel disc. D, 2 steel torsion wire specimens .. .. *r* 30 0 0

A 23-625. Torsion wire fitted with screwed plugs and nuts, pointer, for use as illustrated in Fig. 1 *r* 0 19 0

A 23-630. Steel bar about 30 × 1 × ¾ in. for use in determination of "*g*" (Searle, *Experimental Harmonic Motion*, Expt. 13) .. .. *r* 0 8 0

EXPERIMENTAL NOTES

The following typical experiments give an idea of what can be done with the apparatus. Experimental results are given in one or two cases of particular interest.

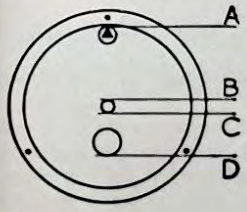
1. Determination of the Moment of Inertia of the wheel by swinging it as a compound pendulum in either of two positions.
2. Determination of the Moment of Inertia of the wheel by suspending it as an inertia table from a torsion wire.
3. Determination of the Moment of Inertia of the wheel by rolling it down inclined rails.
4. Determination of the Moment of Inertia of the wheel by suspending it as a trifilar pendulum.
5. Determination of the Modulus of Rigidity of the wire by dynamic torsion experiments.
6. Investigation of the effect on the periodic time of torsional oscillations of the length, diameter and rigidity of the suspending wire.
7. Determination of the Moment of Inertia of any object using the wheel as an inertia table.
8. Determination of the effects upon the period, of the length of a trifilar pendulum.

Note.—"*g*" may also be determined in Expts. 1 and 3 and additional experiments are possible with the accessories **A 23-625** and **A 23-630.**

SPECIMEN RESULTS

Expt. 1.—Flywheel as Compound Pendulum.

Hang the wheel on the knife edge from each hole in turn and time 200 vibrations. Calculate from the observations the moment of inertia of the wheel about its axis lw. Measure the distances of the edges of the holes from the axis by the use of a cathetometer.



$$T = 2\pi\sqrt{\frac{l^2 + k^2}{lg}}$$

Observations.

Cathetometer readings on A = 2·41 cm.
B = 6·14 „
C = 7·52 „
D = 14·25 „
Mass of wheel = 3530 gms.

Times for 200 swings:

Hanging from A	From D
= 165·0 secs.	= 154·6 secs.
= 165·0 „	= 154·2 „
= 165·0 „	= 154·3 „
	= 154·3 „
	= 154·5 „

Calculations.

Average periodic time $T_A = 0{\cdot}825$ secs. $T_B = 0{\cdot}772$ secs.
$l_A = 4{\cdot}42$ cm. $l_B = 7{\cdot}42$ cm.

Now if *k* is the radius of gyration of the wheel

$$k^2 = \frac{1}{4\pi^2}(l_A g T_A^2 - 4\pi^2 l_A^2).$$

∴ From one set of observations

$$k^2 = \frac{4{\cdot}42 \times 981 \times 0{\cdot}825^2 - 4\pi^2(4{\cdot}42)^2}{4\pi^2} = 56{\cdot}15. \quad \therefore k = 7{\cdot}42 \text{ cm.}$$

Similarly from the other set either $k = 7{\cdot}42$ cm.

Whence $I = Mk^2 = 3530 \times 56{\cdot}1$
$= 194{,}500$ gm. cm.^{2}

or by substituting the value of *k* already found "*g*" may be evaluated.

Expt. 2.—Flywheel Suspended on Torsion Wire.

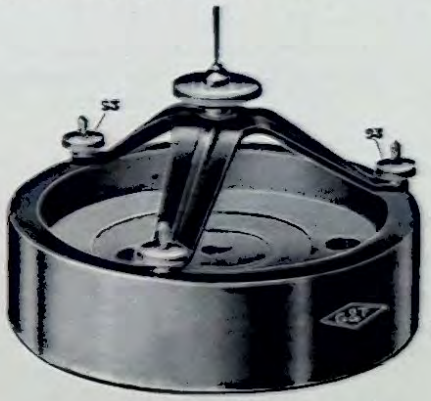


Fig. 3.—A 23-620.

The aluminium spider is attached to the wheel (see Fig. 3) and the latter suspended from a steel torsion wire in the stand. Three experiments are performed in this position. First, by observing the periodic time with the wheel alone, and then with the disc added the moment of inertia lw is determined. Then an irregular body is placed in the wheel (instead of the disc) and its moment of inertia is determined using the wheel as an inertia table. Finally, by measuring its length and diameter, the modulus of rigidity of the wire is determined.

The irregular body used is a hollow ring.

Observations.

Time for 100 oscillations:—

wheel	wheel + disc	wheel + ring
429·5 secs.	402·6 secs.	451·3 secs.
429·1 „	402·1 „	451·5 „
429·2 „	402·2 „	451·4 „
Average period 4·291 secs.	4·021 secs.	4·514 secs.

Length of torsion wire = 40·0 cm.
Diam. of wire (1) 0·122 cm. (2) 0·122 cm. (3) 0·121 cm. (4) 0·123 cm.
Average diam. = 0·122 cm.

[*continued overleaf*

A 23-620. Microid Rotational Inertia Apparatus—*continued.*

Mass of plain disc = 2260 gm. Diam. of disc. = 15·00 cm.

Now $\frac{I_1}{I_2} = \left(\frac{T_1}{T_2}\right)^2$ $\therefore \frac{I_{wheel} + I_{disc}}{I_{wheel}} = \left(\frac{4923}{4293}\right)^2 = 1{\cdot}315$ and

$I_{disc} = \frac{Mr^2}{2} = \frac{2260 \times 15^2}{2 \times 4} = 63{,}580$ gm. cm.^{2}

Whence $I_{wheel} = 201{,}800$ gm. cm.^{2}

and taking the spider as of mass 130 gm. at an equivalent distance of say 4 cm. plus 52 gm. of screws at 8·5 cm. its inertia is 5800 gm. cm.^{2} approx., and the corrected value of

I_n = **196,000 gm. cm.^{2}** or k = **7·45 cm.**

Now let the Modulus of Rigidity of the wire be n and let a = radius of wire.

Then $n = \frac{8\pi Il}{a^4T^2} = \frac{8\pi \times 40{\cdot}0 \times 201800 \times 2^4}{0{\cdot}122^4 \times 4{\cdot}293^2}$

= **7·89 × 10^{11} dynes/sq. cm.**

For the ring, of unknown moment of inertia I_R; we have :—

$\frac{I_R + I_n}{I_n} = \left(\frac{4514}{4293}\right)^2 = 1{\cdot}106$ $\therefore I_R = 0{\cdot}106 \times I_n$

$\therefore$ **I_R = 21,350 gm. cm.^{2}**

Expt. 3.—Wheel down incline.

The stand is now turned on its side and the rails levelled. By means of the large screw in the upper plate any desired gradient can then be given to the rails, and the wheel, now fitted with the long axle, rolled down them. The wheel is timed between two fine engraved lines on the rails. Its moment of inertia is thus determined.

Observations.

Length l of rails between lines .. .. .. = 40·5 cm.
Length L between foot screw and top screw .. = 65·0 cm.
Height h' through which top is raised after levelling = 1·65 cm.
(The pitch of the screw is $\frac{1}{8}$ in. and it was given 17 turns.)
Time of descent of wheel in seconds = 27·7, 26·5, 27·7, 28·0, 28·5, 28·8, 28·5, 27·0, 27·5, 28·1 secs.
Average time t = 27·8 secs.
Diameter of axle at points in contact with rails (average of 10 readings) = $2r$ = 0·953 cm.

Calculations.

If v = velocity at bottom then $v^2\left(1 + \frac{k^2}{r^2}\right) = 2gh$.

but $v = 2l/t = 2{\cdot}915$ cm./sec. and $h = h'/L = 1{\cdot}028$ cm.

$\therefore 1 + \frac{r^2}{k^2} = 237$. $\therefore k^2 = 236 \times \frac{(0{\cdot}9530)^2}{4} = 53{\cdot}8$.

$\therefore$ **k = 7·34 cm.** and **I = 180,000 gm. cm.^{2}**

The inertia of the axle used is negligible (about 100 gm. cm.^{2}).

Expt. 4.—Trifilar Pendulum.

The wheel is hung by three wires as shown in Fig. 4 as a trifilar pendulum. The wires are attached to caps which screw over the screws used for attaching the spider to the wheel. A small levelling adjustment is possible by unscrewing the caps slightly.

The wheel may be hung alone and its moment of inertia found by measurement of the periodic time, length of suspension and diameter (2a) of the circle on which the screws are fixed. The pendulum is equivalent to a bifilar pendulum with the strings separated by a distance equal to 2a. The moment of inertia of the disc or any other object may be found by placing it in the wheel and determining the new periodic time. It is interesting to note that whereas the addition of the disc in the dynamic torsion experiment increases the periodic time, in the trifilar pendulum the periodic time is decreased. This is because the period depends upon the moment of inertia in the former case and upon the radius of gyration in the latter.

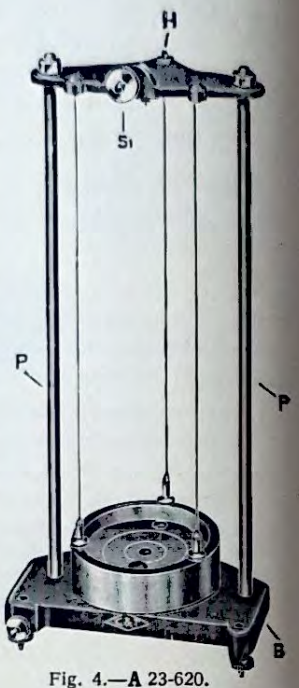


Fig. 4.—A 23-620.

Observations.

Time for 100 swings = 127·2, 127·5, 127·3, 127·6 secs.
Mean = 1·274 secs.
Length of suspension wire l = 52·5 cm.
Diam. of circle 2a = 16·6 cm.

Now $T = 2\pi\frac{k}{a}\sqrt{\frac{l}{g}}$

$\therefore k^2 = \frac{a^2T^2g}{4\pi^2l} = \frac{8{\cdot}3^2 \times 1{\cdot}274^2 \times 981}{4\pi^2 \times 52{\cdot}5} = 52{\cdot}8$ cm.^{2}

$\therefore$ Moment of Inertia of wheel = 3530 × 52·8 = **186,500 gm. cm.^{2}**

Extra Expt. with item A 23-625.—Determination of $\frac{I_{wheel}}{I_{disc}}$ by neutral point in a torsion wire.

The wheel is attached to one end, and the disc to the other end, of a steel wire (see Fig. 1). The whole is then hung from the stand, disc uppermost, by a torsionless string. The wheel and disc are set oscillating in opposite directions, and by means of a pointer which can be clamped on the wire at any point, the point in the wire is found where the wire is not oscillating. The inertias of the wheel and disc are in the ratio of their distances from this point.

Observations.

Distance of wheel from neutral point = 10·9 cm.
Distance of disc from neutral point = 34·9 cm.

$\therefore$ Moment of Inertia of wheel = $63{,}580 \times \frac{34{\cdot}9}{10{\cdot}9}$

= **202,000 gm. cm.^{2}**
(or k = 7·55 cm.).

A 23-680. FLY WHEEL, cast iron, about 12 lb. weight, mounted on ball bearings in a cast iron bracket arranged so that the fly wheel is easily removable for weighing *Price on application*

A 23-690. Ditto, wheel about 56 lb. weight *Price on application.*

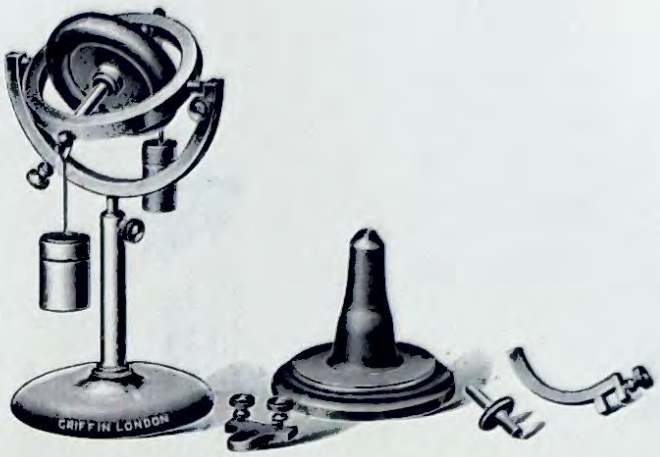
A 23-695. Vibrating Pencil Attachment to scribe a graph of acceleration on paper passed over the wheel when used as an Atwood Machine .. .. .. *Price on application.*



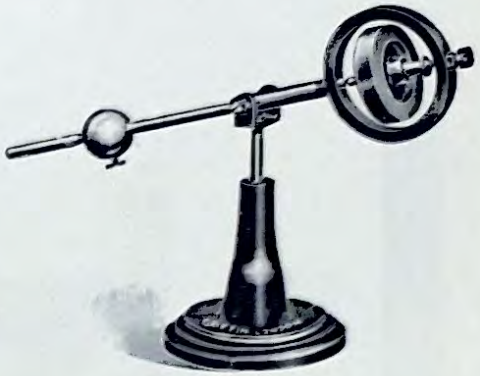
A 23-680.



A 23-770.



A 23-780.

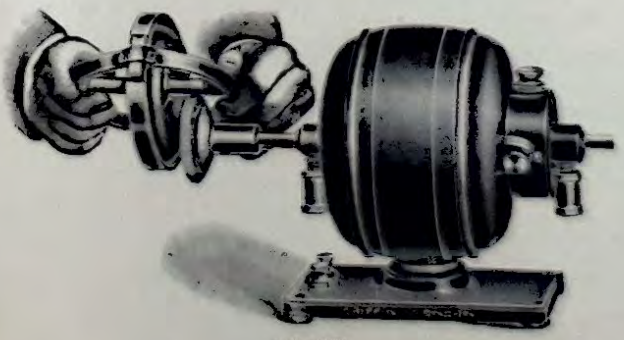


A 23-790.

	£	s.	d.
A 23-770. GYROSCOPE (Davidson: *The Gyroscope and its Implications*), 3 in. diam. heavy gun-metal fly wheel mounted on ball bearings, strong T-section frame, circular protective ring for fly wheel	8	5	0
A 23-780. GYROSCOPE, Wheatstone, with well balanced wheel about 3 in. diam., mounted in ball bearings, suspended freely in gimbals so that it can be made to spin with its axis in any direction in space. A number of accessory parts are supplied by means of which a great variety of experiments may be performed	17	10	0
A 23-790. GYROSCOPE, Simple, in which the spinning disc is balanced by a sliding weight. If the sliding weight is moved so that the beam is out of balance the spinning body rotates round the vertical axis	4	0	0

A 23-795. GYROSCOPE DEMONSTRATION SET. (*Developed by us under the direction of the late Professor J. C. Gray, of Glasgow University.* Andrew Gray: *A Treatise on Gyrostatics and Rotational Motion.*)

The apparatus is designed to render demonstrations of gyroscopic phenomena easy to perform and satisfactory both to the experimenter and the audience. A single gyroscope similar to **A 23-770** is provided, with 3 in. diam. flywheel on ball bearings, to the casing of which are attached a number of fittings, which are so designed that the classical gyroscopic combinations can be realised in the most effective manner possible. The fittings supplied are as follows: (*a*) Fork and Pedestal Mounting ; (*b*) Attachment for showing Kelvin's gyroscope-on-skate experiment ; (*c*) Attachment and ball-bearing suspension ; (*d*) Ball and socket support for performing Wheatstone's experiment ; (*e*) Attachment for supporting the gyroscope on gimbals ; (*f*) Attachments for showing gyroscope on stilts ; (*g*) Attachments for performing Kelvin's gyroscope-on-trapeze experiment ; (*h*) Fittings for mounting the gyroscope as a stilt top and for performing Kelvin's tray experiment ; (*i*) Tripod and fittings for setting up gyroscopic pendulum. In wood transport case .. .. *Price on application.*



A 23-820.

A 23-820. GYROSCOPE SPINNER, Motor with extended shaft and fitted with 4 in. disc. of toughened rubber for spinning gyroscopes. With D.C. or universal motor 100-110, 200-220 or 230-250 volts £ 10 0 0

A 23-825. Foot Switch and Resistance for regulating the speed of the above motor, until the fly wheel is rotating at a speed of about 15,000 r.p.m. With spring return to "off" position .. .. £ 3 5 0


A 24-200.


A 24-240—245.


A 24-315.


A 24-340.


A 24-350.

A 24-120. CORD, India-rubber, square.

1	3	*mm.*
9d.	**4/-**	*dozen yards*

A 24-125. CORD, India-rubber, round.

Diam. .. ..

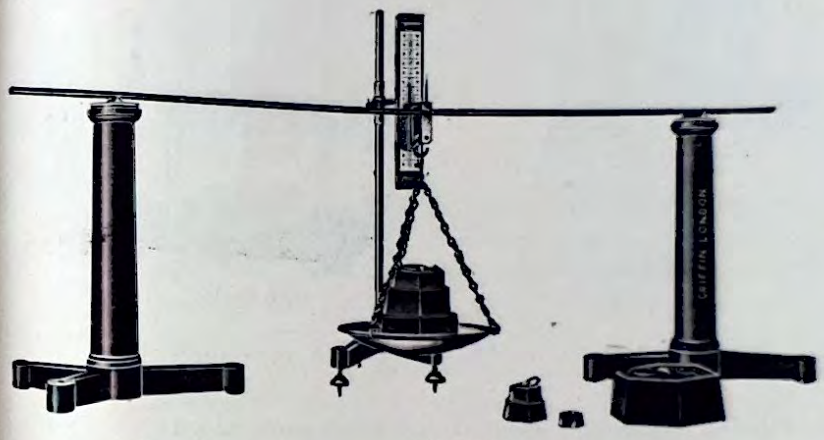
$\frac{1}{8}$	$\frac{1}{4}$	*in.*
5/-	**15/-**	*dozen yards*

	£	s.	d.
A 24-200. DYNAMOMETER, Rintoul, spring, with adjustment for altering the zero, aluminium-alloy mount with scale reading 0-300 grammes	**0**	**8**	**0**
A 24-205. Scalepan, brass, for above, 2½ in. diam.	**0**	**1**	**9**
A 24-240. SPRINGS, Steel, Coiled, with loops and hooks at each end. About 8 × ¼ in., stretching approx. 12 cm. with 250 grams .. .. *each*	**0**	**1**	**0**
A 24-245. Ditto, 12 × ¼ in., stretching approx. 20 cm. with 250 grams .. .. *each*	**0**	**1**	**6**
A 24-315. YOUNG'S MODULUS. Two clamping plates of nickel-plated brass are made to slide one in the other. One plate has a scale 20 mm. divided into 0·5 mm. so that, by means of a vernier upon the other, the extension of a wire can be read to 0·05 mm. .. *p*	**3**	**0**	**0**
A 24-320. Clamp, Brass, for above, for suspending the two wires .. .. *p*	**0**	**7**	**6**
A 24-340. YOUNG'S MODULUS. Two nickel-plated brass clamping plates, with graduated scales, one 70 mm. long in mm., the other with vernier to read to 0·1 mm. Including brass suspension plate and tension weight. **Without** slotted weights and hanger .. *p*	**3**	**10**	**0**
A 24-350. HOOKE'S LAW APPARATUS, Searle, for investigating Hooke's law and determining Young's Modulus for a wire. With set of wires, 4 chucks, tension weight and wall bracket. **Without** slotted weights and hanger (Worsnop & Flint, *Advanced Practical Physics*, p. 85)	**10**	**0**	**0**

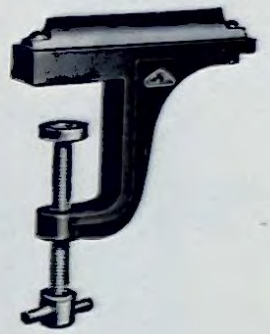
The two frames with connecting link are fitted with steel chucks. One end of a sensitive spirit level is pivoted to the frame suspended by the control wire, the other end rests on the point of a micrometer screw carried by the frame suspended by the test wire. To measure the extension the bubble of the level is adjusted to its fiducial mark and the reading of the micrometer screw recorded. The load is then applied and the micrometer screw turned until the bubble again reaches its fiducial mark. The difference between the readings gives the elongation of the wire. The micrometer screw reads to 0·01 mm. Both wires should be of the same material so that temperature variations shall not affect the result.

WIRES, Hard Drawn. In ¼ lb. coils.

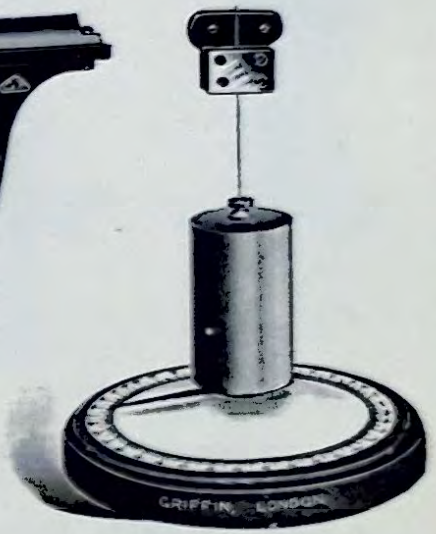
No.		20	22	24	26	28 S.W.G.
Approx. feet/coil	Steel	70	120	190	290	420 *feet*
	Brass	60	100	170	250	380 *feet*
A 24-380. Steel		**3/-**	**3/6**	**4/6**	**5/6**	**9/-** *lb.*
A 24-390. Brass		**3/-**	**3/6**	**4/-**	**4/6**	**4/9** *lb.*



A 24-550.



A 24-590.



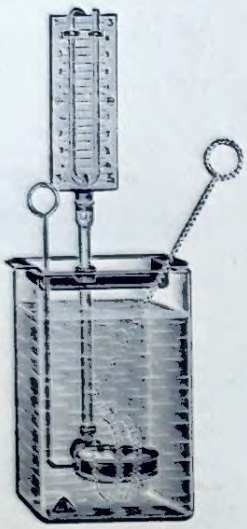
A 24-610.

	£	s.	d.
A 24-550. BEAM DEFLECTION. Apparatus to determine how the deflection of a beam varies with the load. A rod of tool steel is supported on steel knife edges mounted on heavy cast iron pillars with tripod feet. The position of the pointer is read against a silvered glass scale divided in mm. With rod of tool steel 3½ ft. × ½ in. × ⅛ in., and scale-pan. **Without** weights	6	0	0
A 24-560. Rods, tool steel, for use with above, of section ¼ × ⅛ in. but of different lengths: 1½, 2, 2½, 3 and 3½ ft. long .. .. *set of five*	1	0	0
A 24-565. Rods, tool steel, for use with above, each 3½ ft. long, but of different width. The sections are ¼ × ⅛ in., ⅜ × ⅛ in., ½ × ⅛ in., ⅝ × ⅛ in., and ¾ × ⅛ in. .. *set of five*	1	5	0
A 24-580. KNIFE-EDGES, Steel, 2½ in. long, of triangular section, ½ × ½ × ½ in. .. *pair*	0	5	0
A 24-590. KNIFE EDGE CLAMP, for supporting beams for deflection experiments, etc., the ground knife edge, 3 in. long, extends well over the bench top edge	0	15	0
A 24-610. TORSIONAL OSCILLATIONS APPARATUS, for experiments on rigidity. Brass cylinder about 3½ × 2 in., with brass pointer and fixing screw for wire. Wood disc, 6 in. diam., with paper scale graduated in degrees, for placing underneath the pointer and measuring the angle of torsion. Clamp for suspending from a beam or wood support	1	5	0

Mechanics of Fluids



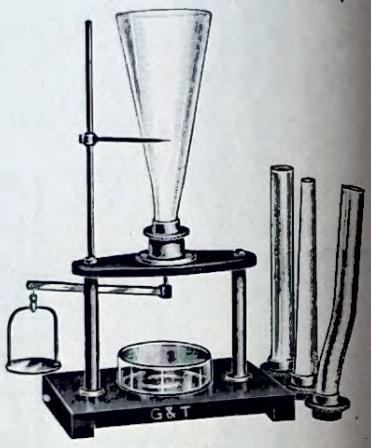
A 25-125.



A 25-130.

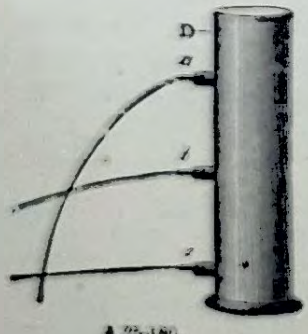


A 25-140.

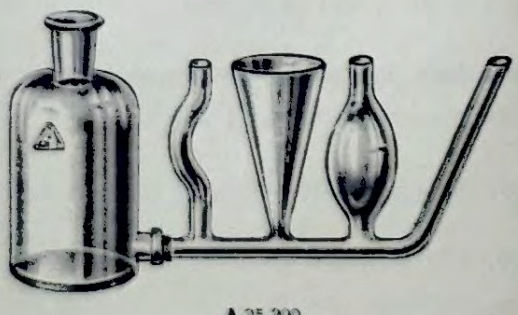


A 25-160.

	£	s.	d.
A 25-125. PRESSURE APPARATUS, glass, demonstrating the equal transmission by liquids of pressure in all directions	0	9	6
A 25-130. INTERNAL PRESSURE OF A LIQUID. A hollow cylindrical capsule covered on both sides with a rubber membrane is connected to a manometer and graduated scale. The capsule is rotatable about a horizontal axis to show equality of pressure in all directions. The depth can be varied. With rectangular glass vessel .. .. *p*	3	5	0
A 25-140. PRESSURE APPARATUS, demonstrating upward pressure of liquids. Zinc disc ground on one face, a glass cylinder and glass jar	0	10	0
A 25-160. VASES, Pascal, to show that the force exerted on the base of a vessel filled with liquid depends only on the area of the base and the depth of liquid and not on the shape of the vessel. The force is determined by weights placed in the balance scale pan forming part of the apparatus. Complete with four interchangeable glass vessels of various shapes, each fitted with screwed brass collar .. .. *p*	10	0	0

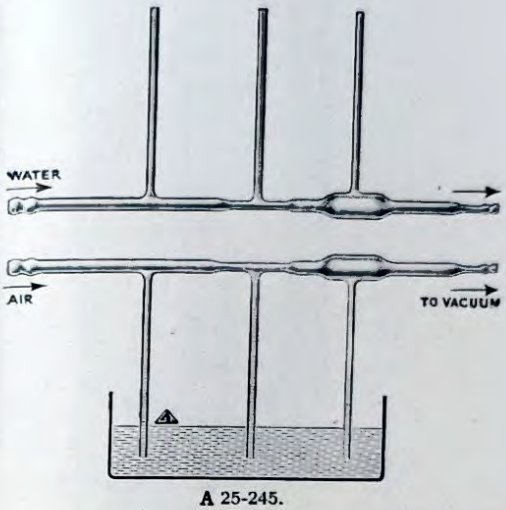


A 25-180.

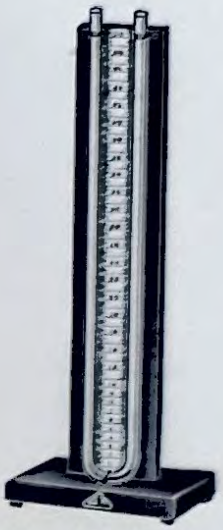


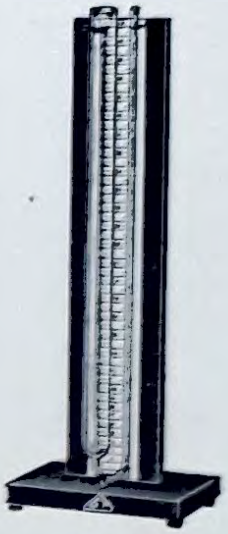
A 25-200.

	£	s.	d.
A 25-180. SPOUTING JAR, Japanned Tin, 25 in. high, 5 in. diam., with three orifices, for demonstrating that pressure varies with the depth of liquid	0	15	0
A 25-200. COMMUNICATING VESSEL, glass reservoir 250 ml. with tube having four branches, to show that water stands at its own level irrespective of the size and shape of the limbs	1	1	0



A 25-245.


A 25-350.

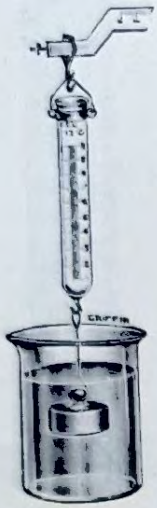

A 25-360.


A 25-415.

	£	s.	d.
A 25-245. PRESSURE AND VELOCITY OF FLOW APPARATUS (Nokes: *The Theory of Flight*, pp. 26–28; Powell: *Mechanics of Liquids*, p. 34), illustrating Bernoulli's theorem. A glass tube about 15 in. long with varying diameters of 12, 4, 15, 4 mm. and ends riffled to take rubber tubing, is provided with three vertical manometer tubes, to demonstrate that the static pressure is least where the velocity of flow is greatest and vice versa. The apparatus may be inverted so that the ends of the manometers dip into a trough of water, when the static pressures due to air-flow along a tube of variable bore can be shown. Mounted on board for transit, **without** trough	0	15	0
A 25-350. U-TUBE, Glass, with limbs of equal diameter, 19 in. long, to compare the densities of **two liquids**, mounted on stand with vertical scale	0	17	6
A 25-355. U-Tube only, for above	0	2	0
A 25-360. U-TUBE, Glass, with limbs of unequal diameter, mounted on stand with vertical scale .. ..



A 25-480.



A 25-490.



A 25-520.

£ s. d.

A 25-480. BUCKET and CYLINDER, Brass, $2\frac{1}{4}$ in. long, $\frac{5}{8}$ in. diam., to demonstrate the principle of Archimedes .. .. r 0 6 6

Suspend the bucket, with cylinder hanging beneath, on a balance, and counterpoise. If now the cylinder be immersed in liquid, equilibrium is restored by filling the bucket with the same liquid, *i.e.* upthrust on the solid = weight of liquid it displaces.

A 25-490. SPECIFIC GRAVITY TUBE, West, glass tube graduated to 10 ml. in 0·01 ml. and arranged for suspension from the arm of a balance 0 5 6

A regular solid is suspended from the lower hook of the West tube and the whole suspended from one arm of a balance. After weighing, immerse solid in liquid and restore balance by adding liquid to tube with a pipette. The volume of liquid in the tube will be found to be equal to the volume of the solid. By the use of different liquids in the tube their densities can be compared, also the volume of an irregular solid may be found.

A 25-520. DENSITY APPARATUS. Large scale apparatus suitable for demonstrating the principle of Archimedes and for determining density of liquids and solids. Spring balance reading 0–200 gms. in 20 gm. intervals, with clamp, and adjustable for height on iron tripod stand; glass measure graduated 0–200 ml. in 20 ml. divisions; bucket weighing 200 gms., external volume greater than 200 ml.; hollow cylinder closed both ends, also weighing 200 gms., volume 100 ml. 4 5 0

The apparatus is suitable for—(i) direct determination of density of liquids by weighing, using the bucket; (ii) direct determination of density of solids by weighing and determination of volume by displacement; (iii) demonstrating principle of Archimedes:—After noting weight of bucket, lower balance and bucket together until bucket displaces 20 ml. of liquid in the glass measure and note weight, continue in 20 ml. steps until bucket floats; (iv) determination of the density of a liquid using Archimedes' principle, with the solid cylinder.

Griffin and Tatlock Limited from their five centrally situated Houses, provide a unique organisation for the supply of Complete Laboratory Equipment.



A 25-580.



A 25-585—595.

	£	s.	d.
A 25-580. HYDROMETER, Simple, 15 × 1 × 1 cm., varnished wood, weighted one end, graduated in cm. .. .. *each* 2/6; *dozen*	1	7	0
A 25-585. HYDROMETER, Nicholson, japanned tin, 8½ × 1½ in. .. *each* 4/6; *dozen*	2	9	0
A 25-590. HYDROMETER, Nicholson, rustless alloy. Improved form with rod continued through body, and joints screwed and riveted. Size about 10 × 2 in. .. .. *each*	0	10	6
A 25-595. Hydrometer Jar, 30 × 6·5 cm., suitable for above hydrometers *each* 2/10; *dozen*	1	11	0
A 25-610. HYDROMETER, Nicholson, wide range, for use in liquids of specific gravities 0·83 to 1·24. Specification generally as **A 25-585.** Size about 10 × 2¼ in. .. .. *each*	0	12	0
A 25-615. Hydrometer Jar, 40 × 7·5 cm., suitable for above hydrometer *each* 6/-; *dozen*	3	5	0



A 25-640—650.

HYDROMETERS, streamlined, wide range, general purpose, with easy-clean cylindrical bulbs, giving maximum strength and excellent floating characteristics. Hand-drawn scales firmly attached in stem.

Cat. No. →	A 25-640		A 25-645		A 25-650	
Range S.G. ↓	Length 6 in. 40 × 0·005 divisions		Length 9 in. 100 × 0·002 divisions		Length 12 in. 100 × 0·002 divisions	
	each	*dozen*	*each*	*dozen*	*each*	*dozen*
600–800	6/9	75/-	7/6	80/-	8/6	90/-
800–1000	6/9	75/-	7/6	80/-	8/6	90/-
1000–1200	7/6	80/-	7/6	82/6	9/-	97/6
1200–1400	7/6	80/-	7/6	82/6	9/-	97/6
1400–1600	7/6	80/-	7/6	82/6	9/-	97/6
1600–1800	8/-	86/-	8/6	90/-	10/-	115/-
1800–2000	8/-	86/-	8/6	90/-	10/-	115/-

CASES for hydrometers **A 25-640—650,** plush lined, with thermometer and trial jar. Leatherette covered with hinged lid and clip, to enable any selected range to be built up.

To hold	3	6	7	*hydrometers*
A 25-660. For 6 in. hydrometers	£1 7 0	£1 10 0	£1 14 0	*each*
A 25-665. For 9 in. hydrometers	£1 8 0	£1 13 0	£1 16 0	*each*
A 25-670. For 12 in. hydrometers ..	£1 10 0	£1 15 0	£1 17 6	*each*

WESTPHAL SPECIFIC GRAVITY BALANCE, see Balances & Weights Section.



A 25-860.



A 25-870.

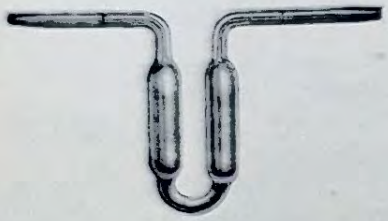


A 25-870—880.

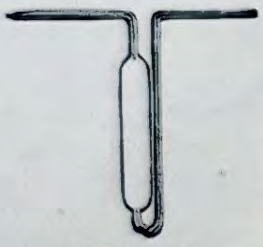
	£	s.	d.
A 25-860. BOTTLES, Specific Gravity, cylindrical shape, providing wide base for stability, with perforated ground-in stopper, for students' use, capacity approx. 50 ml., not adjusted *each p* 1/5 ; *dozen*	0	15	0

BOTTLES, Specific Gravity, usual shape, with perforated stopper. The limits of adjustment on all sizes of bottles **A 25-870** are — 0·0 + 0·2 ml.

Capacity	10	25	50	100	*ml.*
A 25-865. Unadjusted	—	1/10	2/5	2/6	*each*
A 25-870. Adjusted at 20° C.	4/6	5/3	6/-	9/-	*each*
A 25-880. Counterpoise and case only	5/6	6/6	7/-	7/-	*each*



A 25-920.



A 25-930—935.



A 25-950—955.



A 25-980.



A 26-150—155.

	£	s.	d.
A 25-920. BOTTLE, Specific Gravity, Sprengel-Gardiner (*Analyst*, 1934, **59**, 172). The undersurface of the glass of the side arms is white enamelled, defining the meniscus of the liquid in the arms more clearly and permitting its adjustment with both greater ease and accuracy. Alterations in the volumes of liquids with a high coefficient of expansion are avoided as there is no need to remove the tube out of the surrounding water until the final adjustment has been made	0	7	0

A 25-930. BOTTLES, Specific Gravity, Nicol, tubular form.

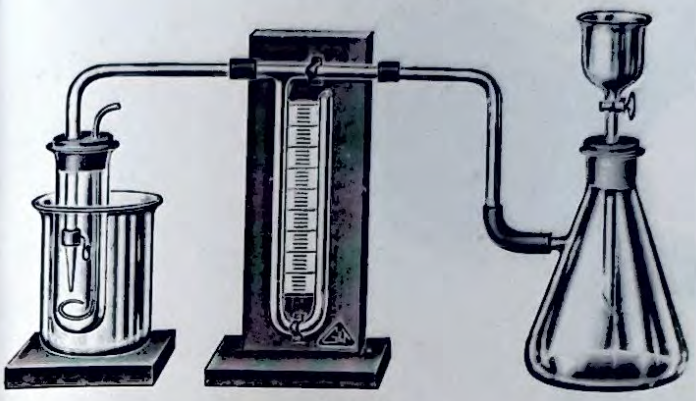
Capacity	5	10	*ml.*
	2/3	2/6	*each*

A 25-935. Ditto, Silica, transparent, capacity about 5 ml.	*tx*	0	8	9
A 25-950. WEIGHT THERMOMETERS, glass, capacity 10 ml. *each* 8d. ; *dozen*		0	7	0

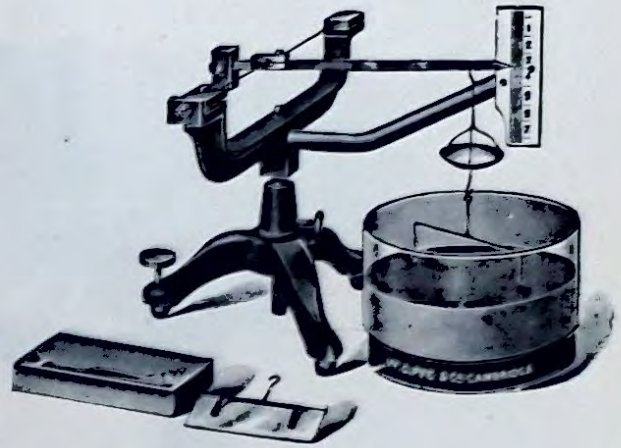
A 25-955. WEIGHT THERMOMETERS, Silica, transparent, having a negligible coefficient of expansion.

Capacity	5	10	25	*ml.*
	tx 2/9	5/-	7/6	*each*

A 25-980. WEIGHTED GLASS BULB, for demonstrating change in density on heating. About 2 in. diam., with quantity of lead shot adjusted so that the bulb will float in cold water and sink in hot water		0	1	9
A 26-145. DISPLACEMENT VESSEL, glass, approx. 4 in. high, 2 in. diam. *each* 2/9 ; *dozen*		1	10	0
A 26-150. Ditto, zinc, with brass spout, 3½ in. high, 2 in. diam. *each* 2/- ; *dozen*		1	2	0
A 26-155. Ditto, japanned tin, large size for demonstration purposes, 8 in. high, 4 in. diam., capacity to spout, approx. 1,250 ml.		0	7	6



A 26-350.



A 26-370—375.

£ s. d.

A 26-350. SURFACE TENSION APPARATUS, Jaeger (*cf.* Friend: *Physical Chemistry*, Vol. I, p. 261 ; Starling: *Mechanical Properties of Matter*, p. 263). Convenient for the determination of relative surface tensions, or, after calibration with a liquid of known surface tension, for the determination of an unknown. Complete with tap funnel, 250 ml. filter flask with side arm, xylol manometer reading to 30 cm., beaker, water bath, tube 5 × 1½ in., with stirrer and three interchangeable jets of different sizes, ends ground and polished; with pointer adjustable for height. .. .. *p* 3 15 0

Air is displaced from the flask by admission of water from the tap funnel and passes to the jet, where the pressure builds up until bubbles just detach themselves from the end. The experiment consists in determining the minimum detachment pressure, which is read on the xylol manometer. The surface tension can then be either compared or evaluated. If the water in the beaker is heated, the variation of surface tension with temperature can be investigated.

A 26-370. SURFACE TENSION BALANCE, Searle, for measuring surface tension of a soap film or of water or any clear liquid by the deflection of a beam carried by a stretched wire. A tripod stand, adjustable for height, carries a metal frame in which a plated steel wire is stretched, the tension being adjustable by means of a screw. Complete with scale-pan, wire frame, clip, six microscope slides and 10 ft. spare wire .. .. *t* 4 11 6

A 26-375. Weights, for use with above, 1 mgm. to 1 gm., in box with forceps .. *set* *t* 0 12 6

In the case of a soap film, the wire frame is depressed into the solution to form a film. After the film has drained for a few seconds, the reading on the scale is noted. The film is then broken, the beam rises, and weights are placed in the scale-pan until the scale reading is the same as before. From the length (a cm.) of the wire frame and the mass (m gm.), in the scale-pan, the surface tension is calculated by

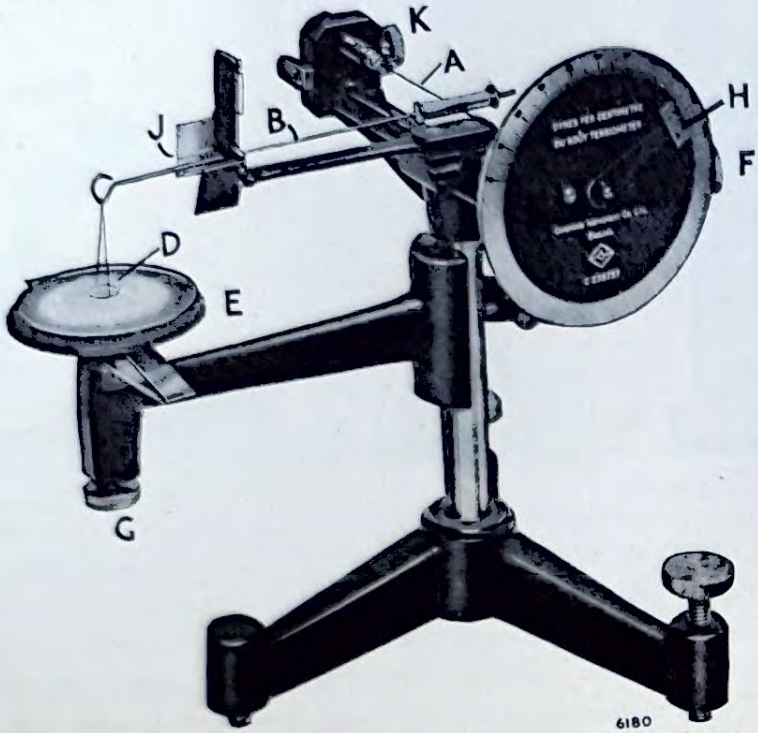
$$T = \frac{981 \times m}{2a} \text{ dynes/cm.}$$

$2a$ is taken because there are two sides to the film.

In measuring the surface tension of water the pull of the film is taken on a thin glass plate, which is so adjusted (the final adjustment is obtained by means of the levelling screw) that the bottom edge of the plate is in the meniscus. The reading of the pointer on the scale is observed, the dish of liquid is removed and the plate is dried; a mass m is placed in the pan to bring the beam to its previous position. Then if a cm. is the length of the plate and t the thickness, the surface tension is given by

$$T = \frac{981 \times m}{2(a + t)} \text{ dynes/cm.}$$

Griffin and Tarlock Limited are makers of Complete Laboratory Equipment, including furniture, fittings and apparatus.



A 26-390.

£ s. d.

A 26-390. SURFACE AND INTERFACIAL TENSION APPARATUS, Cambridge (*J. Gen. Physiol.*, 1919, **1**, 521). Based on the instrument designed by Du Noüy for the measurement of surface tension of liquids by the ring method. An accurate determination is possible in 1 to 2 minutes. Particularly suitable for tests of the surface tension of liquids which are only available in small quantities, as only about 1 ml. is required. It can also be adapted very easily to the measurement of the interfacial tension between two liquids *tx* **30 5 0**

A 26-395. Interfacial Tension Accessories .. .. *extra tx* **3 17 0**

A platinum-iridium ring D, 4 cm. circumference, hangs from the outer end of arm E. The other end of the arm is clamped to the middle of a torsion wire A stretched between two clamps which can rotate in the frame of the instrument. A vessel containing the liquid under test is placed on the platform E, and raised and lowered by means of a screw G. The two ends of the wire A are rotated independently by means of worm-gears actuated by knurled knobs F and K. To the front clamp, a vernier pointer H is attached which moves over a scale graduated directly in dynes per centimetre.

To measure surface tension, the pointer is set to zero by the knob F and by rotating the knob K the arm E is adjusted to its horizontal position as indicated by a sighting device J, the ring D having previously been made wet with the liquid under test. The vessel containing the liquid is raised by means of the screw G until the ring makes contact with the surface. The measurement is now made by rotating the pointer by means of the knurled head F, at the same time lowering the liquid surface by means of the screw G in such a way as to keep the arm E at its original horizontal position. This is continued until the ring breaks away from the surface and the surface tension is then read directly on the scale. Provision is made for checking and adjusting the calibration at any time.

The usefulness of this apparatus has been extended to the **measurement of interfacial tension** by the provision of three extra parts which are easily fitted without any modification to the instrument. The small ring D is made to pass through the interface either in an upward or downward direction, in a manner analogous to the pulling of the ring from the surface of the liquid. In order to make the ring heavy enough to do this and to prevent it from tilting, a large loop of wire is added to the normal type of surface tension ring. The ring is immersed in one of the two liquids under test, which are contained in a shallow square glass vessel supported by a small stand on the table E of the instrument. The pointer H is set to a convenient mark and the ring is then made to pass through the interface by turning the two knurled heads F and G, always maintaining the arm E at its horizontal position. When the ring breaks through the interface, the arithmetical difference between the original and final readings on the scale gives the interfacial tension. During the measurements, the interface is often distorted to a considerable extent and it is therefore advisable to have a good depth of each of the liquids (about 15 ml. of each).

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A 26-450.


A 26-455—460.


A 26-465—485.


A 26-495.


A 26-500.


A 26-505.

	£	s.	d.

A 26-450. PIPETTES, Donnan (*cf.* Reilly and Rae: *Physico-Chemical Methods*, 4th Edn., 1, 526), for the determination of surface tension, interfacial tension, and acidity. The size of the drops is determined from the number formed by outflow of a definite volume. From the number the interfacial tension is calculated.

Capacity	10	25	40 *ml.*
	25/-	26/-	28/- *each*

A 26-455. STALAGMOMETER, Ostwald (Ostwald: *Practical Colloid Chemistry*, p. 35; Mee: *Physical Chemistry*, p. 245). A measure of the surface tension is obtained from the number of drops formed by the outflow of a known volume of liquid taking water as standard. Pipette with capillary bore in lower section and reference marks below and above bulb. Bottom end ground flat. For 50–60 drops 0 6 6

A 26-460. Ditto, for 100 drops 0 7 6

A 26-465. STALAGMOMETER, Traube (Findlay: *Practical Physical Chemistry*, 6th Edn., p. 84). Pipette for determination of surface tension by the drop method. Capillary tube below bulb of pipette flattened and polished at extremity. Fixed volume determined by two marks, enabling comparison to be made between water and other liquids by number of outflowing drops. **Bent form**, 20 drops approx. 0 15 0

A 26-470. Ditto, 50 drops approx. 0 15 0

A 26-480. STALAGMOMETER, Traube, straight form, 50 drops approx. 0 15 0

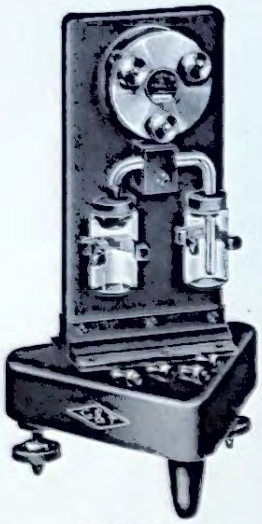
A 26-485. STALAGMOMETERS, Traube, set of 3, in velvet-lined case 3 0 0

A 26-490. Retort Stand with Rod and Clip, for holding stalagmometers 0 10 0

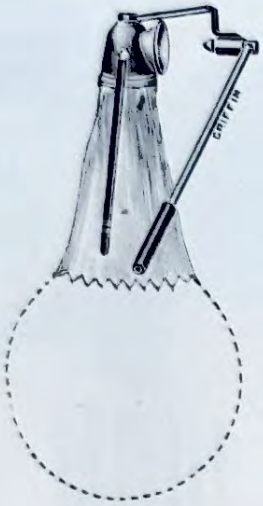
A 26-495. CAPILLARITY APPARATUS, glass vessel on foot with side arm carrying five capillary tubes of different bores, to show that the smaller the bore of the capillary, the greater the height to which the liquid rises 0 8 6

A 26-500. CAPILLARITY APPARATUS. Two glass plates, inclined to each other and mounted in metal frame. To show the hyperbolic surface assumed by the liquid between the plates 0 12 6

A 26-505. ADHESION PLATES, set of two glass plates, 3 in. diam., with handles 0 15 0



A 26-520.



A 26-550.



A 26-750.

£ s. d.

A 26-520. MICROID SURFACE TENSION APPARATUS, Drop Weight Method (Harkins and Brown: *J. Am. Chem. Soc.*, 1919, **41**, 499; for table *cf.* Starling: *Mechanical Properties of Matter*, p. 265). So made that formation of drop is under complete control throughout. Apparatus made heavy and rigid to give the stability necessary for successful experiments of this kind. Triangular cast base 16·5 cm. side. Weight about 11 lbs. With levelling screws and upright supporting capillary tube, solution tube and screw-controlled plate compressing a rubber bulb for formation of drops. With 2 interchangeable glass jets approx. 5 and 7 mm. diam. .. .. *r* 4 10 0

The measurement of the weight of a drop which has been allowed to form slowly, and then fall from the end of a vertical cylindrical tube, is one of the most widely-used and most accurate methods of determining the surface tension of a liquid. The formula, by means of which the surface tension is calculated, contains a constant, the value of which depends upon the radius of a tube on which the drops are formed. For educational purposes, therefore, it is desirable that experiments should be made with a number of tubes of different radii. The present apparatus allows this to be done and possesses the following advantages, which are not shared by the simple arrangement of burette and glass tube, which is frequently used:—

(*a*) The whole apparatus is heavy and rigid, so that the drop is not prematurely shaken from the tube.

(*b*) The drop is formed on interchangeable glass jets of special design.

(*c*) The formation of the drop is under complete control, so that the drop may be allowed to form quickly in its early stages and very slowly in its later stages, thus saving a considerable amount of time.

(*d*) The glass nozzles are interchangeable and are attached by means of rubber tube. The liquid comes in contact only with glass and, therefore, is not contaminated either by rubber or by grease from a glass stopcock.

(*e*) The drops are collected in a vessel, which is nearly closed to the open air, so that evaporation is avoided.

£ s. d.

A 26-550. BALLOON BUBBLE BLOWER, Boys's, for blowing very large bubbles, up to 24 in. diam., by means of an injector jet. With bottle of solution, and full instructions for use *r* 0 18 6

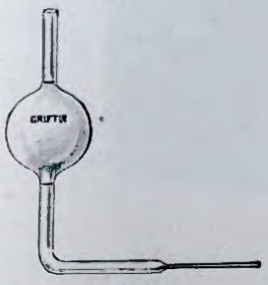
To facilitate distribution of the liquid, the blower is fitted with a skirt of woven fabric having a serrated edge held open by two springs. The bubble is liberated by compressing the springs between the fingers. By holding a Bunsen burner some distance below the injector mouth, the air may be so warmed as to enable the bubble to support itself. The same result may be achieved by delivering coal gas into the injector mouth from a rubber tube connected to the gas supply.

A 26-560. Soap Solution, for above, Boys's recipe. Including bottle.

250 *ml.*	1 *litre*
r 2/9	8/6

A 26-565. *SOAP BUBBLES*—their colours and the forces which mould them—by Prof. C. V. Boys, F.R.S. (postage 6d. *extra*) .. .. *r* 0 5 0

A 26-750. OSMOTIC PRESSURE APPARATUS, Scharf (*Unterrichtsbl. Math. u. Naturwiss.* 1941, **47**, 89; *Physik. Ber.* 1941, **22**, 1708). Wire gauze cylinder, 100 mm. long, 8 mm. diam. with a glass tube 1 mm. internal diam. By dipping the cylinder in a gelatine solution a semipermeable membrane is formed on the gauze. With a 50 per cent. sugar solution a velocity of rise of 19 cm./min. is obtainable 0 15 0



A 26-900.

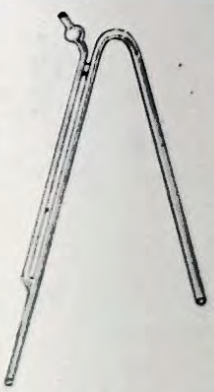


A 26-905.

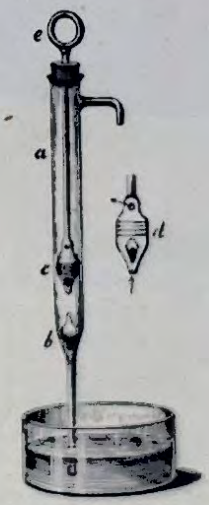


A 26-910.

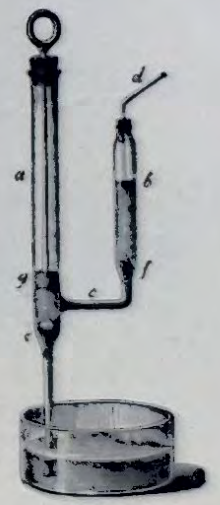
	£	s.	d.
A 26-900. VISCOMETER, Poiseuille (*cf.* Edser: *General Physics for Students*, p. 495), for determining the viscosity coefficient of liquids in absolute units by the application of the Poiseuille formula	0	5	0
A 26-905. VISCOMETER, Ostwald (Findlay: *Practical Physical Chemistry*, 6th Edn., p. 73). The classical apparatus for comparing viscosities in relation to a standard liquid. Capillary approx. 10 cm. long. Upper bulb approx. 15 ml. capacity	0	8	6
A 26-910. VISCOMETER, Bingham (Reilly and Rae: *Physico-Chemical Methods*, 4th Edn., **1**, 550). Designed, by use of air pressure, to overcome the defects of the Ostwald viscometer in which, owing to its use at atmospheric pressure, viscid liquids have a long time of flow and the low total pressure may cause considerable error if the working volume vary slightly. Also the density of the liquid must be known with considerable accuracy. U-tube with bulbs, capillary and internal jet, 20 cm. above bottom of U, as illustrated	1	2	6



A 27-120.



A 27-150.



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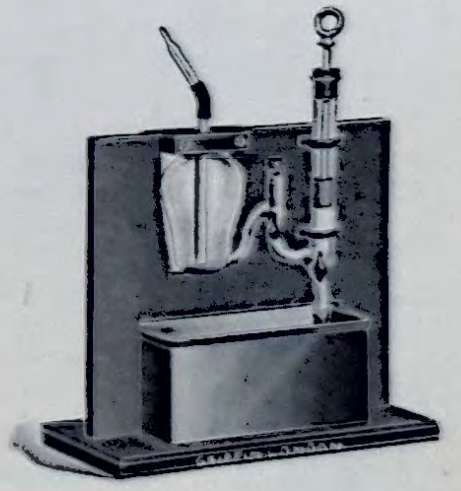
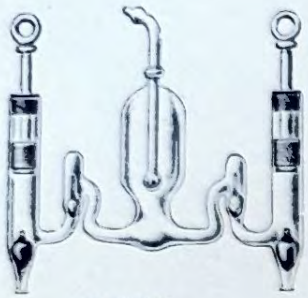
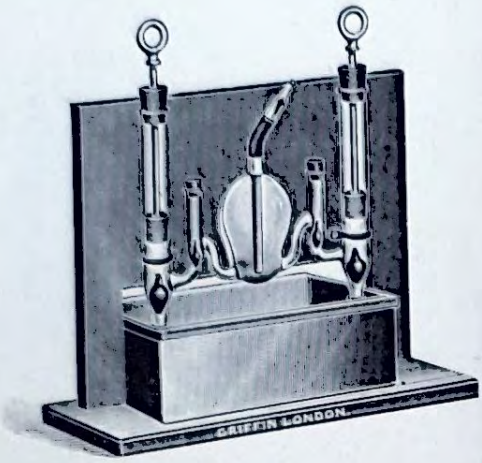


A 27-190—195.

	£	s.	d.
A 27-120. SYPHON, Glass, with suction tube, short limb 12 in. long	0	4	9
A 27-150. LIFT PUMP, working model, glass, **without** trough	0	7	6
A 27-155. Ditto, mounted on wood stand with metal trough	0	19	6
A 27-165. FORCE PUMP, working model, glass, **without** trough	0	8	6
A 27-170. Ditto, mounted on wood stand with metal trough	0	19	6
A 27-190. CONTINUOUS ACTION PUMP, working model, glass, single stroke, with 6 in. rubber tubing for directing jet of water to waste, **without** stand	0	10	6
A 27-195. Ditto, mounted on wood stand with rubber tube and cistern	1	5	0

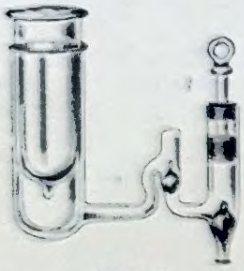


A 27-220.

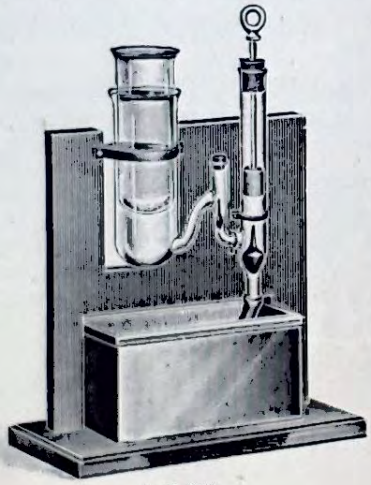


A 27-225.

	£	s.	d.
A 27-220. **FIRE ENGINE**, working model, glass, double stroke, unmounted, with 6 in. rubber tubing for directing jet of water to waste	0	19	6
A 27-225. Ditto, mounted on wood stand with zinc trough	1	12	0

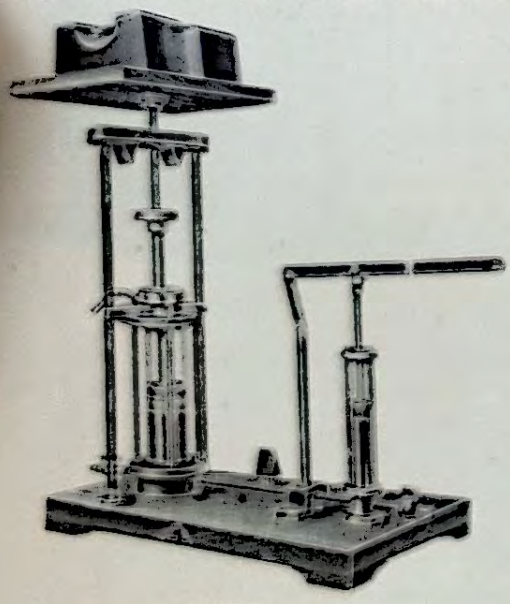


A 27-235.



A 27-240.

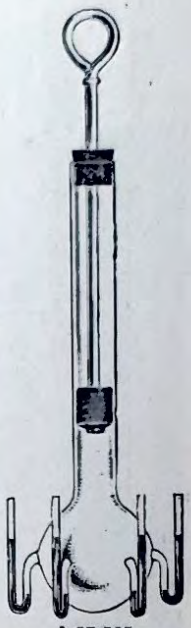
A 27-235. **HYDRAULIC PRESS, Bramah**, working model, glass	0	10	6
A 27-240. Ditto, mounted on wood stand with zinc trough	1	3	0



A 27-250.

A 27-250. HYDRAULIC PRESS, with heavy walled glass cylinders, removable loading platform, safety valve protecting from overload, wedges for breaking metal bars. Strongly constructed and mounted on baseboard 11½ × 7½ in. .. .. *f* 7 15 0

Pascal's Law of the transmission of pressure in a fluid has an important application in the hydraulic or Bramah press, which consists essentially of a large cylinder connected to one of smaller cross-sectional area. The internal diameters of the two cylinders are 1⅛ in. and ⅝ in. respectively, both cylinders are fitted with non-return valves and leather-covered pistons. The pump is worked by a hand lever 12½ in. long, ratio about 2-1, operating the piston of the smaller cylinder. When this piston is forced down, pressure is transmitted by the water to the larger cylinder and its piston raised, the process being repeated as often as required. A safety valve is provided in the larger piston so that pressure in excess of that which can safely be applied to the glass cylinder, enables the water to rise above the piston and escape through the overflow pipe at the top. Max. safe load, 200 lb., placed evenly and centrally on the platform. When in use a length of rubber tubing should be connected to the stop-cock located at the base of the smaller cylinder, dipping into a beaker of water for replenishment.



A 27-505.



A 27-520.



A 27-530.



A 27-540.

	£	s.	d.
A 27-505. PRESSURE APPARATUS, to demonstrate the equal transmission by gas of pressure in all directions	0	13	6
A 27-520. CRUSHING CYLINDERS, Thin Tin-plate, 8½ × 3 in., to demonstrate the pressure of the atmosphere .. .. *each* 1/6 ; *dozen*	0	16	0
A 27-530. BALLOONS, Rubber, small, for showing the expansion of air when placed in a vessel undergoing evacuation on the receiver of an air pump .. .. *dozen*	0	2	6
A 27-540. BREAKING SQUARES .. .. *each* 2/6 ; *dozen*	1	7	6

A small quantity of water is boiled in this vessel, till all the air is expelled by the steam. The cylinder is then closed by a good fitting cork and a quantity of cold water is poured over it, whereupon the cylinder immediately collapses.

These are thin square glass flasks of about half a pint capacity which, if corked and sealed, will be burst by the contained air when placed under a receiver which is subsequently exhausted.



A 27-560.

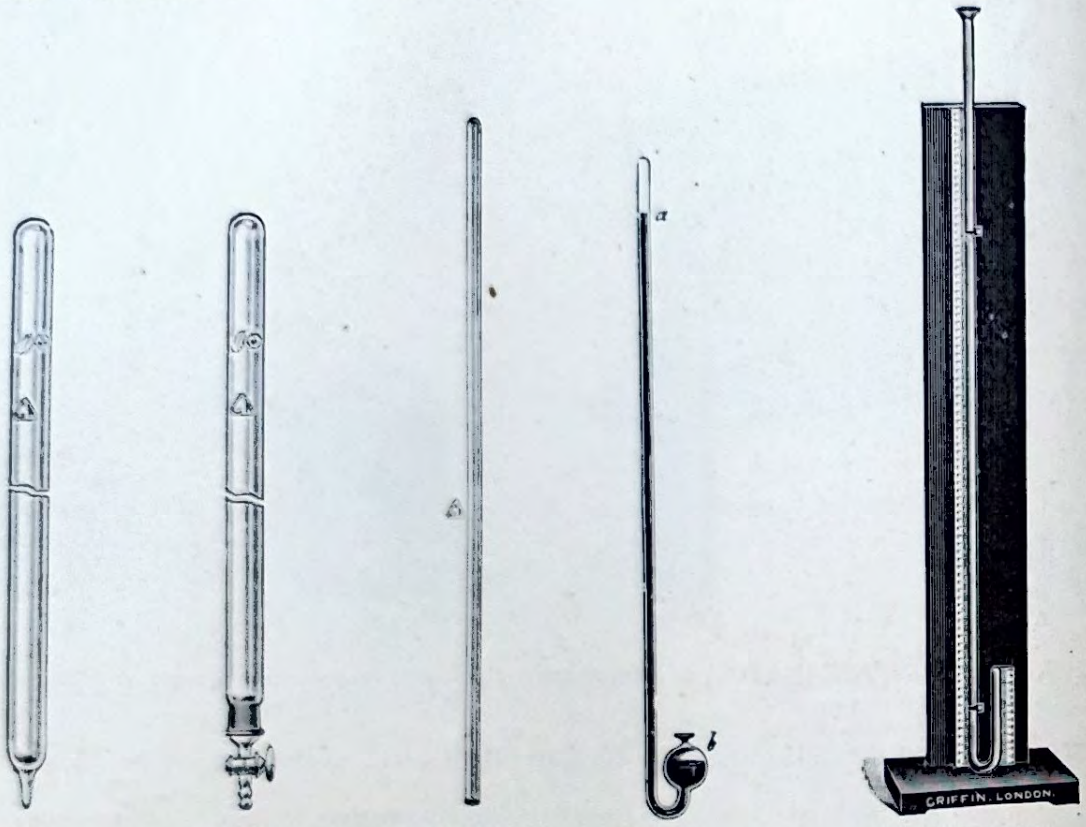
	£	s.	d.
A 27-560. MAGDEBURG HEMISPHERES, cast iron, 3½ in. diam., with brass stopcock and handles	1	5	0



A 27-580.

	£	s.	d.
A 27-580. ASPIRATING ACTION OF AIR CURRENTS, Clément and Desormes, for use in illustrating Bernoulli's Theorem. A light metal disc 9 cm. diam., held in clips, in which it is free to move towards the upper disc, to which is attached a metal tube 15 cm. long. On blowing downwards through the tube the light disc is drawn upwards by the reduction in pressure of the air as it enters a region of higher velocity	0	12	6

AIR PRESSURE GAUGES, see pages 87-89.



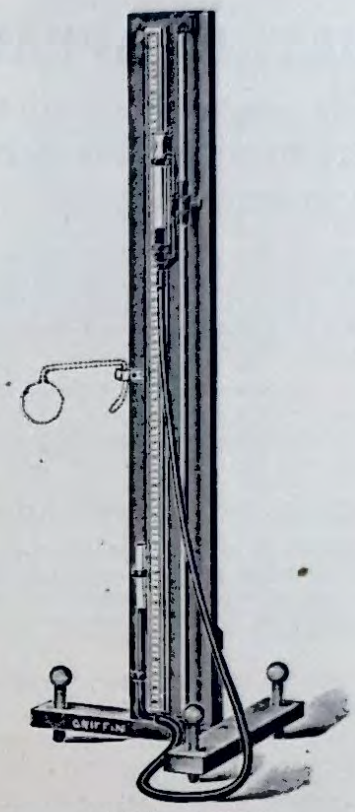
A 27-650. A 27-655. A 27-700. A 27-710. A 27-730—735.

	£	s.	d.
A 27-650. GUINEA AND FEATHER APPARATUS, showing that in a vacuum, the rate of free fall under gravity, at a given place, is the same for all bodies irrespective of size or material. Evacuated glass tube 120 cm. × 40 mm. diam., with falling objects ..	0	15	0
A 27-655. Ditto, glass tube as above, fitted with ground-in stopcock, for evacuating ..	1	5	0
A 27-700. BAROMETER TUBES, straight, stout glass, best quality .. *each tx* 2/1 ; *dozen*	1	2	9
A 27-710. BAROMETER TUBES, Syphon or Cistern, stout glass, best quality .. .. *each tx*	0	3	1
A 27-720. PIPETTES, 15 cm. long, bent at an angle for insertion of ether, etc., into barometer tubes .. .. *each* 8d. ; *dozen*	0	7	6
A 27-730. BOYLE'S LAW TUBE, with funnel end, on stand, with graduated boxwood scales	1	15	0
A 27-735. Ditto, glass tube only .. .. *each tx* 3/1 ; *dozen*	1	13	3

BAROMETERS, see pages 90-92.



A 27-750.



A 27-760. A 27-775.



A 27-765.



A 27-785.



A 27-790.

	£	s.	d.
A 27-750. BOYLE'S LAW TUBE, graduated, 50 ml. divided in 0·1 ml. with stopcock and levelling tube	0	9	6
A 27-760. BOYLE'S LAW APPARATUS, for pressures greater than atmospheric. With reservoir sliding along a scale graduated in mm. Mounted on wood stand with levelling screws	3	12	6
A 27-765. Ditto, for pressures less than and greater than atmospheric. With both reservoir and closed tube sliding along brass rods, mounted on heavy iron tripod with levelling screws	7	10	0
A 27-775. JOLLY'S APPARATUS (Allen and Moore: *Text-Book of Practical Physics*, p. 337), for determining the coefficient of expansion of gases under constant pressure and pressure coefficient at constant volume. Apparatus as **A 27-760** but with constant volume thermometer bulb and clip	3	19	6
A 27-780. Ditto, as **A 27-765**, but with constant volume bulb and clamp for fixing to rod	7	16	0
A 27-785. AIR THERMOMETER BULB, Jolly, with capillary tube, glass part only	0	3	6
A 27-790. VAPOUR PRESSURE TUBE, with two stopcocks	1	5	0
A 27-795. Ditto, with water jacket and clamps for use with **A 27-765**	1	15	0

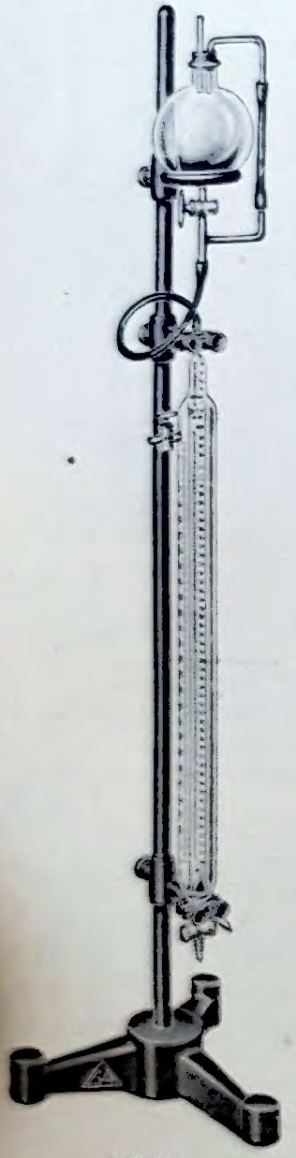
Using **A B** as the fixed tube in a Boyle's Law Apparatus, manipulation of the taps S_1S_2 allows a vacuum to be produced above the mercury level **B**, the use of two taps ensuring exclusion of air. Liquid may be introduced into this vacuum from the funnel above S_1 until a liquid layer shows that the vapour formed is saturated. The rubber tubing and attached reservoir may then be used as a manometer and the pressure of the vapour read at different temperatures.

A 27-810. Reservoir, spare, glass, for **A 27-760**	0	2	6
A 27-815. Ditto, for **A 27-765**	0	2	6
A 27-820. Tube, spare, glass, closed end, for **A 27-760**	0	3	0
A 27-825. Ditto, for **A 27-765**	0	3	0

Griffin and Tarlock Limited are complete Laboratory outfitters and design and manufacture Laboratory Furniture and Apparatus of the most varied character.

THE MICROID GASOMETRIC APPARATUS

An apparatus covering a wide range of experimental work in physics and chemistry involving the accurate measurement of the volume of gases



A 27-950.

The apparatus is designed to perform with a high degree of accuracy experiments involving the measurement of the volume of a gas, where temperature change of the gas is not a factor. Thus, the apparatus is equally useful in demonstrating Boyle's Law, determining gas densities at N.T.P., establishing Gay Lussac's Law of Combination of Gases by Volume, Henry's Law, etc.

A distinct advance is made in the procedure for obtaining the molecular formula of a gas, since the several separate pieces of apparatus usually employed may be replaced by this single unit and errors due to atmospheric changes during the course of experiments minimised.

ADVANTAGES OF THE APPARATUS.

(1) A large number of experiments involving measurement of gas volumes can be performed by the use of this one piece of apparatus, securing greater accuracy as well as convenience and economy in storage space. By the use of simple apparatus ordinarily available in the laboratory the range of experiments may be extended.

(2) Since the mercury columns lie close together, the difference in height between their levels is readily determined.

(3) Although the apparatus is simple it furnishes results accurate to within 5 per cent. and, with suitable care in manipulation, to within 1 per cent.

(4) By its use a gas such as sulphur dioxide may be liquefied.

(5) It enables important physical constants, such as the density of a gas or its solubility in water, readily to be determined.

(6) Important gas laws, both physical and chemical, can be demonstrated without difficulty by its use. These include Boyle's Law, Dalton's Law of Partial Pressures, Gay Lussac's Law of Combining Volumes, Henry's Law, etc.

(7) It bridges the gap between the expensive and elaborate apparatus used in advanced work and the makeshifts often resorted to in elementary teaching.

SPECIFICATION

The apparatus consists of a jacketed tube, about 1 cm. bore, and terminating in a stopcock. Near its lower end is a small hole from which the tube is graduated upwards throughout the remainder of its length in 560 × 1 mm. divisions. From the level of this hole the jacket, approx. 3 cm. diam., is graduated upwards in ml. to about 275 ml. to a side tube with stopcock. A 400 ml. mercury reservoir bulb with air inlet, stopcock and by-pass tube for escape of gases is fitted to the upper end of the graduated tube by pressure tubing. Pressures slightly greater than 1½ atmospheres are obtainable. Supported by a massive stand approx. 140 cm. high with rod 2 cm. diam. on tripod foot, fitted with rubber covered ring support for the bulb and two double-screw clamps for the gas tubes. The apparatus requires about 10 lb. mercury.

PRICES

	£	s.	d.
A 27-950. MICROID GASOMETRIC APPARATUS, with inner tube graduated to 560 mm., with stopcock and graduated jacket, with stopcock, mercury reservoir and pressure tubing. On massive tripod base retort stand 140 cm. high. **Without** mercury	8	0	0

Extra Parts for A 27-950

A 27-950 a. **Float**, for use in experiments involving measurements at pressures below atmospheric. Weighted glass tube, about 230 × 5 mm., with engraved datum line at one end (see Expt. 1)	0	5	0
„ b. **U-tube**, one limb graduated in 1 ml. to 200 ml., and fitted on top with stopcock, other limb fitted with draw-off stopcock near bend. For use in experiments of the type described in Expt. 10 ..	1	12	0

A 27-950. The Microid Gasometric Apparatus—*continued.*

EXPERIMENTAL NOTES

To cleanse the apparatus.—Run in about 50 ml. warm dilute nitric acid and swill out the apparatus after removal from the stand. Follow by successive treatments with warm sodium carbonate solution, distilled water and acetone.

To fill the gas tube with dry gas.—Wire on all rubber connections and place good rubber bands round the stopcocks. Close bottom tap and open tap at side. Run in a slow stream of mercury from the reservoir till the mercury flows through into the outer tube and just covers the hole in the wall of the inner tube. Next generate the gas for the experiment and, after drying, pass into the apparatus through the side arm. When the outer tube is filled with the dry gas disconnect the apparatus from the supply. The gas cannot escape as the hole is covered. Pressure may now be applied as required by running mercury into the central tube.

Physical Experiments

(1) Verification of Boyle's Law.—Fill the outer tube with dry gas. For pressures greater than one atmosphere use the mercury reservoir to vary the pressure, taking measurements of volume and pressure. For pressures less than atmospheric manipulate the reservoir and side tap to expel about two-thirds of the gas. Close the tap and run off mercury by means of the stopcock at the bottom, when pressures less than one atmosphere are produced. The mercury meniscus in the inner tube will be obscured by the higher level of that in the outer tube, but the level in the former may be indicated by previously placing a float, consisting of a weighted glass tube, sealed at the ends, in the inner tube, after having disconnected the pressure tubing. If a datum line is scratched on this tube measurements can be taken from it.

(2) Verification of Dalton's Law of Partial Pressures.—Introduce a gas at known volume and pressure into a burette. Connect this to the gasometric apparatus, which is already partially filled with another gas at a different pressure. Allow the gases to mix and note the resulting pressure and combined volume.

(3) Effect of Change of Pressure on the Boiling Point of any Liquid.—Connect the apparatus to a suitable condenser and boiler fitted with a thermometer. Raise the pressure above atmospheric by adding mercury from the reservoir and decrease by running off from the bottom. Note variations of the B.Pt.

(4) Principles of Liquefaction.—Connect a flask with a suitably fitted stopper to the apparatus and fill both with sulphur dioxide at atmospheric pressure. (i) Surround the flask with ice after closing the inlet. (ii) Remove the ice and compress the gas. In neither case is there liquefaction. Next compress and cool simultaneously. The gas in the flask liquefies.

(5) Density of Gas.—Connect a 600 ml. round bottomed flask to the apparatus and sweep out both with the dry gas. For this purpose the flask should have two stopcocks, one flush with the stopper, the other extended to the bottom. After expulsion of all the air, close the cocks, disconnect the flask and weigh. Re-connect the flask, open the necessary taps and force as much gas as possible from the apparatus into the flask by running in mercury. Close cocks again, disconnect the flask and re-weigh. The amount of gas expelled into the flask from the apparatus is determined by measuring the residue at atmospheric pressure and temperature, whence the density may be calculated.

(6) Density of Volatile Liquids.—Connect the gasometric apparatus to a vapour density or Victor Meyer's apparatus. The air displaced during the course of the determination may be measured in the gasometric apparatus.

(7) Solubility of Gases.—By using an absorption pipette connected to the apparatus it is possible to make a fairly accurate determination of the solubility. The complete system is filled with the gas, say carbon dioxide, and air-free water is drawn up into the pipette by running mercury out of the gasometric apparatus. After bringing the gas in the pipette to atmospheric pressure, the cocks leading to the air are closed and the pipette shaken for several minutes. Run in mercury from the reservoir to restore atmospheric pressure and when no further absorption takes place read off the volume of gas absorbed. Having found the volume of water the solubility may be determined.

If the pipette be warmed it will be seen that gas comes out of solution and may be redissolved by increasing the pressure, thus illustrating Henry's Law of solubility of gases.

(8) Gas Analysis.—The composition of simple gas mixtures may be ascertained by filling the outer tube with the sample, adding mercury from the reservoir, and expelling the sample through absorbents contained in suitable tubes with stopcocks or clips, or if necessary in series with a mercury U-tube, to exclude air. After absorption the mercury levels of the gasometric apparatus are adjusted and the decrease in volume noted. The absorption tubes should be swept out by an inert gas before the experiment.

Chemical Experiments

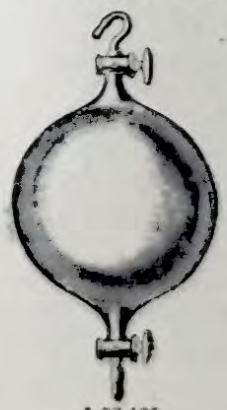
(9) Determination of the Equivalent Weights of Metals.—Almost fill the outer tube of the gasometric apparatus with mercury and connect the side arm to a reaction vessel, preferably A-shaped, containing a weighed amount of the metal in one limb, and dilute acid or water, as necessary, in the other. A flask with a test-tube containing the sample will be satisfactory. Tilt the vessel to bring about the reaction. By running off mercury from the bottom stopcock, the volume of hydrogen evolved may be measured at atmospheric pressure and temperature.

(10) Gay Lussac's Law of Combining Volumes.—A gas, *e.g.* dry ammonia, is introduced into the outer chamber of the gasometric apparatus and, by running in mercury, a measured volume forced through a combustion tube attached to the side arm. This tube contains a solid reactant (copper oxide where ammonia is used), which is heated to decompose the gas. By taking all necessary precautions the gaseous product (nitrogen in the case of ammonia) may be collected by any suitable apparatus and its volume measured at atmospheric temperature and pressure. A satisfactory apparatus for the purpose consists of a U-tube graduated to 200 ml. on one limb and fitted with a stopcock on the other, so that mercury may be drawn off from it and the levels adjusted for taking readings. This apparatus should be flushed out with nitrogen before the experiment and a calcium chloride bulb should be inserted between the U-tube and the combustion tube.

Knowing the vapour density of ammonia, the molecular formula may be deduced from the results obtained by the application of Avogadro's Hypothesis.

(11) Gravimetric Composition of Simple Compounds.—By using the accessory apparatus mentioned in (10) above (a calcium chloride bulb being unnecessary) it is not difficult to determine the gravimetric compositions of water, sulphur dioxide, carbon dioxide, nitrous oxide, hydrogen chloride, etc. The gas densities must be known and an appropriate solid reactant selected such as copper turnings (for N_2O, H_2S), copper oxide (for CO, etc.), sugar charcoal or sulphur (for CO_2 and SO_2), or iron wire (for HCl). The equivalent weights of common non-metals may also be derived from the results.

(12) Measurement of Volumes of Gases liberated during Chemical Reaction.—If the gas evolved does not exceed about 250 ml. the reaction apparatus may be connected to the gasometric apparatus. If the density is known, the weight of gas evolved is readily calculated.



A 28-105.

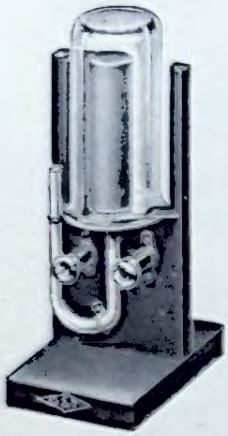
A 28-105. GLASS BALLOONS, Stoppered, for determining the density of gases.

Capacity	1000	2000 *ml.*
	25/-	30/- *each*

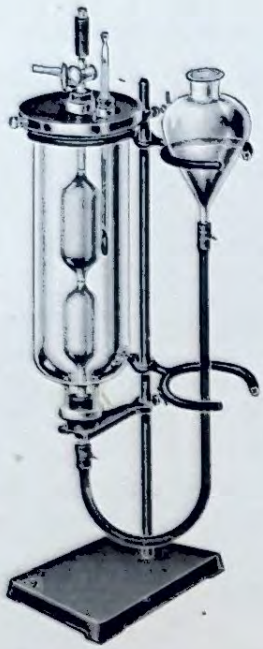
A 28-110. FLASK, Specific Gravity, Chancel, for determining the density of gases, about 250 ml. capacity. With extra flask, displacing about the same volume of air, for use as a counterpoise .. .. £ s. d. 0 18 6



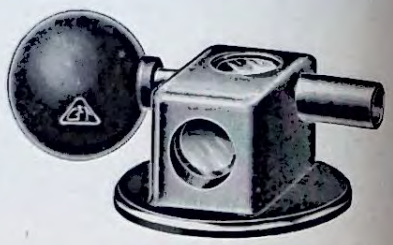
A 28-110.



A 28-250.



A 28-270.



A 28-290.

£ s. d.

A 28-250. MICROID GAS DIFFUSION DEMONSTRATION APPARATUS, for use in demonstrating in a unique manner the change of pressure resulting from diffusion into or out of a closed, porous receptacle. Porous pot carried by a rubber bung with U-tube having electrical contacts, two 2-volt bulbs, dry battery, beaker. Mounted on stand 7 in. high. Complete as illustrated .. .. *r* 1 15 0

Method of Use.—Clean, dry mercury is poured into the U-tube, leaving a space of about ¼ in. between the levels and the side contacts, and the open end of the tube is plugged with cotton wool to exclude dust. An increase of pressure is produced in the porous pot by surrounding it with a gas lighter than air, causing a movement of mercury, which, on touching the side contact, completes a flashlamp circuit. After a few seconds the beaker containing the enveloping gas is removed. The less dense gas then escapes from the porous pot faster than the heavier air can enter, resulting in a reduction of pressure. This causes the mercury to break contact and then to complete it on the other side, lighting the second lamp.

A 28-270. EFFUSION APPARATUS, Edwards (Bureau of Standards, *Technical Paper* 94 ; Dennis, *Gas Analysis, Revised Edn.*, p. 52), for determining the density of gases, rate of effusion being inversely proportional to square root of density. Complete as illustrated, with thermometer 0-110° C. **Without** mercury (about 6 lb. required) .. .. .. *r* 10 0 0

The older form of effusion apparatus, generally known as Schilling's apparatus (Lunge-Ambler : *Technical Gas Analysis*, p. 180), was found to be liable to several errors, the chief being due to the shape and design of the orifice. In this improved form the platinum foil orifice is sealed in a glass tube enclosed in an outer metal tube, so that it can be easily removed for cleaning. It is made sharp and free from burrs against which a speck of dust could lodge. The apparatus is designed to work with mercury to avoid difficulties due to condensation of moisture round the orifice. Other improvements are the provision of a water jacket, 30 cm. long to shoulder and 10 cm. diam., and the design of the gas chamber, with two bulbs approx. 160 ml. and 50 ml. respectively, which allows the use of an accurate mean pressure and an easier reading of the time of the approach of the mercury to the lower and upper marks.

£ s. d.

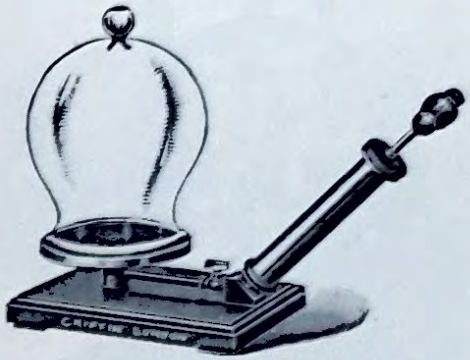
A 28-290. BROWNIAN MOVEMENT APPARATUS, metal base, about 5 cm. diameter, chamber fitted with legs and plane glass observation plate, inlet tube and rubber bulb *r* 3 10 0

The demonstration of Brownian movement is usually thought to be difficult, to require the use of an accurately centred Pointolite lamp or other powerful light source and to be operated in a darkroom.

With this new design, demonstration is simple. Smoke is drawn into the chamber through a lighted cigarette inserted in the tube at the right, by compressing and releasing the rubber bulb. The apparatus is then placed on the microscope stage and a parallel beam of light directed on the side lens, the axis of which is directed upwards to bring the convergent beam near to the upper, plane glass disc. The microscope, fitted with a ⅔ in. or ½ in. objective, is then focussed through the plane disc on to the beam seen in the smoke. The particles appear as brightly illuminated stars, moving with the characteristic Brownian motion. The phenomenon is easily observed and strikingly illustrates the kinetic theory of gases.


A 28-400.


A 28-410.

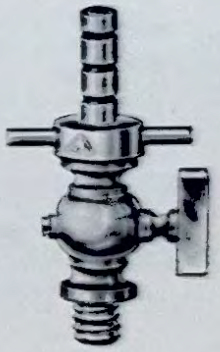

A 28-415.

	£	s.	d.
A 28-400. PUMP, Air, Pressure or Vacuum, Hand, with connector for rubber tubing. The pump as supplied is for exhausting. By reversing plunger and valve may be converted to compression pump. Barrel 8 × 1⅜ in. bore	2	10	0
A 28-410. PUMP, Air, Pressure-Vacuum, Hand, with both valves at the end of the barrel and no valve in the piston. Barrel 8 × 1⅜ in. bore .. .. *r*	2	5	0
A 28-415. PUMP, Air, Vacuum, Demonstration. Diam. of plate 4½ in., barrel 8 × 1⅜ in. bore. **Without** receiver	4	7	6
A 28-425. OILED SILK, for valves, for Pumps **A 28-400—415** .. .. *sq. ft.*	0	3	6


A 28-440.


A 28-445 + 465.


A 28-460.


A 28-465.

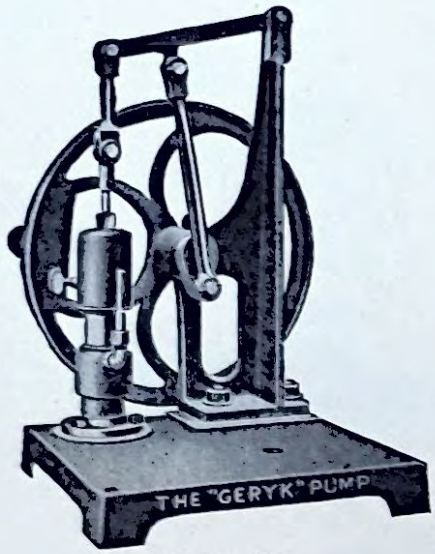
A 28-440. PUMP PLATE, Brass, on cast iron foot with tube for connection to pump. Plate fitted with screwed plug for regulating the re-admission of air, and detachable central suction tube. **Without** receiver.

Diam.	17·5	20	22·5	*cm.*
t	£3 5 0	£3 15 0	£5 0 0	*each*

A 28-445. PUMP PLATES, ground plate glass on cast iron table mounted on three legs. **Without** Stopcock **A 28-465.**

Diam.	20	25	30	*cm.*
	£3 0 0	£3 10 0	£4 10 0	*each*

	£	s.	d.
A 28-460. CONNECTOR, with male screw for screwing into air pump plate for attaching a rubber tube connection	0	8	6
A 28-465. Ditto, with stopcock and union	2	7	6



A 28-550—560.



A 28-565—570.

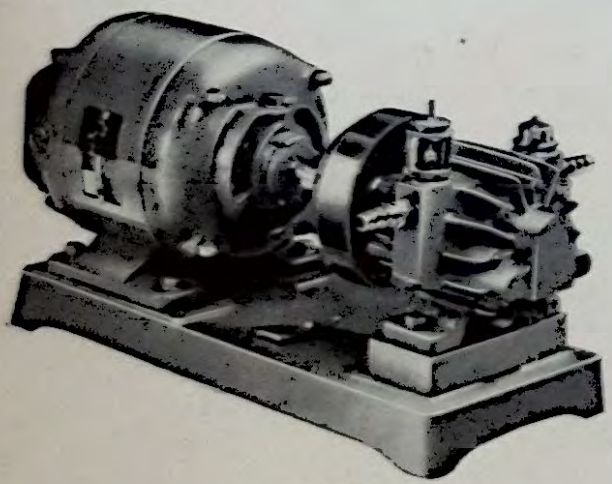
VACUUM PUMPS, Geryk, single stage, capable of giving a vacuum up to 0·02 mm.

Cat. No.	TYPE	Diam. of Cylinder inches	Stroke inches	Speed revs. per minute	Piston Displacement per minute cubic inches	PRICE £ s. d.
A 28-550	Geryk, No. 0 . . .	1½	4	100	700	*t* 11 0 0
A 28-555	Ditto, No. 1 . . .	2	4	100	1250	*t* 13 8 9
A 28-560	Ditto, No. 2 . . .	2	10	100	2820	*t* 25 6 3
A 28-565	Geryk Rocker, No. 7 . .	1½	4	100	700	*t* 9 1 3
A 28-570	Ditto, No. 8 . . .	2	4	100	1250	*t* 11 0 0

£ s. d.

A 28-575. Grooved Wheel for **A 28-550—570** for driving by motor .. .. .. *extra t* 0 11 6

A 28-580. PUMP OIL, specially prepared for Geryk Pumps. In cans .. *pint t* 2/3 ; *quart* 0 3 6



A 28-650.

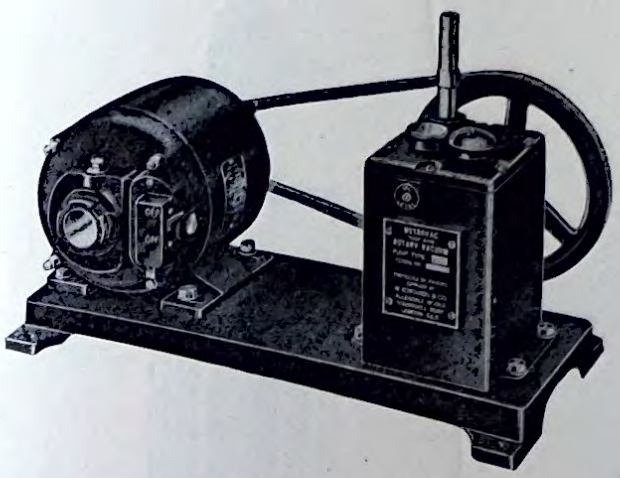
A 28-650. ROTARY COMPRESSOR AND VACUUM PUMP, for rough vacuum up to 26 in. Hg. and for compressed air up to 10 lb./sq. in., displacement 85 litres/min. Pump, fitted with automatic release valve, is direct coupled to ¼ h.p. motor with cooling fan—no water cooling, and mounted on cast-iron bedplate. Weight 56 lb. complete, dimensions about 17 × 9 × 9 in. Only occasional oiling is required. As a dual purpose machine for the laboratory or lecture room it has many applications, *e.g.*, filtration, operating blowpipes, etc.

For use on ..	A.C. 50 *cycles*	D.C.
tx	£18 18 0	£20 10 0

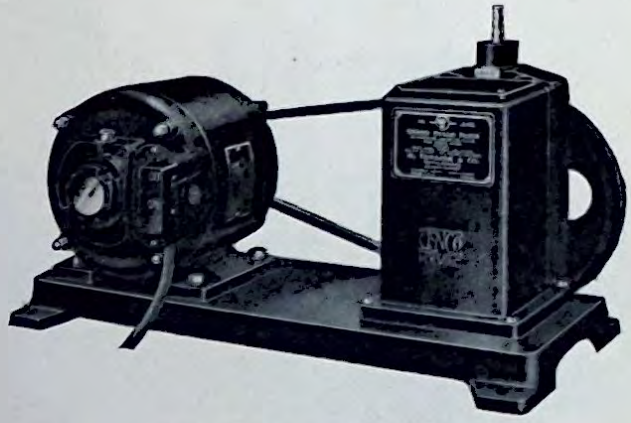
When ordering please state voltage and whether A.C. or D.C.

£ s. d.

A 28-655. Oil, for above .. .. *pint tx* 0 1 6



A 28-720.—Base : 18¼ × 8½ in.



A 28-740.—Base : 18 × 8½ in.

ROTARY AND DIFFUSION PUMP EQUIPMENT for General Experimental and Demonstration Work. The applications of high vacuum technique have developed greatly in the past few years. Teaching and experimental work requiring vacuum equipment may now employ new apparatus developed for demonstrating the most recent industrial technique. A selection of modern pumps and accessories is given, but we welcome enquiries for apparatus not listed herein.

ROTARY PUMPS. Slotted rotor and sliding vane principle. Suitable for continuous operation. The specifications should be studied carefully before selecting. The S.R. 2 (**A 28-720**) and Speedivac 1 (**A 28-725**) are single stage pumps with approximately the same end vacuum. The Speedivac 1 Pump has a displacement approximately five times greater for fast pumping. For higher vacuum with small displacement the Hyvac Pump (**A 28-740**) is convenient. For fast two-stage pumping the D.R. 1 (**A 28-730**) and Speedivac 2 (**A 28-735**) pumps are more suitable.

SPECIFICATIONS AND PRICES

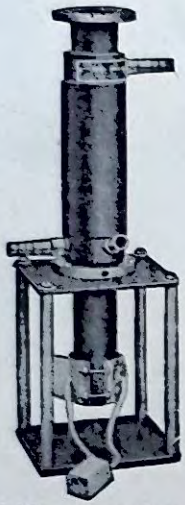
Type	Vacuum Hg.	Displacement litres/sec.	Motor h.p.	Drive	Oil Charge galls.	Weight, lbs.	
						Pump only	Pump and Motor
	mm.						
S.R. 2 . .	0·005	9·3	¼	V-belt	0·27	15	56
Speedivac 1 .	0·005	48	¼	V-belt	1·25	56	93
D.R. 1 . .	0·0005	42	¼	Direct coupled	0·75	Not supplied separately	170
Speedivac 2 .	0·00001	48	¼	V-belt	1·5	78	124
Hyvac . .	0·00001	10	¼	V-belt	0·25	17	56

Cat. No.	Type No.	Pump only with oil	Outfit, A.C. 50 cycles	Outfit, D.C.	Oil, extra per gall.	Spare belt
		tx £ s. d.	tx £ s. d.	tx £ s. d.	tx £ s. d.	tx £ s. d.
A 28-720	S.R. 2	16 6 3	22 19 6	24 11 6	0 7 6	0 3 3
A 28-725	Speedivac 1 . . .	27 18 9	38 2 6	39 14 6	0 8 0	0 3 6
A 28-730	D.R. 1	Not supplied separately	53 0 0	53 0 0	0 7 6	Not used
A 28-735	Speedivac 2 . . .	57 4 0	68 0 0	69 12 0	0 8 0	0 4 0
A 28-740	Hyvac	18 0 0	24 0 0	25 0 0	0 8 0	0 3 3

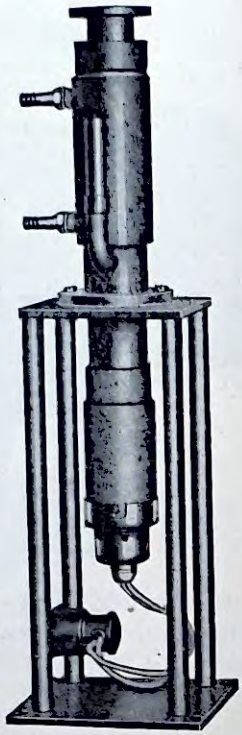
When ordering please state voltage and if A.C. or D.C.



A 28-800.—Type 2.



A 28-800.—Types 3 and 6.



A 28-800.—Type 02.

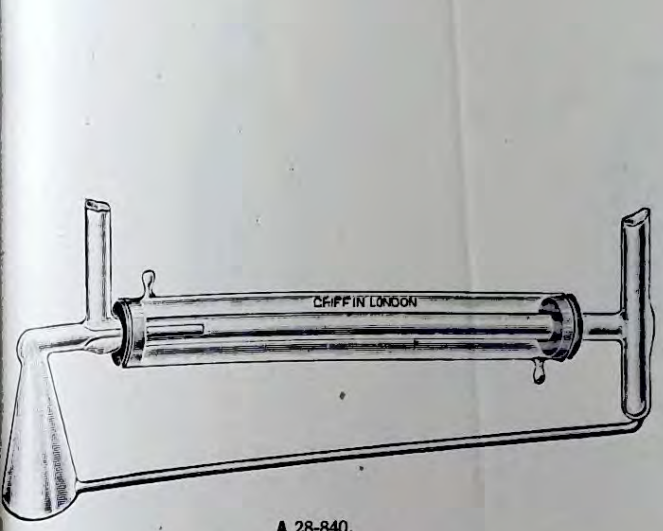
DIFFUSION PUMPS. The wide variety of diffusion pumps which are now made, range in speeds from a few litres per second for general vacuum processes, to several thousand litres per second for large industrial projects. They operate with mercury, oil or organic fluids but all need to be worked in conjunction with a mechanical pump which provides the necessary "fore" or "backing" pressure. The types listed are the smaller sizes operated with mercury or with low-vapour pressure oil. Usually the selection of an oil or mercury vapour pump is determined by the work involved but generally a mercury vapour pump requires less attention and can withstand rougher treatment although suffering from the disadvantage that a cooling trap is necessary if the diffusion of mercury vapour back into the system is to be avoided. Oil diffusion pumps cannot be used in systems employing mercury as the oil is susceptible to oxidation and decomposition whereas air can be allowed to pass through the hot mercury pumps. Both types of pumps have their particular applications and if the user is unable to choose the type and size of pump we shall be glad to advise. If a rotary pump is already in use full details of its performance should be given.

All pumps are fitted with standard flange fitting on the high vacuum side for connection to metal apparatus. Standard soda glass sockets (female) with ground connection to screw-in steel cones (male) are listed for connection to glass apparatus.

PUMPS, Diffusion, on stand with heater. Types 2, 3 and 6 are for mercury. Type 02 uses Apiezon Oil A or B (**A 28-980—985**). Connections are provided for rubber tube for cooling water.

Type →	2	3	6	02
Description	Single stage, Hg.	Single stage, Hg.	Two stage, Hg.	Single stage, Oil
Ultimate vacuum mm./Hg.	10^{-6}	10^{-6}	10^{-6}	10^{-5} to 10^{-6}
Displacement litres/sec.	6-8	2-3	2-3	7
Backing pressure mm./Hg.	0·5	0·5	4	0·3
Heat Input watts	300-500	150-200	400	450
Charge Hg. ml.,	50	20	20	50 ml. Apiezon Oil A or B
Weight lb.	9	3	3¼	7
	tx £ s. d.	*tx* £ s. d.	*tx* £ s. d.	*tx* £ s. d.
A 28-800. Pump, with stand	26 1 6	12 18 3	18 12 0	19 2 6
A 28-805. Heaters, spare	0 19 3	0 7 9	0 15 6	1 7 0
A 28-810. Cone, steel	3 19 9	1 18 3	1 18 3	3 12 0 complete
A 28-815. Socket, soda glass for **A 28-810**	1 6 3	0 5 8	0 5 8	

When ordering please state voltage and whether A.C. or D.C.





A 28-840.

		£	s.	d.
A 28-840.	**PUMP, Mercury Diffusion, Waran** (*J. Sci. Instruments*, 1923, 1, 51 ; Smith: *Intermediate Physics*, p. 91). This pump is of a simplified design and will exhaust a litre volume to a pressure of about 10^{-3} mm. in 2–3 minutes after starting at atmospheric pressure. A quick-acting backing pump should be used in order to keep the condenser exhausted to a pressure of less than 1 mm. It is advisable to use a deflecting board of asbestos to prevent hot gases from heating flame touching joint of condenser. Heat should be cut off from the boiler whenever air is let in, otherwise, at the higher pressure, the mercury rises in temperature and as soon as the pre-vacuum is restored by a quick-acting pump, boils violently, rendering the boiler liable to damage .. .. *p*	1	5	0
A 28-845.	**Ditto**, with constricted nozzle for high vapour pressure. Will operate satisfactorily using a good filter pump as backing pump .. .. *p*	1	5	0

VACUUM GREASES, WAXES, OILS, Etc.

A 28-905.	**TALLOW specially prepared**, in sticks of ½ lb. .. .. *lb.* *r*	0	5	0
A 28-910.	**RUBBER GREASE, Stevens**, for lubricating stopcocks, desiccator covers, etc. *tin p* 2/6 ; *dozen tins*	1	7	0
A 28-920.	**TAP LUBRICANT, Everett**, suitable for vacuum work, or lubrication of all glass or metal taps. As used at Cavendish Laboratory, Cambridge .. .. 2 *oz. jar* *t*	0	4	0
A 28-925.	**WAX, Everett**, very low vapour pressure, for vacuum work. As used at Cavendish Laboratory, Cambridge. In sticks.			

Type	Soft	Hard	Very Hard	
Melting Point	60° C.	57° C.	54° C.	
	t 6/3	6/3	6/3 ½	*lb.*
2 *oz. stick* *t*	9d.	9d.	9d.	

A 28-940.	**GREASE, Ramsay type, soft grade**, for taps, etc. Suitable for pressures down to 10^{-3} mm. Hg., ... 1 *oz. jar* *t* 1/9 ; 4 *oz. jar* *t*	0	5	3
A 28-945.	**Ditto, hard grade**, for lubricating metal or glass joints 1 *oz. jar* *t* 1/9 ; 4 *oz. jar* *t*	0	5	3
A 28-960.	**GREASE, Apiezon "L,"** for glass taps, ground connections and temporary connections .. .. 1 *oz. tube* *t*	1	0	6
A 28-965.	**PICEIN.** A well-known plastic which softens with heating, adheres firmly to glass, porcelain, metals, etc., and hardens at temperatures below 75° C. to form a tight seal. Very useful for sealing electrodes into glass tubes, repairing cracks in glassware and especially for vacuum work where working temperatures are below the softening point of the wax. It is insoluble in water, only slightly soluble in alcohol, but is easily dissolved by benzene and turpentine. Not attacked by dilute acids. It is sufficiently yielding at 15° C. to avoid cracking in use .. .. 2 *oz. stick* *t*	0	1	0
A 28-970.	**Wax No. 3.** Has a wider variety of uses than Picein and is stronger and suitable for somewhat higher temperatures .. .. 1 *oz. stick* *t*	0	4	0
A 28-975.	**Compound "Q."** An ideal material for making permanent joints in vacuum systems, moulds easily like Plasticine .. .. 2 *lb. tin* *t*	1	3	0
A 28-980.	**OIL, Apiezon "A,"** for diffusion pumps, vapour pressure 10^{-6} mm. Hg. after evolution of dissolved air .. .. 4 *oz.* *t* 10/6 ; 16 *oz.* *t*	1	14	6
A 28-985.	**OIL, Apiezon "B,"** for diffusion pumps, vapour pressure 10^{-7} mm. Hg. after evolution of dissolved air .. .. 4 *oz.* *t* 20/6 ; 16 *oz.* *t*	3	5	6



A 29-120.



A 29-125.



A 29-130.

The dimensions of the bell jars listed below are approximate. Every endeavour is made to conform to them, but exact adherence cannot be guaranteed. The inside height is measured to the shoulder. The flange is usually 10–20 mm. wide and varies according to the size of the jar. With the exception of **A 29-150**, *the internal diameter of the neck is about 30 mm.*

BELL JARS, heavy, clear glass, with ground flange.

Height to shoulder	15	17·5	23	20	30	30	20	*cm.*
Diam. inside flange	7·5	10	12·5	15	20	21·5	25	*cm.*
A 29-120. With knob .. .. *tx* **4/-**	**5/9**	**7/6**	**8/6**	—	—	**20/-**	*each*
A 29-125. Unstoppered .. .. *tx* **4/-**	**5/9**	**7/6**	**8/6**	**44/-**	**50/-**	—	*each*
A 29-130. Stoppered .. .. *tx* **5/-**	**7/6**	**9/9**	**10/9**	**52/-**	—	—	*each*



A 29-150.



A 29-155.



A 29-160.

A 29-150. BELL JARS, wide mouth, open at top with ground flange at base.

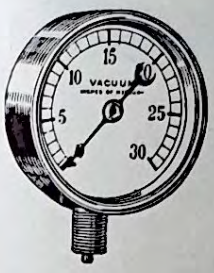
Inside height × inside diam.	20 × 15	25 × 10 *cm.*
Neck bore about	45	63 *mm.*
	23/-	**24/-** *each*

A 29-155. BELL JARS, graduated, open at top, with ground flange at base.

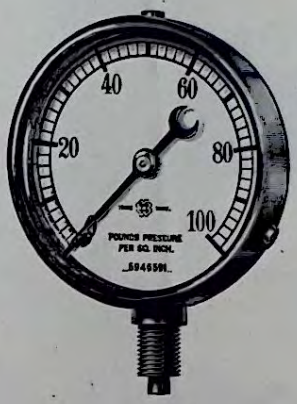
Inside height × inside diam. ..	15 × 9	17·5 × 10	20 × 15 *cm.*
Capacity	500	1000	2000 *ml.*
Divided in	10	20	50 *ml.*
	14/-	**16/-**	**22/-** *each*

	£	s.	d.
A 29-160. BELL JAR, fitted ground-in glass stopcock at top, with ground flange at base ; inside dimensions 30 × 15 cm. diam.	1	4	0

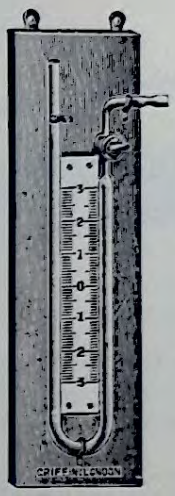
Particular attention is given to the production of apparatus designed for special purposes by our customers.



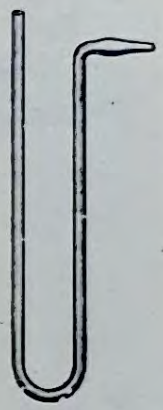
A 29-400.



A 29-415.



A 29-430.


A 29-445.



A 29-460.

	£	s.	d.
A 29-400. GAUGE, Vacuum, for general laboratory use on pumps, etc. In brass case, dial 2 in. diam. Thread $\frac{1}{8}$ in. gas. Graduated 0–30 in. .. .. *r*	0	17	6
A 29-405. Ditto, graduated 0–760 mm. .. .. *r*	0	17	6

A 29-415. GAUGES, Pressure or Vacuum, with brass bezel and painted back, suitable for air, gas, oil, and water. These gauges are only satisfactory for cold pressures, and must be fitted with an efficient syphon if used for steam. The dial may be graduated for vacuum, or any one of the following pressures—10, 20, 30, 60, 80, 100, 120, 150, 200, 250 and 300 lb. per sq. in.

Diam. of dial	$2\frac{1}{4}$	$2\frac{1}{2}$	3 *in.*
Size of thread	$\frac{1}{8}$	$\frac{1}{4}$	$\frac{1}{4}$ *gas*
	r 17/6	19/6	23/- *each*

If these gauges are to be used with oxygen this must be stated when ordering so that danger arising from the presence of oil can be eliminated.

A 29-430. MANOMETER, with stopcock, 12 in. long, $\frac{3}{8}$ in. bore, mounted on board for hanging on wall, with boxwood scale in $\frac{1}{10}$ in. Graduated to 3 in. on both sides of zero, giving a total range of 6 in. In using the gauge, the level on each side of the zero is read and the two readings added	0	17	6
A 29-435. Ditto, without stopcock	0	12	6
A 29-440. Manometer Tube, spare, unmounted, with stopcock	0	7	6
A 29-445. Ditto, without stopcock	0	2	6
A 29-460. GAUGE, Mercury, Vacuum and Pressure, unfilled, mounted on board with movable wood scale graduated from 0 to 30 in. × $\frac{1}{10}$ in. If required as a pressure gauge the connection is made to the bulb end; as a vacuum gauge to the upper end. **Without** Mercury	2	5	0

Customers abroad indenting through an agent would oblige by quoting our name and address in full, and sending a copy of order direct to us



A 29-120.



A 29-125.



A 29-130.

The dimensions of the bell jars listed below are approximate. Every endeavour is made to conform to them, but exact adherence cannot be guaranteed. The inside height is measured to the shoulder. The flange is usually 10–20 *mm. wide and varies according to the size of the jar. With the exception of* **A 29-150**, *the internal diameter of the neck is about* 30 *mm.*

BELL JARS, heavy, clear glass, with ground flange.

Height to shoulder	15	17·5	23	20	30	30	20	*cm.*
Diam. inside flange	7·5	10	12·5	15	20	21·5	25	*cm.*
A 29-120. With knob .. .. *tx*	**4/-**	**5/9**	**7/6**	**8/6**	—	—	**20/-**	*each*
A 29-125. Unstoppered .. .. *tx*	**4/-**	**5/9**	**7/6**	**8/6**	**44/-**	**50/-**	—	*each*
A 29-130. Stoppered .. .. *tx*	**5/-**	**7/6**	**9/9**	**10/9**	**52/-**	—	—	*each*



A 29-150.



A 29-155.



A 29-160.

A 29-150. BELL JARS, wide mouth, open at top with ground flange at base.

Inside height × inside diam.	20 × 15	25 × 10	*cm.*
Neck bore about	45	63	*mm.*
	23/-	**24/-**	*each*

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Inside height × inside diam. ..	15 × 9	17·5 × 10	20 × 15	*cm.*
Capacity	500	1000	2000	*ml.*
Divided in	10	20	50	*ml.*
	14/-	**16/-**	**22/-**	*each*

	£	s.	d.
A 29-160. BELL JAR, fitted ground-in glass stopcock at top, with ground flange at base ; inside dimensions 30 × 15 cm. diam.	1	4	0

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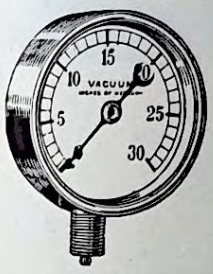
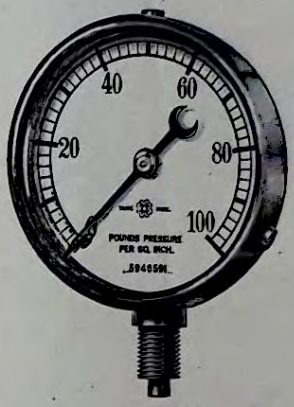
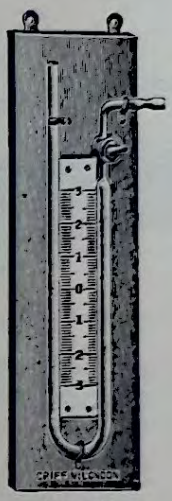


A 29-400.



A 29-415.



A 29-430.


A 29-445.



A 29-460.

	£	s.	d.
A 29-400. GAUGE, Vacuum, for general laboratory use on pumps, etc. In brass case, dial 2 in. diam. Thread $\frac{1}{8}$ in. gas. Graduated 0–30 in. .. .. *r*	0	17	6
A 29-405. Ditto, graduated 0–760 mm. .. .. *r*	0	17	6

A 29-415. GAUGES, Pressure or Vacuum, with brass bezel and painted back, suitable for air, gas, oil, and water. These gauges are only satisfactory for cold pressures, and must be fitted with an efficient syphon if used for steam. The dial may be graduated for vacuum, or any one of the following pressures—10, 20, 30, 60, 80, 100, 120, 150, 200, 250 and 300 lb. per sq. in.

Diam. of dial	$2\frac{1}{4}$	$2\frac{1}{2}$	3 *in.*
Size of thread	$\frac{1}{8}$	$\frac{1}{4}$	$\frac{1}{4}$ *gas*
	r 17/6	19/6	23/- *each*

If these gauges are to be used with oxygen this must be stated when ordering so that danger arising from the presence of oil can be eliminated.

A 29-430. MANOMETER, with stopcock, 12 in. long, $\frac{3}{8}$ in. bore, mounted on board for hanging on wall, with boxwood scale in $\frac{1}{10}$ in. Graduated to 3 in. on both sides of zero, giving a total range of 6 in. In using the gauge, the level on each side of the zero is read and the two readings added	0	17	6
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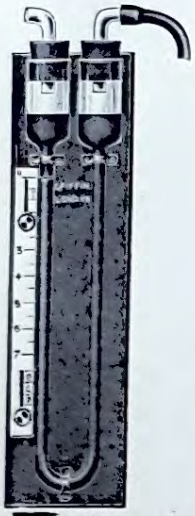
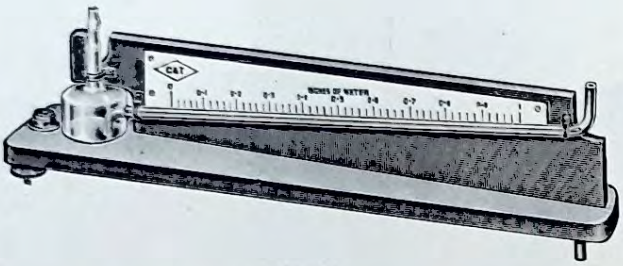


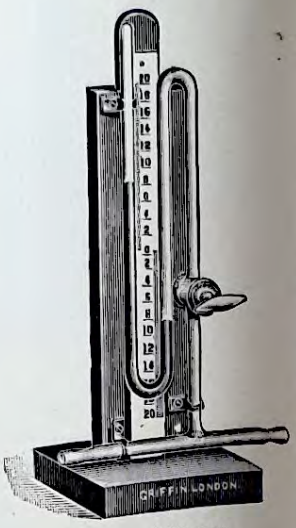
A 29-480.



A 29-490.



A 29-505.



A 29-520.

	£	s.	d.
A 29-480. GAUGE, Micro-Manometer (or Differential Vacuum and Pressure), for measuring the draught in flues by means of a Pitot tube and for other applications in which a sensitive gauge for reading accurately to 0·01 in. small pressure differences up to 1 in. water is required .. .. *r*	4	5	0

The gauge ends in two wide cups of equal bore which are many times the area of the communicating U-tube. It is filled with two liquids of different colour, which do not mix and are about the same density. A difference of level in the cups results in a movement of the surface separating the two fluids. This displacement is as many times greater than the difference of level at the top as the area of the cups is greater than the area of the U-tube. Arranged for a maximum difference of level in the cups of 1 in. and with the sectional area of the cups from 15 to 20 times greater than the area of the U-tube. Each instrument is individually calibrated, each scale division representing 0·02 in. water.

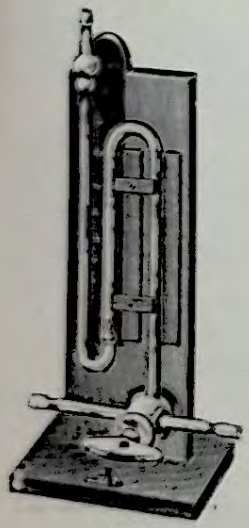
A 29-490. GAUGES, Manometer, Inclined (Draught Gauge). A very useful instrument for measuring small pressure differences. Particularly suitable for use in conjunction with Pitot tubes. The tube and scale are mounted on a stand 18 × 3¼ in., fitted with a spirit level and two levelling screws. Scales calibrated in 50 divisions.

Range	0–0·5	0–1	*in. water*
	r £4 0 0	£4 0 0	*each*

A 29-505. GAUGE, Mercury, U-form, with scale, mounted on flat base, for placing on air pump plate. Height about 7 in. With mercury 0 19 0

A 29-520. GAUGE, Mercury, Vacuum, Bennert, closed tube filled with mercury, with stopcock and **mirror sliding scale,** on wood stand .. .. *r* 1 19 0

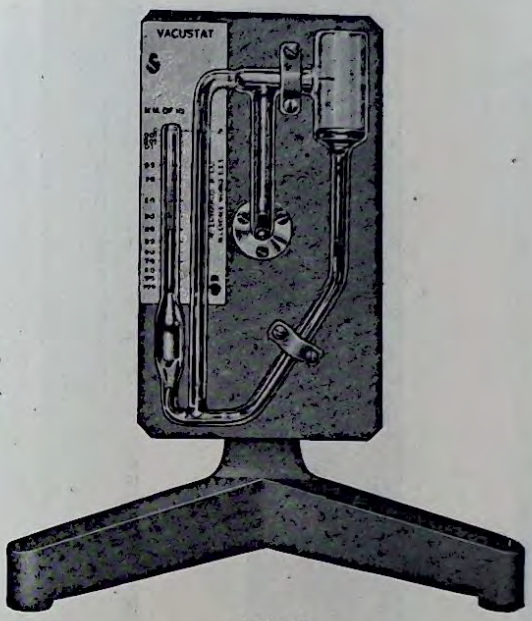
For safety in transit the gauge is filled with mercury up to the stopcock. Before using, the excess mercury must be removed from the open limb.



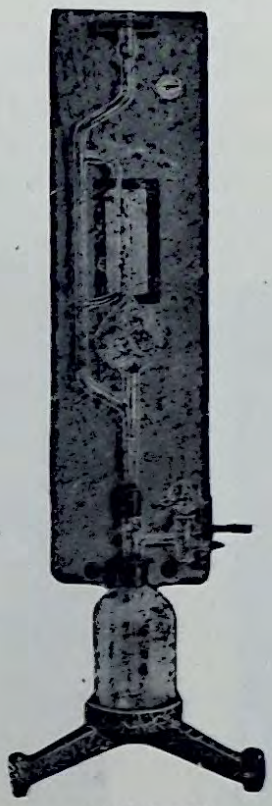
A 29-530.

A 29-530. MANOMETER, mercury valve. Similar to Bennert Vacuum Gauge **A 29-520,** but with sintered glass mercury valve, 3-way stopcock at junction of vertical and horizontal limbs, mirror glass scale graduated cms. in 2 mm. divisions and with sintered glass membrane, permeable to air but impermeable to mercury, fitted to end of limb normally closed. **Without** mercury .. .. *r* 3 12 6

The advantage of this manometer over the Bennert gauge is that it does not need boiling out during filling. With one end of the horizontal limb immersed in a bottle of mercury, suction can be applied above the sintered glass plate. Mercury will then rise in the gauge tube, and if on top of the sintered glass membrane there is placed a plug of mercury, when all the air has been evacuated from the gauge, air cannot re-enter.



A 29-580.



A 29-605—615.

	£ s. d.
A 29-580. VACUSTAT, direct reading, range 10–0·01 mm., compact, McLeod type gauge, 23 cm. high, rotatable through 90°, on metal stand, with stainless steel riffled vacuum connection. **Without** mercury (*Requires about* 8 *ml.*) .. .. *tx*	5 7 6
A 29-585. Case, wood, for storing above .. .. *tx*	1 10 0

The Vacustat is a modification of the well-known McLeod gauge and whilst similar in principle it differs considerably both in construction and method of use. Whereas the normal type of McLeod gauge must have an overall height well in excess of the barometric column, the Vacustat measures only 23 cm. high. The small quantity of mercury needed (approx. 8 ml.) makes the gauge readily portable. It is so designed that rotation about its centre causes compression of the residual gas and is the only operation necessary to take a reading. The glass part of the gauge is mounted on a metal backplate, with a direct-reading scale, range 10 to 0·01 mm., and fitted with a stainless steel riffled connection to take rubber tubing, which provides the necessary flexibility for rotation through 90°. The gauge is left in the horizontal position during evacuation and is turned to the vertical position to take a reading.

GAUGES, McLeod, Bench type. A new compact form, suitable for use where an all-glass system is essential or the use of a full length McLeod gauge undesirable. Air, which is allowed to enter through the capillary bore of the two-way tap connected to the reservoir, forces mercury up into the centre tube permitting a reading to be taken. To lower the mercury, the tap is turned to the other arm, connected to a rough vacuum supply or evacuated vessel, and the air is thus withdrawn from the mercury reservoir. The gauge is available in three standard ranges and is supplied on a board approx. 26 × 6 in. wide, mounted on tripod foot.

	£ s. d.
A 29-605. Gauge, McLeod, Bench type, as specified above, with instructions for use. Range 10 to 0·01 mm. Hg. **Without** mercury (5 *lb. required*) .. .. *tx*	8 16 0
A 29-610. Ditto, range 2 to 0·001 mm. Hg. **Without** mercury (6 *lb. required*) .. .. *tx*	8 16 0
A 29-615. Ditto, range 0·1 to 0·00001 mm. Hg. **Without** mercury (7 *lb. required*) .. *tx*	8 16 0

Orders for Export are handled in a department organised for the purpose and are packed with special care by an expert staff.

Geophysics



A 31-250.
0·25 in. bore.



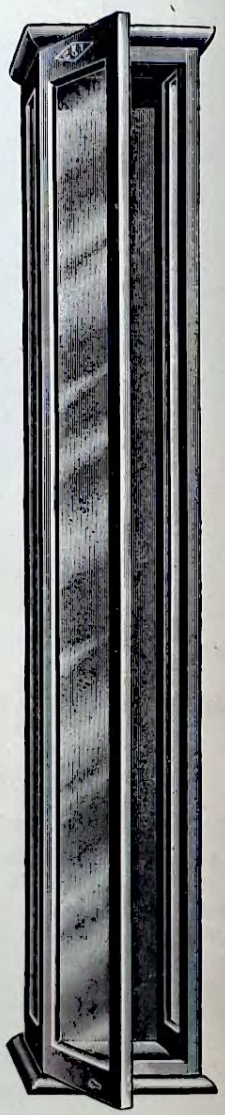
A 31-250.
0·3 in. bore



A 31-250.
0·5 in. bore.



A 31-250.
0·75 in. bore.



A 31-260.

STANDARD BAROMETERS

Specifications and prices see next page.

Directions for Fixing.—The barometer must not be fixed where the sun can shine on it, nor where it is exposed to the direct heat of a fire or radiator. It should be placed at a convenient height for observation, with the cistern between two and three feet from the ground. The mahogany board should be fixed in a vertical position with the aid of a plumb-line.

Rail Transit.—We take every possible care in packing barometers and are not responsible for damage in transit. Standard Barometers should always be carried with the cistern uppermost, and the cases are distinctly marked accordingly.

Export.—Barometers which are to be used at a place near to the port of discharge, are, wherever possible, placed in the care of a ship's officer, and are not packed in a case. Arrangements should be made for collection from the ship.

Barometers which must be sent for considerable distances overland from the port of discharge are similarly placed in the care of a ship's officer and similar arrangements should be made regarding collection from the ship. Such instruments are, however, dismantled before packing, and the tube of the instrument is packed separately from the body, inside a metal packing case, which is screwed to the neck of the cistern. The baseboard of the instrument is packed with the metal case inside a suitable wooden case. In unpacking, the barometer is held upright and the metal case unscrewed and withdrawn from over the tube, care being taken not to subject the latter to any side strain. The soft packing may then be removed from the tube and the body of the instrument screwed into its place up to the shoulder.

Insurance.—Whenever possible, barometers for export will be insured against damage in transit, and the insurance fee charged at cost.

Standard Barometers—*continued.*

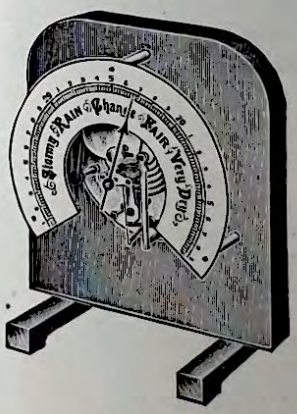
A 31-250. BAROMETERS, Standard, Fortin. The mercury cistern is of glass, and is closed in at the bottom by a leather bag, which can be raised or lowered by means of the screw shown in the illustration. With silvered metal scales reading 27 to 32 in., and 690 to 810 mm., with vernier reading 0·002 in., and 0·1 mm. Attached thermometer graduated on stem with Fahrenheit and Centigrade scales. Mounted on polished wood board, with opal glass reflectors and adjusting screws at base.

Bore of tube	0·25	0·3	0·5	0·75	*in.*
r	£11 15 0	£18 5 0	£24 5 0	*each*	*Price on application.*

A 31-255. N.P.L. Certificates, for above .. .. *t* £2 16 0 £2 16 0 £2 16 0 £2 16 0 *each*

A 31-260. CASES, mahogany frame, glazed sides and front, with lock and key, for barometers A 31-250.

Barometer tube bore	0·25	0·3	0·5	0·75	*in.*
r	£7 5 0	£7 5 0	£7 15 0	£8 10 0	*each*



A 31-290.



A 31-300.



A 31-310.

£ s. d.

A 31-290. BAROMETER, Aneroid, open face, with metal dial 4½ in. diam., mounted on wood frame, suitable for placing under bell jar or on air pump plate for demonstrating the action. Minimum size bell jar required, 20 cm. high, 17·5 cm. diam. 2 0 0

A 31-300. BAROMETERS, Aneroid, aluminium dial, in turned circular oak frame.

Diam. of dial ..	3½	4½	5½	6½	*in.*
	£1 15 0	£2 0 0	£2 10 0	£3 3 0	*each*

A 31-310. BAROMETER, Aneroid, porcelain dial 5 in. diam., in heavy cast iron case with fixing lugs and brass bezel; strong dependable movement 2 15 0



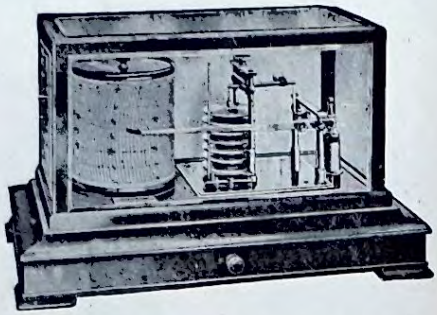
A 31-340.



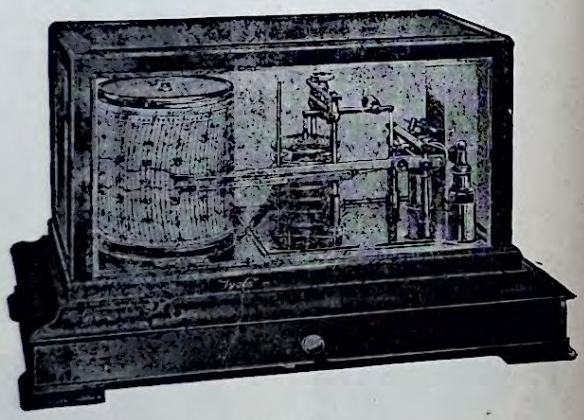
A 31-350.



A 31-360.



A 31-370.



A 31-380.

A 31-340. BAROMETER, Gee, boxwood scale in mm. with two sliding pointers, mounted on polished board with thermometer .. .. *r* 5 5 0

A 31-350. BAROMETER, Pediment, oak frame, xylonite scale and sliding vernier. Bold tube visible throughout its length. Fahrenheit thermometer. With screw for portability .. 4 15 0

A 31-360. BAROMETER, Syphon, mounted on polished oak board with reflectors. With scales in mm. etched on the tube .. .. *r* 6 0 0

A 31-370. BAROGRAPH, in oak or mahogany case $14\frac{1}{2} \times 8\frac{3}{4} \times 8$ in. high, with bevelled plate glass sides and top, on moulded base with front-opening drawer, with two compartments for used and unused charts. Gold-plated and lacquered eight-vacuum movement, compensated for temperature, set pen adjustment, pen throw-off device, and weekly clock drum. Complete with set of 52 charts and bottle of ink .. .. *t* 18 10 6

Accessories for A 31-370

A 31-370 a.	Barograph Charts	*box of 52*	*t* 0	6	9
„ „ b.	Barograph Ink, without dipper	*bottle*	0	2	2
„ „ c.	Barograph Pens	*each*	*t* 0	3	2

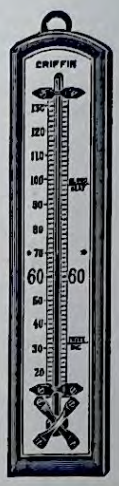
A 31-380. BAROGRAPH-THERMOGRAPH, recording on one chart. The barometer range is 28 to 31 in. ; the thermometer range 0 to 120° F. in 2° divisions. Inks of two colours are used so that records are kept distinct. In oak, walnut or mahogany case $14\frac{1}{2} \times 8\frac{3}{4} \times 8$ in. high, plate-glass sides and top, drawer with two compartments for used and unused charts. Gold-plated and lacquered high-grade movement compensated for temperature, with weekly clock drum, set of charts, and two bottles of ink .. *t* 21 9 0

The instrument can be supplied with metric charts without extra charge.
Unless otherwise ordered we supply oak case.

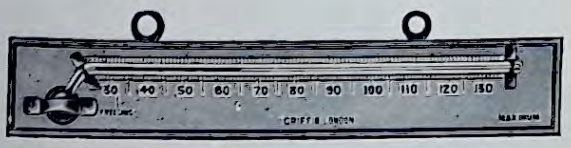
Accessories for A 31-380

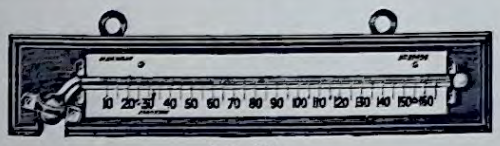
A 31-380 a.	Charts, double range, 28 to 31 in., and 0 to 120° F. × 2°	*box of 52*	*t* 0	9	0
„ „ b.	Pens	*each*	0	3	2

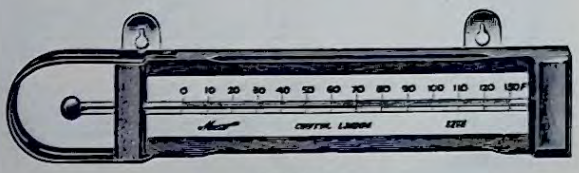

A 31-415.


A 31-420—425.


A 31-430.

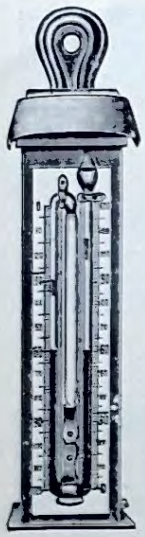

A 31-460.


A 31-480.


A 31-500.

	£	s.	d.
A 31-400. THERMOMETER, Wall, Fahr. scale, on boxwood mount, spirit filled, 8 in. long ..	0	3	0
A 31-405. Ditto, 10 in. long	0	4	6
A 31-415. THERMOMETER, Wall, Fahr. and Cent. scales, on boxwood mount, mercury filled, 8 in. long	0	7	0
A 31-420. THERMOMETER, Wall, Fahr. scale, on white xylonite, mounted on boxwood, lens front tube, mercury filled, 8 in. long	0	9	6
A 31-425. Ditto, blue spirit filled, very bold scale, 8 in. long	0	9	6
A 31-430. THERMOMETER, Wall, Fahr. and Cent. scales, on wide bevelled boxwood mount, best quality tube, mercury filled, 8 in. long	0	8	6
A 31-435. Ditto, 10 in. long	0	10	0
A 31-440. Ditto, on white porcelain, 10 in. long, for outdoor use to withstand exposure to the weather	0	12	6
A 31-460. THERMOMETER, Maximum Registering, mercury filled, enamelled back tube, mounted on graduated boxwood scale, approx. 8 in. long	0	8	0
A small constriction in the bore of tube, above the bulb, allows the mercury to pass when heat is received but does not allow the mercury to recede when cooling. To reset the thermometer, the mercury is returned to the bulb by gentle shaking.			
A 31-470. THERMOMETER, Minimum Registering, red spirit filled, enamelled back tube, with floating index, mounted on graduated boxwood scale, approx. 8 in. long	0	6	0
The index is so constructed that when the temperature falls the surface of the spirit draws the index with it, but on rising, the spirit alone ascends the tube, leaving the index at the lowest point to which it has been drawn. The thermometer is set by raising the bulb, allowing the index to return to the end of the column of spirit. When in use the thermometer must be mounted horizontally.			
A 31-480. THERMOMETER, Maximum Registering, Standard, mercury filled, enamelled back tube, with constricted bore, with opal glass scale on oak mount, approx. 11½ in. long *r*	1	15	0
A 31-490. THERMOMETER, Mininum Registering, Standard, spirit filled, enamelled back tube, with floating index, with opal glass scale on oak mount, approx. 11½ in. long .. *r*	1	15	0
A 31-500. THERMOMETER, Maximum Registering, Standard, mercury filled, engine divided tube, with constricted bore, mounted on opal glass scale in mahogany frame, approx. 14 in. long .. .. *r*	2	2	0
A 31-510. THERMOMETER, Minimum Registering, Standard, spirit filled, engine divided tube with floating index, mounted on opal glass scale in mahogany frame, approx. 14 in. long *r*	2	2	0
A 31-520. N.P.L. Certificates for A 31-480—510 .. .. *extra t*	0	5	4

THERMOMETERS, Maximum and Minimum Registering, Six's, enamelled back tubes with steel indices. Each thermometer supplied with magnet to be used when resetting indices. Range to 130° F.



A 31-600—610.

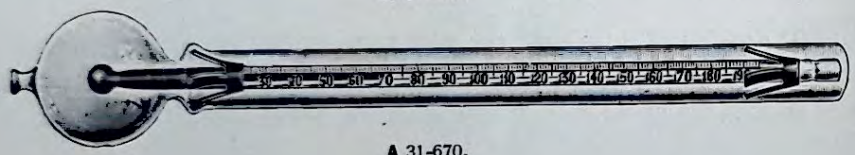
Cat. No.	Type	Length 8 in. £ s. d.	10 in. £ s. d.	12 in. £ s. d.
A 31-595	**Zinc Scale** with turned-up sides ..	0 14 0	0 18 6	—
A 31-600	**Boxwood Scale** in japanned tin case	0 12 6	0 17 0	—
A 31-605	**Engraved Zinc Scale** in japanned tin case	0 14 0	0 18 6	—
A 31-610	**Opal Glass Scale** in japanned tin case	—	—	1 10 0



A 31-650.

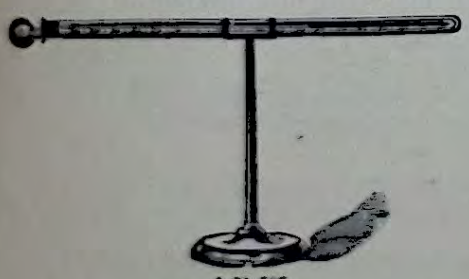


A 31-660.



A 31-670.

	£ s. d.
A 31-650. THERMOMETER, Terrestrial Minimum, with scale in sealed glass shield to protect from dew	*r* 1 17 6
A 31-655. N.P.L. Certificate, for above	*t* 0 4 8
A 31-660. THERMOMETER, Solar Radiation, with black bulb, to record the maximum temperature attained in the full rays of the sun	*r* 2 0 0
A 31-665. N.P.L. Certificate, for above	*t* 0 9 4
A 31-670. THERMOMETER, Solar Radiation, with black bulb and stem in vacuo	*r* 2 10 0
A 31-675. N.P.L. Certificate, for thermometer before it is mounted in vacuum jacket ..	*t* 0 9 4
A 31-680. N.P.L. Certificate of comparison with standard thermometer, or certificate giving corrections after testing the mounted thermometer in sunshine ..	*Price on application.*



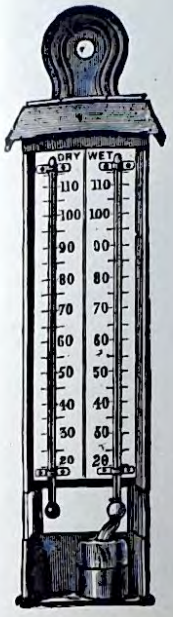
A 31-685.

A 31-685. Stand, brass, for thermometer **A 31-660. Without** thermometer .. .. .. *r* 0 17 6

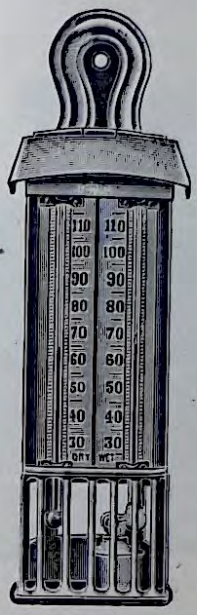
A 31-690. Ditto, for thermometer **A 31-670** .. *r* 0 17 6

A 31-695. THERMOMETERS, Earth, for ascertaining the temperature of the soil. Range 20° to 100° F. or — 5° to 40° C. Meteorological Office pattern, consisting of steel tube, 6 in. longer than the depth at which temperature is required, into which a thermometer is lowered by means of brass chain. The thermometer is enclosed in protecting glass shield with rubber shoe

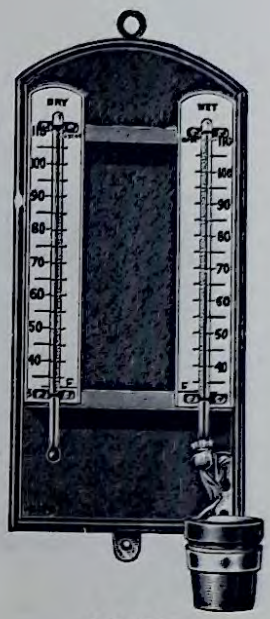
For temperatures	1 ft.	2 ft.	3 ft.	4 ft.	*below surface*
	£2 12 6	£2 15 0	£3 0 0	£3 10 0	*each*



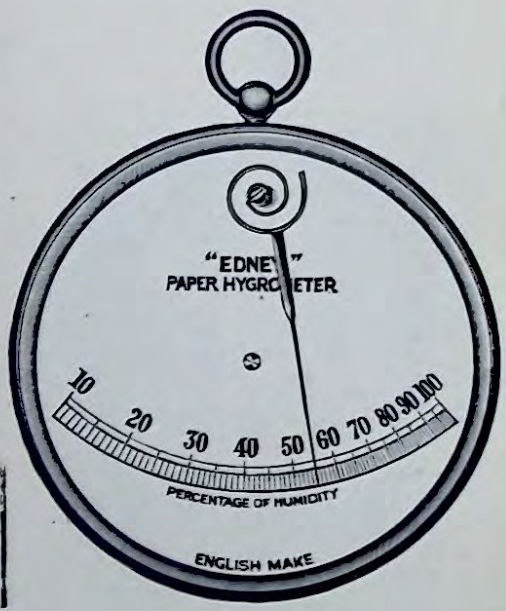
A 31-805.



A 31-810.



A 31-825.



A 31-875.

		£	s.	d.
A 31-805.	**HYGROMETER, Mason,** clear reading mercury tubes, engraved zinc scale, range approx. 30° to 120° F., in white japanned tin case, 10 in.	0	14	0
A 31-810.	**Ditto,** with hinged guard over thermometer bulbs	0	16	0
A 31-815.	**Ditto,** with opal glass scale	1	9	6
A 31-820.	**Ditto,** with opal glass scale and hinged guard over thermometer bulbs	1	12	0
A 31-825.	**HYGROMETER, Standard, Mason,** clear reading mercury tubes, approx. 7 in. long, divided on stem, mounted on porcelain scales range 10° to 130° F., with bold figures. Complete with copper water reservoir, enamelled inside, and mounted on polished mahogany board .. .. *p*	2	15	0
A 31-830.	**N.P.L. Test and Certificate,** for above .. .. *t*	0	8	0
A 31-850.	**PSYCHROMETRIC TABLES, Marvin** (U.S. Department of Agriculture, Weather Bureau), for obtaining the vapour pressure, relative humidity, and temperature of the dew point, from readings of the wet-and-dry-bulb thermometers .. .. .. *tx*	0	1	8

HYGROMETERS, Paper. Robust workshop and laboratory instruments in which the actuating element is a strip of a specially selected linen paper. The pointer movement is directly controlled by the linen paper element which is attached to a nickel-silver spring, and the absence of any intricate mechanism makes the instrument suitable for robust usage. The careful construction of the element allows the dial to be graduated in equally spaced divisions, the calibration being in percentage relative humidity.

A 31-875. HYGROMETERS, Paper, with enamelled metal dial, in chromium-plated brass case, with ring for suspension.

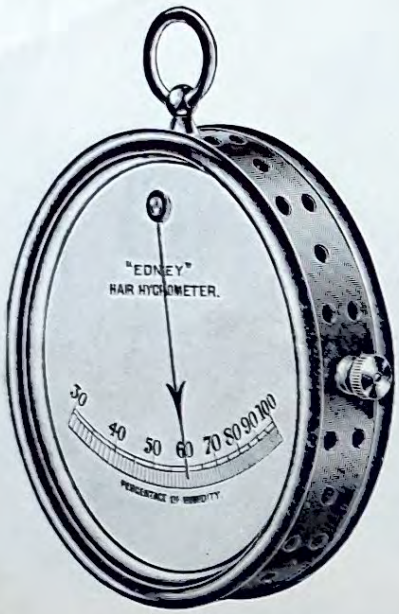
Diam. of dial	2	3	5	*in.*
r	£1 0 0	£1 7 6	£2 0 0	*each*

A 31-880. HYGROMETERS, Paper, with Thermometer, similar to above, with thermometer in tubular protective case fixed at top, with ring for suspension.

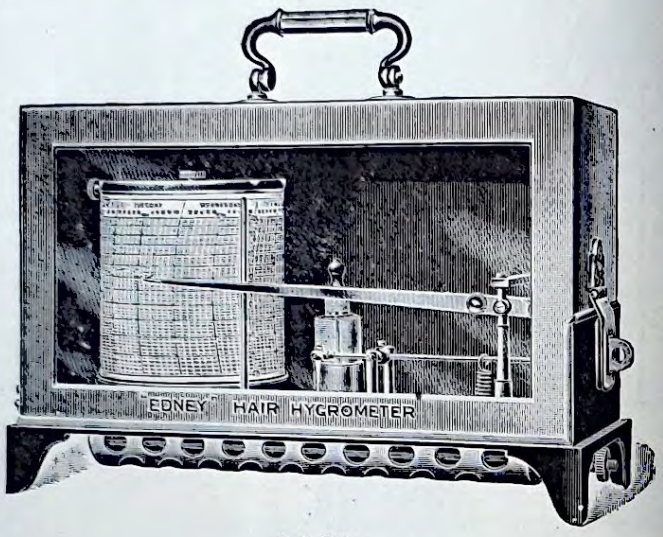
Diam. of dial	2	3	*in.*
r	£1 10 0	£2 2 6	*each*

A 31-885. THERMO-HYGROMETERS, Paper, similar to A 31-875, with auxiliary bimetallic thermometer element and scale.

Diam. of case	3	5	*in.*
r	£2 6 0	£3 5 0	*each*

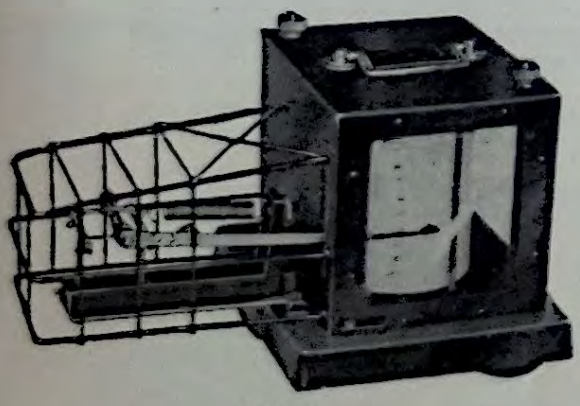


A 31-920.



A 31-940.

	£	s.	d.
A 31-920. HYGROMETER, Hair, reading in percentage relative humidity, with silvered metal dial, in chromium-plated case 5 in. diam., with adjusting screw and ring for suspension *r*	4	0	0
A 31-925. THERMO-HYGROMETER, Hair, 5 in. diam., similar to **A 31-920,** with auxiliary bimetallic thermometer element and scale .. .. *r*	6	0	0
A 31-940. HYGROGRAPH, Self Recording. The recording mechanism is actuated by a bundle of specially prepared hairs beneath the frame. The percentage of humidity of the atmosphere where test is taking place, is recorded directly on the chart. The clock drum revolves once in seven days. Strongly mounted on a cast iron base with hinged copper cover, overall dimensions 11 × 5 × 7½ in. Complete with supply of charts for one year, range 0–100 per cent. .. .. *r*	13	15	0
A 31-945. Hygrometer Charts .. .. *box of* 52 *r*	0	10	0



A 31-970.

A 31-970. THERMOGRAPH (Ambient Temperature Recorder). The conventional helix is replaced, in this recorder, by a pair of bimetallic strips supporting a floating differential roller to which the pen arm is attached. The drum is driven by a synchronous electric motor for use on 200–250 volts A.C. Mounted on cast iron base, sheet metal case with windows and carrying handle. 24 hour record .. .. *tx* | 12 | 10 | 0

A 31-972. Ditto, 7 day record .. .. *tx* | 12 | 10 | 0

A 31-975 Charts, for above, set of 50, range 0 to 45° C.

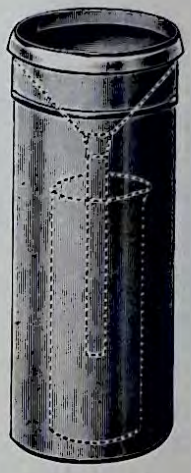
24 *hour, tx* **10/-** ; 7 *day* | 0 | 10 | 0

A 31-980. Ditto, range 20 to 110° F.

24 *hour, tx* **10/-** ; 7 *day* | 0 | 10 | 0



A 32-250.



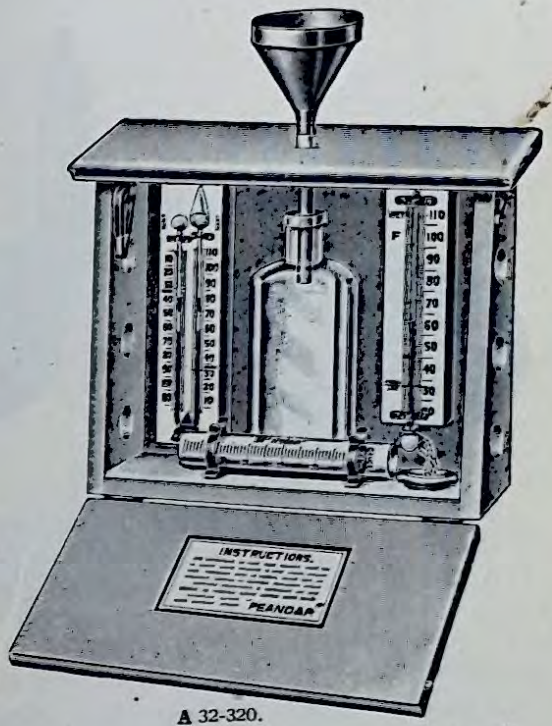
A 32-260—265.



A 32-280.



A 32-290.



A 32-320.

	£	s.	d.
A 32-250. RAIN GAUGE, Howard, japanned tin funnel, 5 in. diam., with brass rim, glass bottle and graduated glass measure	0	15	0
A 32-255. Ditto, with copper funnel, 5 in. diam. with accurately turned brass rim, ...	1	0	0
A 32-260. RAIN GAUGE, Symons, japanned tin, with 5 in. brass rim and graduated measure	1	1	0
A 32-265. Ditto, copper	1	10	0

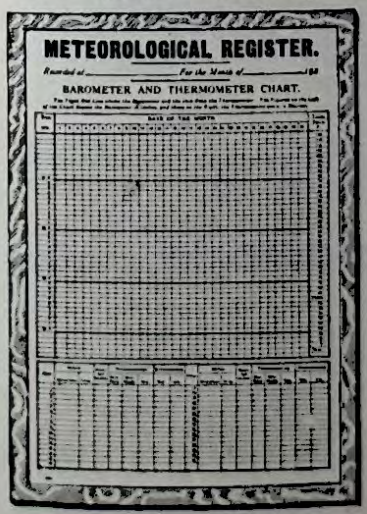
A 32-280. RAIN GAUGE MEASURES, holding 0·5 inch, graduated in 0·01 in.

For funnel	5	8 *in.*
	5/-	6/6 *each*
A 32-285. Ditto, holding 1 inch, graduated in 0·01 in.	9/-	13/6 *each*

A 32-290. RAIN GAUGE MEASURES, Standard Camden Pattern, holding 0·5 inch, reading to 0·005 in.

For funnel	5	8 *in.*
	p 15/-	18/6 *each*

A 32-320. METEOROLOGICAL SET, Students'. The set includes rain gauge of stout polished copper 3 in. diam., glass receiving bottle holding up to 2½ in., measure capacity 0·5 in. graduated in 0·01 in., maximum and minimum thermometer mounted on milk-glass scale including magnet for resetting, and a wet bulb thermometer also mounted on milk-glass scale. The screen is of hardwood painted white with hinged front and ventilated sides. It can readily be attached to a post by two screws passing through the back of the screen. With register to record readings for 12 months .. .. *r* 3 15 0

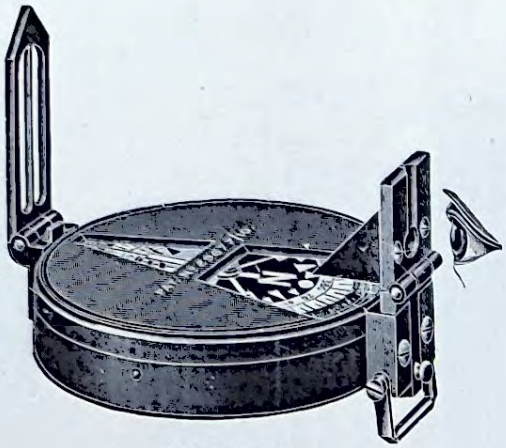


A 32-385—390.

A 32-380. METEOROLOGICAL CHARTS, 10 × 5½ in., for recording thermometer and barometer readings, direction of wind, and rainfall. Pad of 12 monthly charts, with pencil .. .. (*a*)	0	2	6
A 32-385. METEOROLOGICAL CHARTS, 12 × 8 in., for recording barometer, thermometer (solar, maximum shade and minimum), humidity (wet and dry thermometer), rainfall, direction and velocity of wind. Twelve monthly charts in containing case	0	4	0
A 32-390. Charts only as A 32-385 .. .. .. *dozen*	0	3	0



A 32-605.



A 32-610—615.



A 32-650.

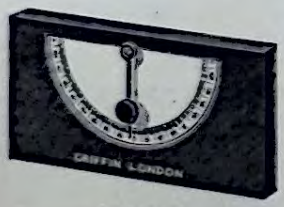
	£	s.	d.
A 32-605. COMPASS, Prismatic, card dial 3 in. diam., jewelled centre, in circular wood case, with sights .. .. *p*	1	15	0
A 32-610. COMPASS, Prismatic, Hutchinson's form, 3 in. diam., with opening in cover, aluminium dial with transparent edge illuminated by radium compound underneath, so that divisions can easily be read at night. In sling leather case .. .. *p*	6	6	0
A 32-615. Ditto, card dial, without radium. In sling leather case .. .. *p*	4	10	0
A 32-650. MODEL THEODOLITE, Potter. Complete with stand in strong deal carrying case *t*	5	5	0

The model is made of seasoned mahogany with circle of hard white celluloid 6 in. diam. engine divided to 1°. The telescope, magnifying about 4 diams., is fitted with fixed diaphragm and cross wires. Both object glass and eyepiece can be focussed. A spirit level with graduated tube in brass case, and a trough compass are fitted to the frame.

A 32-660. Plane Table, 16 × 11½ in., with sighting rule 11½ in. long, which can be fitted to the stand of **A 32-650** on removal of theodolite .. .. *t*	0	15	0



A 32-705.



A 32-710.

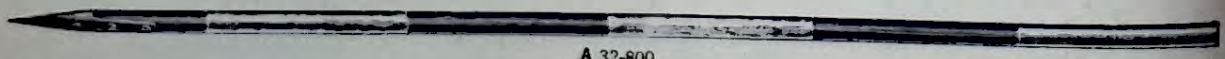


A 32-820.



A 32-825.

	£	s.	d.
A 32-705. SIGHTING RULE, boxwood, 15 ins. long, with bronzed brass sights. The rule is bevelled along one edge and divided every $\frac{1}{10}$ in. With T-pattern level	1	5	0
A 32-710. CLINOMETER, simple form, with paper scale on wood block with plumb line ..	0	12	6

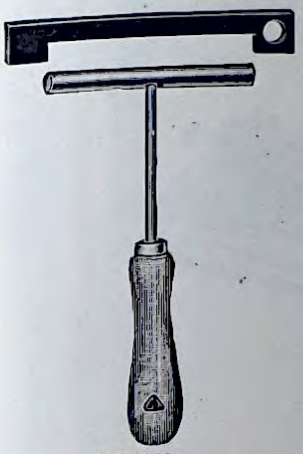


A 32-800.

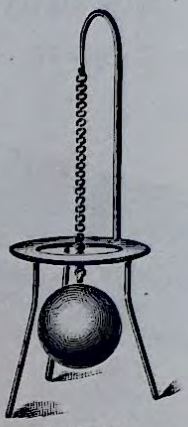
A 32-800. RANGING POLES, 6 ft., painted red, white and black, in feet. End fitted with steel point .. .. *each*	0	10	6
A 32-820. LAND CHAIN, Surveyor's, 4 poles, best galvanized iron wire, No. 8 S.W.G., with 3 oval rings, brass swivel handles, divided into links and tallied every 10 links .. *p*	1	10	0
A 32-825. ARROWS, No. 7 S.W.G., galvanized iron wire, 15 in. long .. .. *set of* 10 *p*	0	4	0

Tape Measures, see page 3.

Heat



A 41-120.



A 41-130.

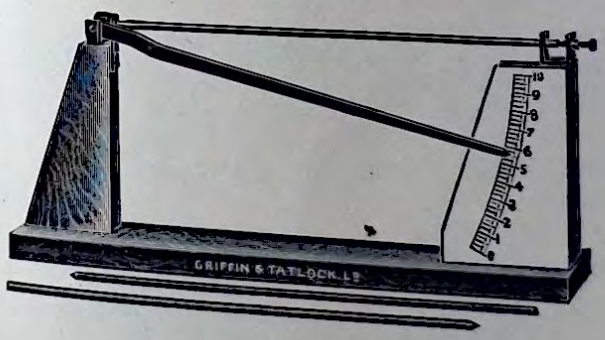


A 41-135.



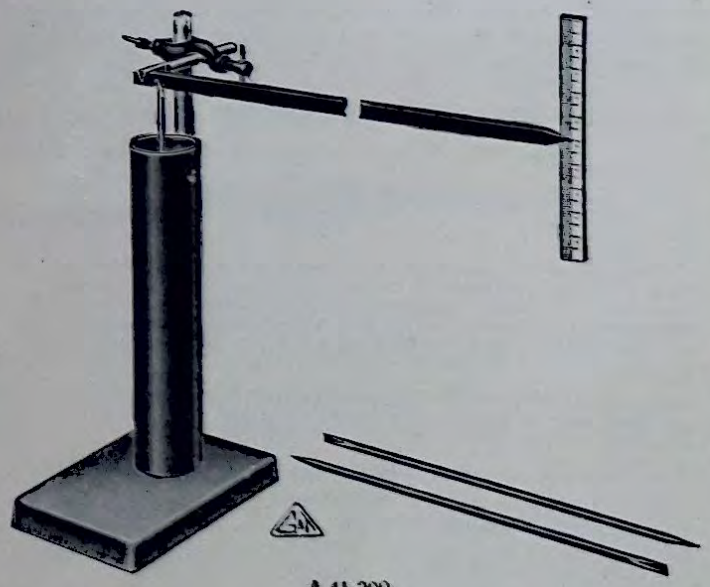
A 41-150—155.

	£	s.	d.
A 41-120. BAR AND GAUGE, Iron, 5 in., to show that on heating the bar expands, both in length and diameter and ceases to enter the gap and hole respectively of the gauge ..	0	7	6
A 41-130. RING AND BALL, Gravesande, brass, with 1 in. ball; on tripod	0	10	6
A 41-135. Ditto, with wood handle and 1 in. ball	0	6	6
A 41-150. EXPANSION AND CONTRACTION APPARATUS for breaking a bar of iron ¼ in. diam., by the contraction or expansion of another bar 9 in. long. With twelve short cast iron bars 2 × ¼ in.	1	2	6
A 41-155. Iron Bars, for use with above .. .. *dozen*	0	1	6



A 41-190.

A 41-190. EXPANSION APPARATUS, Ferguson, hardwood stand, 18 in. long, metal index needle, paper scale, and with one each rods of iron, brass, and copper, 15 in. long. The expanding rod presses on one face of a pivoted metal block causing it to tilt and rotate the pointer attached to it **2 10 0**



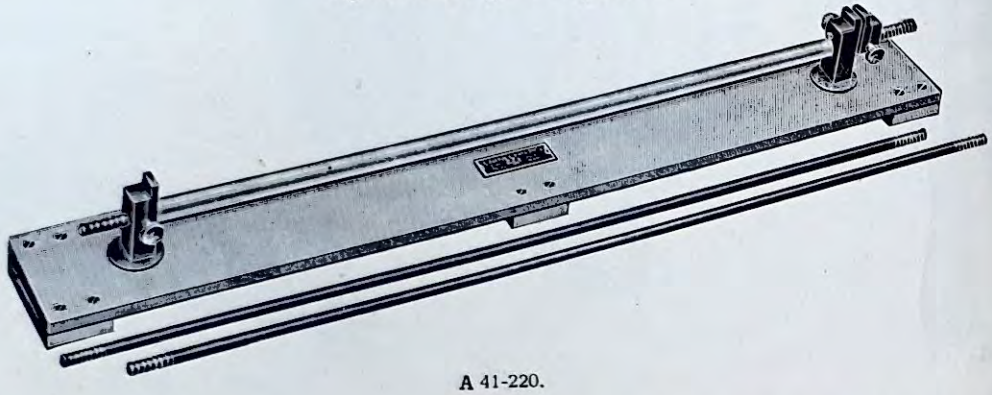
A 41-200.

	£	s.	d.
A 41-200. EXPANSION APPARATUS (Sinclair: *Second Year's Course in Practical Physics*, p. 32). Brass hot water cylinder 25 × 5 cm. with fulcrum, wood pointer about 1 metre long, and one each metal rods:—copper, brass and iron. **Without** rule, stand and bosshead ..	1	4	0

THE MICROID MICROMETER EXPANSION APPARATUS

A new design combining simplicity and accuracy

Registered Design No. 768608.



A 41-220.

The apparatus is extremely simple and accurate. The expanding element carries a movable block, the movement of which relative to a stationary block is measured directly and precisely by a micrometer screw gauge.

SPECIFICATION.

The base is of rigid material, having a negligible coefficient of expansion, and carries two pillars about 50 cm. apart. The expanding elements are metal tubes about 1 cm. diam. × 60 cm. long, riffled at both ends for rubber tubing connections. An asbestos tube is slipped over the tubes to minimise condensation therein.

The left hand pillar is provided with a screw for clamping one end of a tube (see illustration).

The right hand pillar is made in two parts:—

(*a*) A part firmly fixed to the base and through which the expanding tube passes freely. It contains a second hole, radially to which a clamping screw is fitted.

(*b*) A part which should be clamped to the expanding tube. It is provided with a small pin, fitting into the second hole in (*a*). The two parts may be clamped together by means of the pin and screw. When in use the distance of separation of these parts (*a* and *b*) is increased by the amount of the expansion which is measured directly with a screw gauge.

A 41-220. MICROID MICROMETER EXPANSION APPARATUS, on base, with pillars, one each iron, copper and brass tubes and asbestos sleeve .. .. £ 2 10 0

EXPERIMENTAL NOTES

Simple expansion apparatus may conveniently be classified as direct and indirect reading types. The former are generally inaccurate. The latter, involving the use of somewhat complicated multiplying or similar devices, are unsuitable for elementary students. The new direct-reading model here offered is both simple and accurate.

The essential feature is the juxtaposition of the parts of the right hand pillar, one of which is fixed to the base and the other to the expanding member.

The method of operation is as follows:—

(1) Insert the tube through the left-hand pillar, asbestos sleeve and the parts of the right-hand pillar.

(2) Close up the parts of the right-hand pillar and screw up the three clamping screws.

(3) Measure length of tube between marks engraved on pillars (an error of 1 mm. in this measurement introduces an error of only 0·2 per cent. in the final result).

(4) Measure with a micrometer screw gauge the distance between the two plane faces at the top of the right-hand pillar.

(5) Loosen the screw holding the parts of the right-hand pillar together.

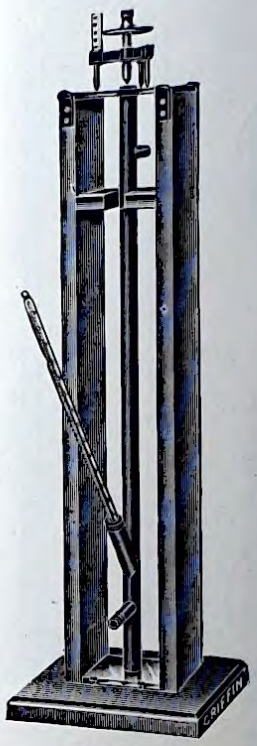
(6) Insert a thermometer into the tube and measure the temperature of the tube.

(7) Pass a current of steam through the tube.

(8) Tighten the screw in (5) and measure the new distance between the plane faces on the right-hand pillar. The difference between this reading and that obtained in (4) gives directly the amount of expansion.

(9) Unscrew the clamping screw and disconnect the steam supply.

MICROMETER SCREW GAUGES, 25 mm., for use with above, see A 13-750, page 10.



A 41-240—250.



A 41-260—265.



A 41-280.

	£	s.	d.
A 41-240. EXPANSION APPARATUS, Pullinger, brass tube, 50 cm. long, with inlet, outlet and thermometer tubes, on stand. **Without** thermometer and spherometer	2	10	0

A 41-245. Tubes, 50 cm. long, for above.

Brass	Copper	Iron	Aluminium	
14/-	15/-	12/-	17/6	*each*

A 41-250. Glass Plates, spare, with hole in centre, for above *each*	0	6	0

A 41-260. EXPANSION APPARATUS. Brass tube 49 cm. long, with riffled steam inlet and outlet, supported by insulated end-castings, between two brass tubes with riffled ends for connection to cold water supply. Amount of expansion of centre tube is measured by spherometer reading to 0·001 mm. mounted on end-casting. Terminals on centre tube and end-casting for connection to electrical circuit indicate electrically the moment of contact between end of centre tube and point of spherometer .. .. *p* 3 15 0

A 41-265. Tubes, additional, for above.

Brass	Copper	Iron	
10/-	10/-	10/-	*each*

A 41-280. EXPANSION OF CRYSTALS APPARATUS (Noakes: *Text-Book of Heat*, pp. 88–90; Edser: *Heat*, pp. 60–61), for determining the coefficients of linear expansion of a crystal. Circular metal table 1½ in. diam., supported on three levelling screws, on the upper projecting extremities of which rests a small plate of optically worked glass. **Without** crystal .. .. *r* 1 5 0



A 41-300.



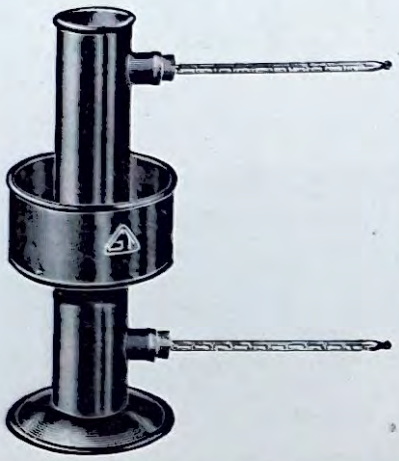
A 41-310.

	£	s.	d.
A 41-300. UNEQUAL EXPANSION PLATES, Brass and Iron, 14 × 1½ in., riveted together from **end to end** to show the curvature resulting from the unequal expansion of the plates when heated. With handle	0	11	6
A 41-310. Ditto, Copper and Iron, 10 × 1¼ in., riveted together, **at the ends only**	0	9	6
A 41-320. BIMETALLIC STRIP, Brass Invar, piece about 6 × 1 in. × 20 s.w.g., to demonstrate curvature on heating (Typical application see **A 41-420**)	0	2	6

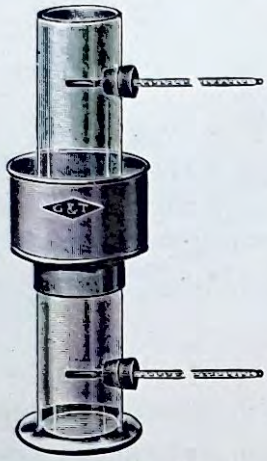
The General Index at the end of this Catalogue is a complete guide to its contents. Please consult it.



A 41-420.



A 41-700 + 715.



A 41-710 + 715.



A 41-730.



A 41-760.



A 41-770—775.



A 41-790.

	£	s.	d.
A 41-420. THERMOSTAT, Bimetallic, for operation on gas supply, with adjustable screw valve, and connections to gas supply and burner. Overall length 5½ in.	1	5	0

Demonstrates a commercial application of the principle of the unequal expansion of different metals. Unscrew thermostat valve, connect up to gas supply and burner, place V-shaped bars in beaker of water, turn on gas and allow water to attain the temperature at which it is desired to control it; screw down thermostat valve until Bunsen flame is just at by-pass height. As water cools the bars diverge, valve opens, Bunsen flame is raised and the water temperature restored. The process is continuous.

	£	s.	d.
A 41-700. HOPE'S APPARATUS, japanned sheet iron, about 12 in. high × 2 in. diam., for determining the temperature corresponding to the maximum density of water. **Without** thermometers	0	12	6
A 41-710. Ditto, with glass cylinder and brass ice trough. **Without** thermometers	0	19	6
A 41-715. Thermometers, for above, range — 15 to 40° C. in 1° .. .. .. *each*	0	9	6
A 41-730. WEIGHTED GLASS BULB (Noakes: *Text-Book of Heat*, p. 107), about 2 in. diam., to sink in cold water for determination of density or expansion of a liquid	0	1	9
A 41-760. DILATOMETER BOTTLE, for determining the coefficient of expansion of a liquid *dozen*	0	10	6
A 41-770. CAPILLARY TUBES, Graduated, 20 cm. long, about 1 mm. bore, graduated into mm., **without** bulbs .. .. *each*	0	3	0

These tubes with the bulbs mentioned below, into which they are fitted with a piece of thin-walled rubber tubing, make an excellent laboratory apparatus for experiments on the expansion of liquids.

A 41-775. Glass bulbs, for above, about 3 ml. capacity .. .. *dozen*	0	3	6
A 41-790. DILATOMETER, Direct Reading, Pyrex. Flask with capillary tube; capacity of flask up to zero, 10 ml. Capillary tube graduated 0-1 ml. in 0·01 ml. *each* 5/-; *dozen*	2	14	6

The flask is filled to the zero mark from a burette, to the jet of which is attached a length of fine bore capillary tubing. The increase in volume of the liquid in ml. is directly read at different temperatures using a water bath.

Leaflets on new apparatus supplementary to this catalogue are frequently published.

Names added to our Mailing List on request.



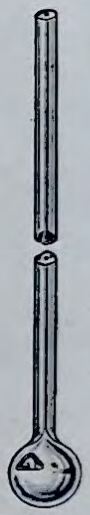
A 41-850—855.



A 41-870—875.



A 41-900—905.



A 41-920.



A 41-925.

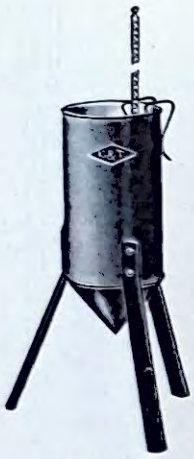
	£	s.	d.
A 41-850. EXPANSION OF WATER (Gregory & Hadley, *A Class-Book of Physics*, Part III). Apparatus for observation of the changes in volume near the temperature of maximum density. Glass tube with a cylindrical bulb, one-seventh part of which is occupied by mercury and remainder by distilled water. With scale and mercury	0	7	6
A 41-855. Glass Tubes, empty, for above. **Without** scale .. .. *dozen*	0	19	6
A 41-870. EXPANSION OF LIQUIDS. Apparatus to show the difference in expansion of different liquids over the same temperature range. Six glass bulbs with stems 32 cm. long, about 2 mm. bore, are mounted in a japanned tin trough. The stems are visible against a varnished paper scale attached to the vertical support. Suitable liquids with various coefficients of expansion are mercury, water, turpentine, alcohol, aniline and toluene. The rise of temperature may be obtained by pouring hot water into the trough ..	2	12	6
A 41-875. Glass Bulbs for above .. .. *dozen*	0	19	6
A 41-900. THERMOMETER TUBES, mercury filled, ungraduated, 7 in. long, to cover the range 0–100° C. .. .. *dozen*	1	10	0
A 41-905. Ditto, spirit filled, to cover the range 0–100° C. .. .. *dozen*	0	8	6

THERMOMETER TUBES, empty.

Length of stem	29	45	*cm.*
Bulb diam.	1·5	3·5	*cm.*
A 41-920. Without filling funnels	**5/6**	**7/-**	*dozen*
A 41-925. With filling funnels	**7/6**	**10/6**	*dozen*

£ s. d.

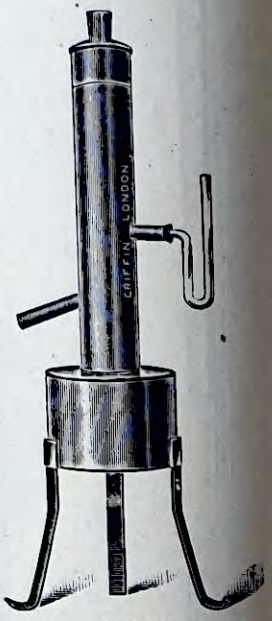
A 41-950. ICE PAIL, copper, 8 in. high, $2\frac{3}{4}$ in. diam., overall height 12 in., for determining the lower fixed point of a thermometer. With Griffin beaker clip. **Without** thermometer **0 15 0**



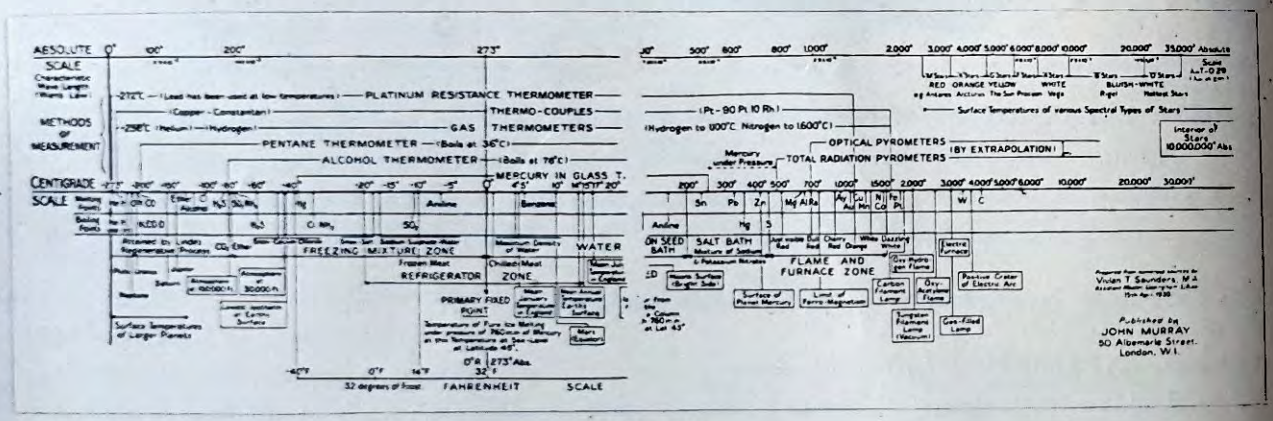
A 41-950.

A 41-960. HYPSOMETER, Regnault (Allen and Moore: *Text-Book of Practical Physics*, p. 318; Friend: *Text-Book of Physical Chemistry*, Vol. I, p. 79). Used for ascertaining the upper fixed points of thermometers, the apparatus may also be employed for determining boiling points at barometric pressures other than normal. Since for every 1000 ft. (≑ 27 mm. Hg) increase in altitude the boiling point of water falls approximately 1° C., heights above sea level may be estimated by utilising the hypsometer.

Copper boiler with double-walled steam jacket, thermometer tubulure at the top, side outlet tube and manometer; 15 in. high, on detachable legs. **Without** thermometer **1 10 0**



A 41-960.



A 41-980—990.

TEMPERATURE CHART by V. T. Saunders, M.A. Designed to show the methods by which temperatures at different zones in the whole range from 0° Abs. to 4000° Abs. are attained and measured. Particular attention has been given to displaying the overlap between the various thermometric procedures. Melting points and boiling points of the more common elements and compounds are shown, and meteorological and astronomical data are included. Size 78 × 26 in.

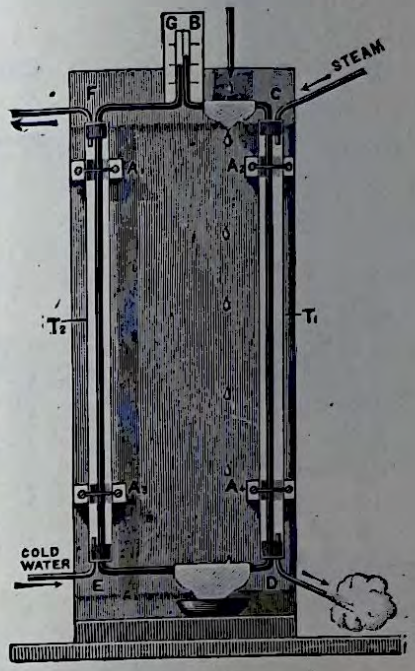
£ s. d.

A 41-980. Chart, unmounted, and packed in cardboard roll .. .. *l* 0 5 6

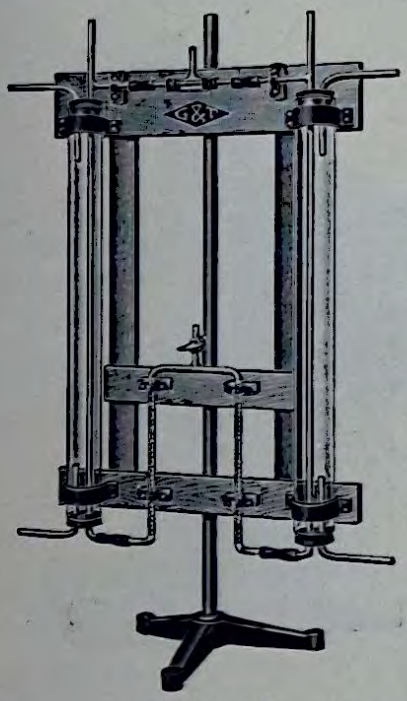
A 41-985. Ditto, mounted on strong white linen, packed in cardboard roll .. .. .. *l* 0 9 6

A 41-990. Ditto, mounted on linen, varnished, on rollers .. .. *l* 0 15 6

If the apparatus you require is not found in this catalogue, please write to us for quotations and specifications.



A 42-120.



A 42-130—140.

£ s. d.

A 42-120. ABSOLUTE EXPANSION OF MERCURY (Edser: *Heat*, fig. 37; Yarwood: *Inter. Pract. Physics*, p. 64). A glass tube having two vertical limbs, each about 18 in. long, one being surrounded by a steam jacket and the other by a cold water jacket. Mercury is contained in the tube. The relative densities of mercury at the two temperatures of the jackets is found from measurement of the difference in level on the scale provided, and the coefficient of expansion may therefrom be calculated. Mounted similarly to **A 42-130** (not as illustrated) **6 10 0**

£ s. d.

A 42-130. ABSOLUTE EXPANSION OF A LIQUID, Regnault Apparatus (Edser: *Heat for Advanced Students*, p. 77). The expansion is deduced by observing the difference in level of the balancing columns in the graduated limbs of the inverted U-tube. Before starting the experiment a small quantity of air is forced into the latter, until the liquid in the graduated tubes stands at convenient heights *r* **7 10 0**

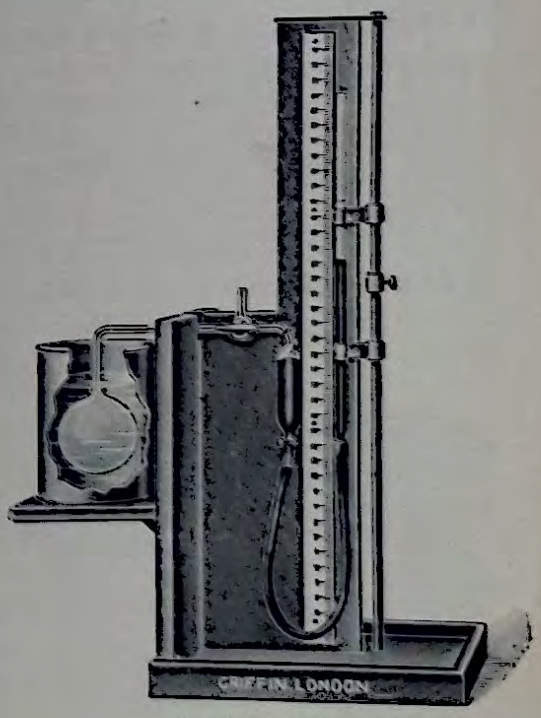
A 42-135. Graduated U-Tube, with stopcock for above .. .. *r* **0 16 0**

A 42-140. Glass Jackets for above .. .. *each* **0 6 0**

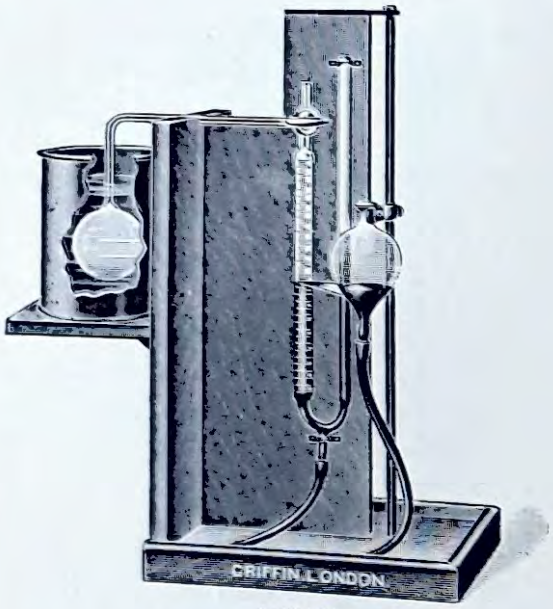
A 42-160. AIR THERMOMETER, Constant Volume (Noakes: *Text-Book of Heat*, p. 12), with 3-way stopcock for filling with dry air, and zero index fused into the top of the mercury tube **5 10 0**

The base of the stand is made in the form of a mercury tray, and a removable shelf is provided for supporting the copper pot in which the bulb is immersed. The manometer tube has a sufficient range for expansion of air over 100° C.

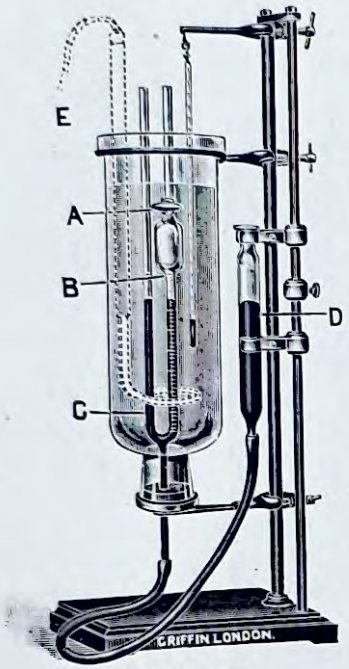
A 42-165. Bulb, Constant Volume, spare, for above, with 3-way stopcock and zero index fused into top of mercury tube **2 15 0**



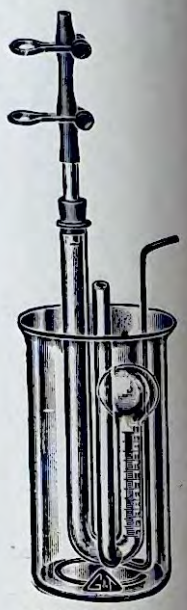
A 42-160—165.



A 42-190.



A 42-210—220.



A 42-240—250.

	£	s.	d.
A 42-190. AIR THERMOMETER, Constant Pressure (**Charles's Law**), with 3-way stopcock for admitting or removing air, rubber tube connection to air bulb, and graduated tube for measuring the expansion at air temperature	5	10	0

The capacity of the graduated limb is sufficient to measure the expansion of air over 100° C. The base of the stand is made in the form of a mercury tray, and a removable shelf is provided for supporting the copper pot in which the bulb is immersed. This apparatus, although satisfactory for elementary work and capable of giving good results, is yet inherently subject to an error of the " exposed stem " type. For accurate work, the apparatus **A 42-210** should therefore be specified.

A 42-195. Air Bulb, spare, for connection by rubber tube to **A 42-190**	0	3	0
A 42-210. AIR THERMOMETER, Constant Pressure (**Charles's Law**) (Edser: *Heat*, p. 96), accurate form. **Without** thermometer and electric heater E .. .. *r*	6	0	0
A 42-215. Tube, C, graduated, spare, for **A 42-210**	1	2	6
A 42-220. Electric Heater, for above, as shown dotted in illustration (E), with the heating end bent into loop, for voltages 100/120, 200/220 or 230/250 .. .. *r*	1	15	0

Please state voltage when ordering.

The graduated tube for measuring the expansion of the air is totally immersed in the same vessel as the air bulb, thus eliminating the type of error to which apparatus **A 42-190** is subject.

Dry air is introduced into the bulb AB, the capacity of which (about 20 ml. at 0° C.) is marked on the glass. The expansion of the air below B is read off on the graduated tube BC. The stopcock, which is immersed in water, must be lubricated with a little rubber grease. The height of the mercury in the manometer is regulated by raising or lowering the mercury reservoir D.

A 42-240. MICROID CHARLES'S LAW APPARATUS. A constant pressure apparatus of novel design with simple method of pressure adjustment. U-tube with short limb terminating in a bulb and graduated from 25–35 ml. in 0·2 ml., reservoir limb 22·5 cm. long, carrying rubber stopper fitted with short rubber tube having two clips and narrow levelling tube 18·5 cm. long fused on. Tall form Pyrex beaker 800 ml. capacity. Brass ring stirrer *r*	1	8	0
A 42-245. Cover, wood, for above. To facilitate storage of the filled apparatus. Two wood semi-circles, one cut away to accommodate levelling tubes and stirrer. Enables apparatus to be put away in its beaker and kept vertically .. .. *r*	0	3	9

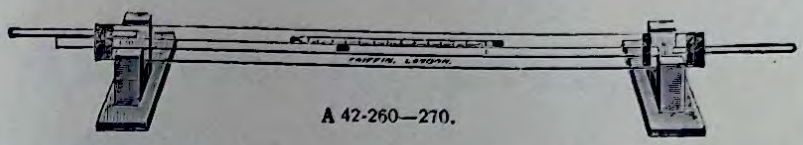
Method of Use.—In order to obtain good results the gas sample must be thoroughly dried. Fill the bulb with the gas. By manipulation of the apparatus introduce mercury (about 30 ml.) into the three tubes to about the 25 ml. mark on the graduated scale when the gas is at atmospheric pressure. Care should be taken that the stopper is an airtight fit and that the clips are functioning properly.

To lower level in levelling tube, open upper clip and pinch rubber tube flat. Close upper clip. Open lower clip momentarily. Repeat as necessary. To raise level, reverse the process. Errors due to slight differences of level are small.

To find the Coefficient of Expansion of a Gas at Constant Pressure.—Clamp apparatus so that it rests on the bottom of the beaker and bulb is covered with water. Stir. Read temperature after 2 mins. by means of thermometer 0–110° C. in 1° C. Bring mercury in graduated and levelling tubes to same level. Read volume. Heat water gently. Repeat temperature and volume readings at intervals of 10° C. till boiling, adjusting mercury levels each time. Remove clips before allowing to cool.

Plot a volume-temperature graph with 0° C. as origin. The slope of the mean straight line through the points plotted is the increase of volume of the gas per degree C. This divided by the volume at 0° C. gives the coefficient of expansion.

Sulphuric acid may be used instead of mercury and ensures dryness, but its use is liable to cause accidents in the event of breakage of the apparatus during an experiment.



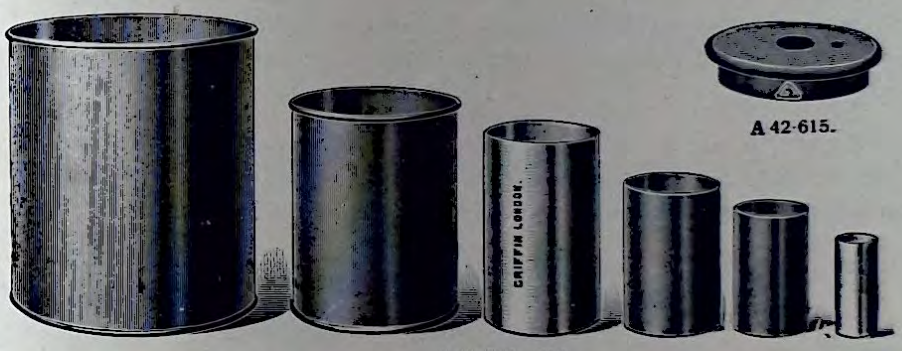
A 42-260—270.

£ s. d.

A 42-260. **CHARLES'S LAW APPARATUS** (Robson: *Heat*, fig. 32), mounted on wood supports. A wide glass tube forms a steam jacket round an inner tube about 70 cm. long, of uniform bore, and closed at one end. After passing steam the expansion of air in the inner tube is found from the alteration in position of a pellet of mercury, the temperature being noted from a thermometer attached to the tube. **Without** thermometer and mercury plug 1 0 0

A 42-265. **Jackets, spare,** glass, for above .. .. *each* 0 5 0

A 42-270. **Tubes, Inner, spare,** glass .. .. *each* 0 2 6



A 42-600—610.

A 42-615.



A 42-635.

CALORIMETERS, Metal, best quality, smoothly finished. Covers have hole for thermometer and for stirrer.

Height × diam.	2 × ¾	2½ × 1½	3 × 1½	3 × 2	4 × 2½	4 × 3	4 × 3½	6 × 5	*in.*
A 42-600. **Spun Copper** ..	—	1/6	1/8	1/10	2/6	2/9	3/-	15/-	*each*
A 42-605. **Spun Aluminium**	1/6	—	—	2/-	3/-	—	—	—	*each*
A 42-610. **Tin, Soldered** ..	—	—	—	—	—	—	1/6	2/6	*each*
A 42-615. **Covers,** wood ..	—	—	—	2/-	—	—	2/6	—	*each*

£ s. d.

A 42-630. **CALORIMETER, Spun Copper,** 2½ × 1½ in., suspended in a copper vessel 4 × 3½ in. 0 7 6

A 42-635. **CALORIMETER, Spun Copper,** 3 × 2 in., suspended in copper vessel 4 × 3½ in., fitted with support for thermometer. With stirrer but **without** thermometer 0 10 0

A 42-670. **CALORIMETERS, Thick Metal** (*Science Masters' Book*, Part 1, p. 42), for determining specific heats. Approx. 4 × 2 in., walls ¼ in. thick.

£ s. d.

Iron.	Brass.	Copper.	Aluminium.	
r 7/6	10/-	12/-	16/-	*each*

A 42-675. **Covers, felt,** for above .. .. *each* r 0 3 9

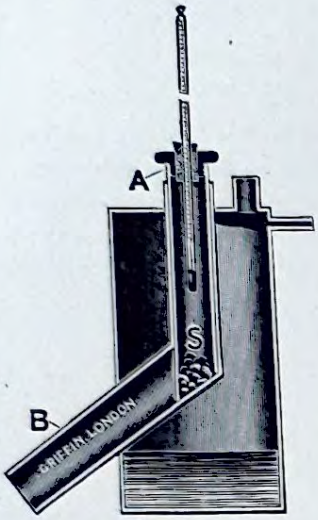
Since the thermal capacity is large, boiling water poured into a thick calorimeter drops considerably in temperature, and the final temperature is steady for some little time, thus making the reading a simple matter. Weighing to the nearest gramme is all that is required. The specific heat of the metal is obtained by a simple calculation. **See also Latent Heat Apparatus, A 43-320, page 112.**



A 42-670—675.



A 42-710.



A 42-720.



A 42-750.



A 42-760.



A 42-825.

£ s. d.

A 42-710. HEATER, Steam, Copper, body about 8 in. high, diam. $3\frac{1}{2}$ in., with handle, filling tube and steam escape tube. The heater should be inclined until the handle is horizontal, then quickly inverted. The heated substance drops into the calorimeter without loss of heat or spillage of water **0 12 6**

A 42-720. HEATER, Steam, Copper, about 8 in. high × 4 in. diam., with brass sliding tube fitted with ebonite top for holding thermometer. On raising the tube A the heated substance S falls through the chute B directly into the calorimeter **1 8 6**

A 42-750. GENERATORS, Steam, tinned iron, fitted with cork and bent glass tube. Capacity 2 litres .. .. *each* **1/8** ; *dozen* **0 17 6**

GENERATORS, Steam, Copper.

Capacity	1	2	3 *litres*
A 42-760. With water gauge and side tube	**17/6**	**20/-**	**25/-** *each*
A 42-765. Without water gauge and side tube ..	**13/6**	**15/-**	**21/-** *each*

A 42-800. METALS, for Specific Heat Experiments, rivets.

Iron.	Copper.	Brass.	Aluminium.	Lead (pellets).
1/6	**3/-**	**3/6**	**6/-**	**2/6** *lb.*

A 42-810. CYLINDERS, Metal, $1\frac{1}{2} \times \frac{5}{8}$ in., with hole drilled through top for suspending.

	Iron.	Copper.	Brass.	Lead.	Aluminium.	
	1/6	**2/-**	**1/6**	**2/6**	**2/-**	*each*
A 42-815. Ditto, 100 grams.	**2/6**	**2/6**	**2/6**	**4/-**	**2/6**	*each*

A 42-825. CYLINDERS, Metal, Set of four, lead, copper, iron and aluminium, of equal mass, 100 grams, in wood block, for specific heat experiments. With holes drilled through the top **0 18 6**

Griffin and Tatlock Limited are complete Laboratory outfitters and design and manufacture Laboratory Furniture and Apparatus of the most varied character.

THE MICROID APPARATUS FOR NEWTON'S LAW OF COOLING

A very simple highly effective design

Registered Design No. 769143.

This apparatus incorporates another application of the Solid Block Calorimeter as in the MICROID Mechanical Equivalent of Heat Apparatus. It serves not only for the demonstration of Newton's Law, but for comparative measurement of Specific Heat and for the comparative emissivity of bright and black surfaces.

SPECIFICATION

The apparatus consists of two cylinders, one of aluminium and one of copper, about $2\frac{1}{2}$ in. long × $\frac{5}{8}$ in. diam., each with a hole to take a thermometer, and a metal sleeve which is made to fit freely over either of them.

PRICES

	£ s. d.
A 42-850. MICROID NEWTON'S LAW OF COOLING APPARATUS, one each aluminium and copper cylinders, and metal sleeve to fit. **Without** thermometer .. .. *set* r 6/6 ; *dozen*	3 10 0
A 42-855. Aluminium Cylinder, only for above .. .. r	0 2 6
A 42-860. Copper Cylinder only, for above .. .. r	0 2 6
A 42-865. Metal Sleeve only, for above .. .. r	0 1 6
Thermometer, for above, range 0 to 150° C. in 1°.	See **B 47-635.**



A 42-850—865.

EXPERIMENTAL NOTES

For demonstration of **Newton's Law** either of the two cylinders is used. The thermometer should read to not less than 150° C. It may be held horizontally in a clamp, and will be strong enough to carry the cylinder placed over its bulb. Various methods may be used to heat the cylinder. A candle not only heats at a suitably slow rate but may be used for blackening the surface at the same time. A convenient temperature at which to start observations is 140° C. This being considerably above room temperature and the cylinder being of low thermal capacity, the cooling is reasonably fast. A time-temperature graph is made and the curve is usually smooth. The student should derive the rate of cooling at several selected temperatures by drawing tangents to the curve at the corresponding points. All the information is now available for constructing a second graph between rate of cooling and excess temperature.

The use of this form of apparatus affords a great saving in time owing to the speed with which time-temperature readings may be taken.

In determining **specific heat,** a cooling curve is made for each of the two cylinders. Assuming the specific heat value for one of them (either copper or aluminium) the specific heat of the other may be calculated by the usual method. The apparatus gives surprisingly good results. Owing to its high thermal conductivity, the uniformity of temperature throughout the block is remarkable and fully compensates for the absence of a uniform temperature enclosure, in which, if liquid be employed, only the most efficient stirring gives any approximation to really uniform temperature conditions.

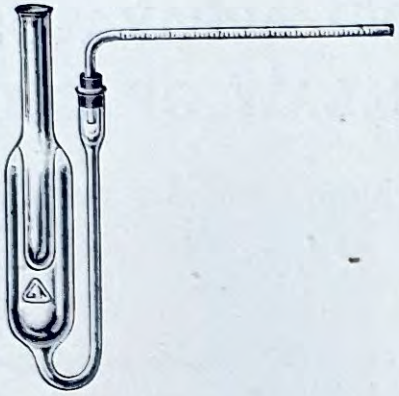
The metal sleeve may be fitted over one of the cylinders to preserve its brightness when being heated. A time-temperature curve is made for bright and for black surface conditions. The graphs illustrate vividly the difference in emissivity.

We are continually engaged on the development of new and interesting Chemical and Physical Apparatus.

We shall be glad to forward literature on request.



A 42-920.



A 42-925.



A 42-940.



A 42-950—960.

	£	s.	d.
A 42-920. ICE CALORIMETER, Bunsen, glass, about 20 cm. long, **without** capillary tube ..	0	7	6
A 42-925. Ditto (Worsnop & Flint: *Advanced Practical Physics for Students*, p. 203), with capillary tube, 50 cm. long, graduated in mm.	0	12	6

In determining specific heats a solid is dropped into water contained in the central tube. Ice previously formed externally on the bottom of this tube is melted and the volume of water formed indicated by the mercury column in the graduated tube. The density of ice may also be determined.

A 42-940. DEWAR VESSELS, Cylindrical, double walled, evacuated, silvered.

Inner length	150	150	200	200	250	250	300	400 *mm.*
Inner diameter	30	40	40	50	40	50	60	60 *mm.*
Capacity about	150	200	250	300	360	500	750	1250 *ml.*
p	15/-	17/6	18/6	20/-	19/6	22/-	25/-	35/- *each*
A 42-945. Wooden Foot .. *p*	7/6	9/6	9/6	10/6	10/-	11/-	12/-	12/- *each*

DEWAR FLASKS, double walled, evacuated.

Capacity about ..	125	250	500	750	1000 *ml.*
A 42-950. Unsilvered .. *p*	16/-	19/6	28/6	35/-	42/6 *each*
A 42-955. Silvered .. *p*	18/6	22/-	31/-	37/6	45/- *each*
A 42-960. Wooden Foot .. *p*	9/6	9/6	10/6	11/-	12/- *each*

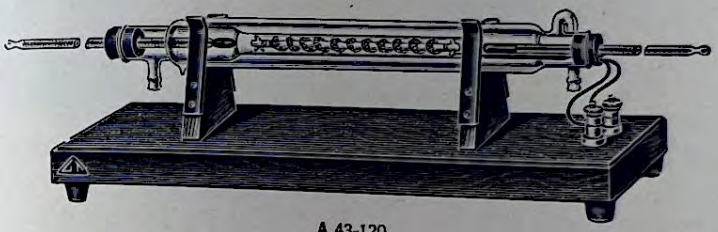


A 42-990.

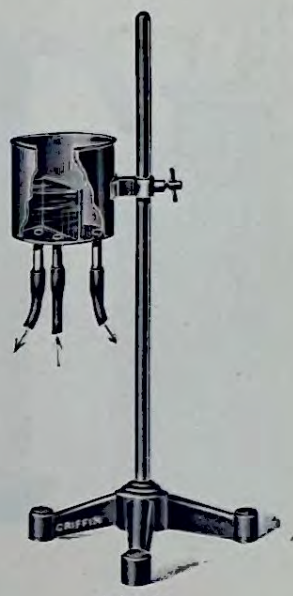
A 42-990. CALORIMETER, Specific Heat of Liquids (Allen and Moore: *Text-Book of Practical Physics*, p. 363; Noakes: *Text-Book of Heat*, pp. 57-59). Apparatus for determining by the method of cooling. **Without** thermometers 3 0 0

Thermometer, for above, range — 5 to 105° C. in 0·2°. See **B 47-675.**

Two calorimeters 2 × ¾ in. of spun aluminium are suspended by means of the thermometers inside a zinc vessel, which stands in an outer zinc tank 8½ × 6½ × 6 in. high. The latter is provided with a wood top lined with felt; the space between the inner and outer vessels should be filled with water.



A 43-120.



A 43-130.

	£	s.	d.
A 43-120. CALORIMETER, Continuous Flow (Noakes: *Text-Book of Heat*, pp. 71–72; Smith: *Intermediate Physics*, 2nd Edn., pp. 191–194), for the determination of the specific heat of a liquid. Double walled glass tube, overall length 32 cm., with evacuated jacket, centre tube fitted with coiled-coil heating element, resistance about 2 ohms, wound on a removable glass rod positioned with glass pips. Rubber stoppers, spring clips for tube support. On wood baseboard, with terminals and rubber feet. **Without** thermometers	4	10	0
Thermometers, for above, range −5 to 50° C. in 0·2° C. .. See **B 47-675.**			
A 43-130. CONSTANT LEVEL TANK, on stand, for connecting to the water supply, to obtain a constant head. Suitable for **A 43-120** and other calorimetric apparatus where a constant flow is required	1	10	0
A 43-135. Ditto, simple form, 1 litre glass aspirator fitted with constant level tube ..	0	9	6

EXPERIMENTAL NOTES

Connect the calorimeter in series with a 6-volt cell, variable resistance (approx. 10 ohms); switch and ammeter; connect voltmeter across the calorimeter terminals.

Connect the inlet tube of the calorimeter to the constant flow vessel, adjust rate of flow of liquid and current until the difference between the thermometer readings is constant at about 5° C., the ammeter and voltmeter readings being steady.

Collect the outflowing liquid in a weighed vessel and record time of commencement of flow with a stop-watch. Thermometer, ammeter and voltmeter readings should be recorded at regular intervals.

Collect a suitable quantity of liquid, record the time of flow, remove the vessel, switch off current, turn off liquid flow and record as follows:—

Voltage E, current C, inlet temperature T_1, outlet temperature T_2, rise in temperature θ, mass of liquid m, time in seconds t.

The relation between electrical energy expended and heat gained is expressed as follows:—

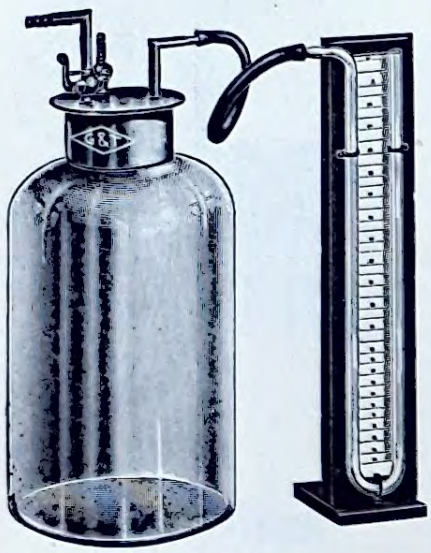
$$EC = J\left(\frac{ms \cdot \theta}{t} + H\right)$$

where J = Joule's equivalent,
s = specific heat of liquid,
H = heat loss/sec. under given temperature conditions.

Repeat the experiment with a similar temperature difference but altering E, C and m. Then:—

$$E_1C_1 = J\left(\frac{m_1s \cdot \theta}{t_1} + H\right).$$

By combining both equations H may be eliminated, and given one of the constants J or S, the other may be determined. With only a small increase in temperature, the variation of specific heat with temperature can be investigated.



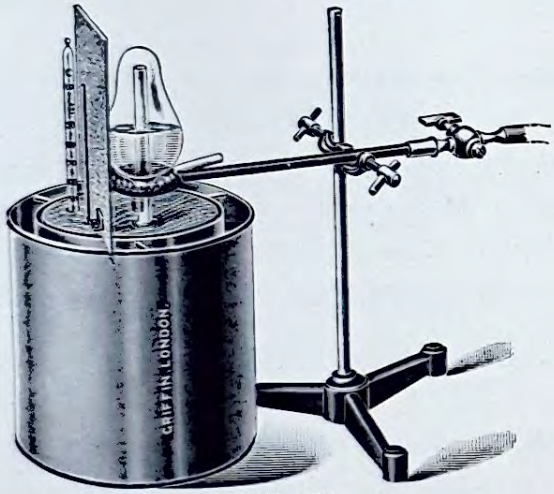
A 43-180.

A 43-180. SPECIFIC HEAT OF GASES. Clément and Desormes' Apparatus (Worsnop & Flint: *Advanced Practical Physics for Students*, p. 212; Edser: *Heat*, p. 322; Yarwood: *Intermediate Practical Physics*, p. 70) for determining the ratio of the two specific heats of a gas. The gas container is a glass vessel of about 10 litres capacity. A metal cap is cemented to the neck and is fitted with a bent tube with tap for connection to a pump, a wide bore tap for opening to air and a bend for connection to the manometer .. .. £ 4 15 0

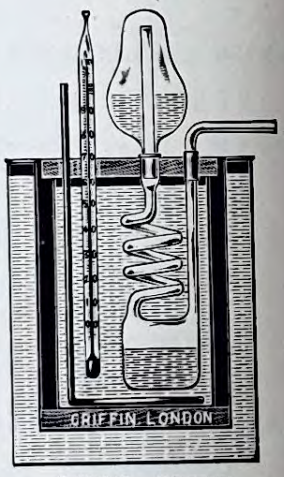
Air in the container under a pressure of 30 cm. water is allowed to expand adiabatically to atmospheric pressure by rapidly opening the wide bore tap, the subsequent increase in pressure as the enclosed air, cooled by the expansion, absorbs heat, is noted, when the ratio of the specific heats can be calculated from the respective manometric readings. Dibutyl phthalate is a convenient liquid for the manometer.



A 43-320.



A 43-340—360.



A 43-340.—Diagram.

£ s. d.

A 43-320. LATENT HEAT OF STEAM APPARATUS, Marshall (*Science Masters' Book*, Part 1, pp. 43–44). Thick brass calorimeter, **A 42-675**, with felt cover, and fitted with rubber bung and glass inlet and outlet tubes; the straight tube being an easy fit in the stopper of the steam heater. The whole inverted over a tinned iron steam heater fitted with rubber stopper, complete 0 19 6

Calorimeters, thick iron, copper and aluminium, see p. 107.

When steam issues freely from the outlet tube, the calorimeter is at once removed, the bung taken out and the quantity of condensed steam measured in a burette. The calculation is simple and the average pupil obtains results between 510 and 540 cals./gm.

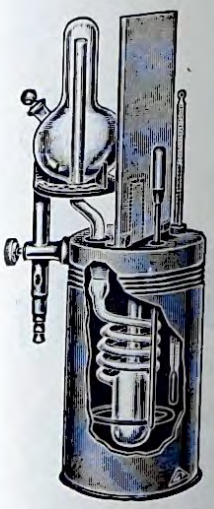
A 43-340. LATENT HEAT APPARATUS, Berthelot (Edser: *Heat*, p. 152; Worsnop and Flint: *Advanced Pract. Physics*, p. 208; Noakes: *Text-Book of Heat*, pp. 55–57). With glass receiver and spiral condenser, glass boiler with B10 standard interchangeable ground joint, tin water jacket, spun copper calorimeter and wood cover, burner and stand, stirrer, asbestos screen. **Without** thermometer 4 10 0

A 43-345. Boiler, glass, spare, with B10 standard ground joint, for above 0 7 6

A 43-350. Ditto, electrically heated 0 12 6

A 43-355. Receiver and Spiral Condenser, glass, spare, with B 10 standard ground joint, for above 0 15 0

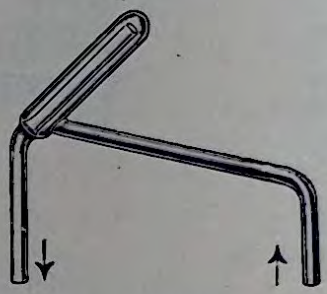
A 43-360. Ring Burner, with tap, for above, **without** stand .. .. r 1 15 0



A 43-370.



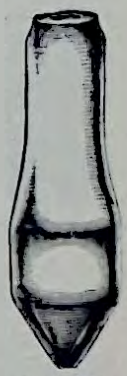
A 43-425.



A 43-440.



A 43-480.



A 43-485.

£ s. d.

A 43-370. LATENT HEAT APPARATUS, Berthelot, improved form, in silvered Dewar cylinder, approx. 140 mm. deep and 65 mm. internal diam., eliminating radiation corrections. With glass boiler, spiral condenser (both with B 10 standard joints) and ring stirrer. In metal vessel with wide mouth from which the reservoir can easily be removed for weighing. Ring gas burner and asbestos-cement thermometer shield. **Without** thermometer **5 10 0**

A 43-375. Ditto, electrically heated **5 10 0**

A 43-425. STEAM TRAPS, glass, with corks .. .. *each* 1/9 ; *dozen* **0 19 0**

A 43-440. STEAM TRAPS, all glass .. .. *each* **0 7 6**

The delivery tube to calorimeter being jacketed by steam, no condensate passes with the steam into the calorimeter. The whole should be lightly lagged with cotton wool.

A 43-480. RUPERT DROPS (Sutton: *Demonstration Experiments in Physics*, p. 202). Indicating the necessity of annealing .. .. *dozen* **0 4 0**

Made of glass which has been allowed to cool suddenly. The outer surface solidifies before the inner surface, so that a considerable stress is set up between the inside and the outside. The stress is distributed uniformly over the surface so that a state of equilibrium obtains. As soon as the tail of the drop is broken off the equilibrium is no longer maintained, and the drop shatters to powder.

N.B.—To perform this experiment the drop should be placed under an inverted beaker, and the tail broken off with tongs in such a manner that observers are not exposed to the flying fragments.

Rupert Drops being in a permanently strained condition exhibit phenomena of double refraction and show fringes when viewed through crossed Nicol prisms. For this purpose they should be placed in a small rectangular cell of glass filled with a mixture of ten parts of chloral hydrate dissolved in one part of hot glycerine ; this has the same refractive index as the glass. (Wood : *Physical Optics*, 3rd Edn., p. 387.)

A 43-485. BOLOGNA PHIALS .. .. *Price on application.*

Small flasks of thick glass which have been cooled quickly, so that the same kind of stress prevails between the outer and the inner surfaces as in Rupert Drops above. The slightest scratch, caused by dropping in and shaking some small pieces of flint, breaks down the equilibrium and the bottom flies out.

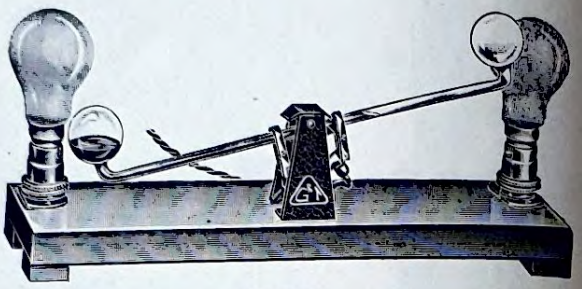
CHANGE OF STATE, DEW POINT



A 43-540—550.



A 43-590.



A 43-595.

BURSTING BOTTLES, Iron, to show the increase in volume when water freezes. The force of the expansion bursts the bottles.

	Small.	Large.	
A 43-540. With Screw Stopper	3/-	4/-	*each*
A 43-545. Without Screw Stopper	1/10	2/9	*each*
A 43-550. Stopper only	1/2	1/3	*each*

	£	s.	d.
A 43-590. PULSE GLASS, containing coloured spirit which has been boiled to expel the air from the apparatus	0	7	0

When one bulb is held in the hand, as shown in the figure, the heat is sufficient to produce a pressure, which drives the liquid into the other bulb and causes brisk ebullition. The cooling of the liquid consequent on the evaporation produced is distinctly felt.

A 43-595. PULSE GLASS DEMONSTRATION APPARATUS, Pulse Glass **A 43-590** with mercury switch, pivoted on stand with two lamp-holders, **without** lamps	2	10	0

The pulse glass is pivoted at its centre and fitted with a mercury switch. The heat radiated from the left-hand lamp produces pressure in the left-hand bulb, driving the liquid into the right-hand bulb. This causes the pulse glass to tilt. The mercury switch also tilts, switching off the left-hand lamp and switching on the right-hand; the process is continuously repeated.



A 43-810—820.

A 43-810. HYGROMETER, Regnault, for determining the temperature of the dew point. Simple form. Glass tube with silver thimble ground on, thermometer and stand	0	19	0
A 43-815. Thimbles, spare, silver .. .. *each*	0	4	6
A 43-820. Glass Tubes, spare .. .. *each*	0	1	9

Thermometers, spare, range — 5 to 50° C. in 0·2°. See **B 47-675.**

The thimble should be filled with ether, which is evaporated by means of rubber hand bellows attached to the longer tube. The temperature should be lowered very slowly near the dew point. The temperature at which deposition of dew begins may be regarded as the temperature of the dew point. The thimble must be kept full and well agitated and its surface must be perfectly clean. Precautions should be taken by the observer that in breathing, the moisture content of the air in the vicinity of the thimble shall not be affected.

Please consult the General Index at the end of the Catalogue.



A 43-850.



A 44-230.



A 44-260.



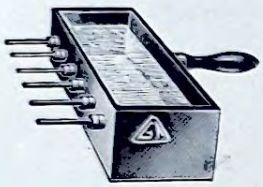
A 44-270.

		£	s.	d.
A 43-850.	**DEW POINT APPARATUS**, brass box 17 × 7·5 × 4·5 cm., with ether funnel, plane mirror, observation window and thermometer, range 20 to 120° F. in 1° .. .. *t*	6	0	0

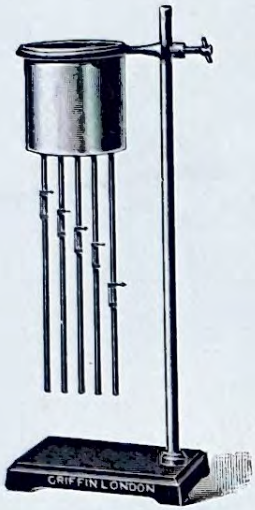
A thermometer passes into an ether chamber in front of which is a compartment for holding the sample of air under examination. Air is drawn into the sample chamber by means of a rubber bulb or by sucking the end of a rubber tube, and the temperature is lowered to the dew point by evaporating ether in the usual way. The use of a flat mirror in front of the thermometer bulb in place of the customary curved thimble adds greatly to the ease and accuracy of the dew point observations.

A 43-855.	**Thermometer**, spare, for above .. .. *t*	0	9	0
A 43-860.	**Aspirator**, rubber .. .. *extra t*	0	7	0
A 43-865.	**National Physical Laboratory Certificate for A 43-850** .. .. *extra tx*	0	4	6
A 44-230.	**IRON and COPPER WIRES**, of same length and thickness, joined together at centre and terminating in phosphorus cups to show different conductivity, overall length 24 in.	0	3	6
A 44-235.	**COPPER WIRES**, 12 × ⅛ in., for use in demonstrations of conduction of heat *dozen*	0	5	9
A 44-240.	**IRON WIRES**, 12 × ⅛ in. .. .. *dozen*	0	4	6
A 44-250.	**RODS**, 12 × ⅛ in. Iron, copper, brass, wood, glass and ebonite .. *Set of* 6	0	2	6
A 44-260.	**WOOD ROD AND BRASS CYLINDER**, with handle, overall length 11½ in., to show different conductivities, *e.g.* by wrapping with paper and noting different degrees of scorching when passed through a Bunsen flame	0	4	6
A 44-270.	**CONDUCTIVITY APPARATUS**, to show the different conductivities of iron, copper, zinc, and brass. The four bars are fixed to a ring, so that they meet in the centre where they are to be heated. Each bar terminates in a small cup for holding phosphorus ..	0	15	0

Suggestions as to the improvement of and new designs in apparatus are welcomed.



A 44-290.



A 44-300.



A 44-305.

£ s. d.

A 44-290. CONDUCTIVITY APPARATUS, Ingen-hausz (Preston: *Theory of Heat*, Noakes: *Text-Book of Heat*, pp. 332–334,) with one each rods of iron, copper, aluminium, glass, wood and slate, to be coated with paraffin wax and inserted by corks in the metal tank, which measures approx. 10 × 3 × 4¼ in. high. Heat conducted from hot water in the tank melts the paraffin wax on the rods at rates depending on their conductivities .. 0 17 6

A 44-300. Ditto, Edser (*Heat*), for determining the relative conductivities of five different metals. Rods of iron, copper, brass, zinc, and nickel-silver 12 in. long are fixed in the bottom of a brass vessel and coated with wax. As the wax melts, small indexes (see enlarged illustration above) slide down the rods to distances depending on the conductivities of the rods. On stand 1 8 6

A 44-305. Indexes, spare, for above .. .. *each* 0 1 6



A 44-340.



A 44-360.



A 44-365.

£ s. d.

A 44-340. HEAT SENSITIVE PAPER, to show thermal conductivity and radiation, in sheets 11 × 17¼ in. .. .. *sheet* 1/-; *dozen* 0 10 6

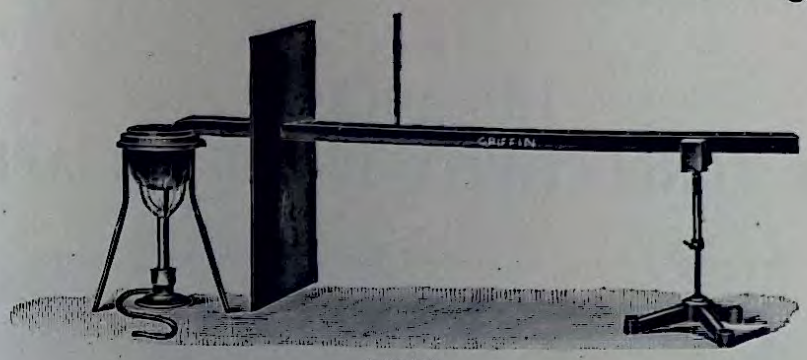
Normally pale pink in colour, the paper indicates the reception of heat by turning a vivid blue-green. It may be used many times as it quickly recovers its original colour, in which it is assisted by breathing on the coloured areas.

It may be used to show:—the temperature gradient of a wire heated at one end and placed in contact with the paper; relative conductivities; that radiant heat travels in straight lines, may be reflected and focussed, and casts shadows in similar manner to light; comparison of absorptive and emissive powers, etc. Heat sensitive liquid, see p. 119.

A 44-360. SAFETY LAMP, Davy, original pattern 1 5 0

The hot gases produced by the flame are cooled by the gauze so that if the lamp be placed in an inflammable mixture of gases, they are not sufficiently heated for ignition to occur. At the same time, atmospheric air readily passes through the gauze to keep the lamp burning.

A 44-365. SAFETY LAMP, Clanny, a modification of the Davy lamp, with glass window to provide greater illumination 1 10 0



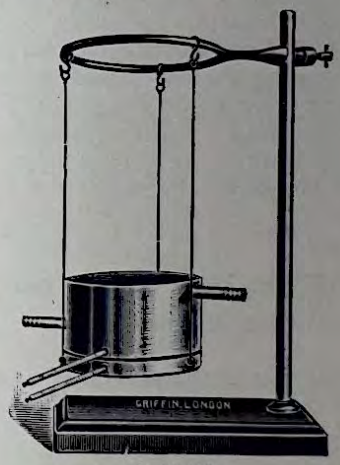
A 44-430.

£ s. d.

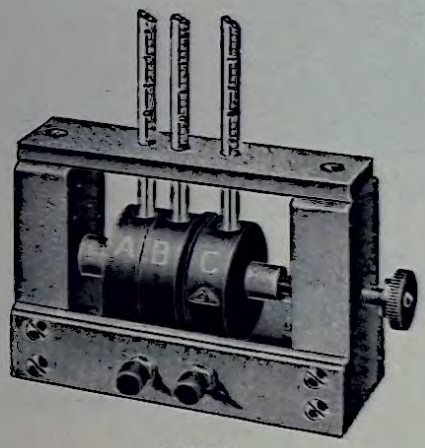
A 44-430. FORBES' BAR, for determining the thermal conductivity of an iron bar (Smith: *Intermediate Physics*, p. 279; Worsnop and Flint: *Advanced Practical Physics*, p. 230), with hard asbestos-cement screen, stand, crucible, and tripod. **Without** thermometers and burner .. .. *r* **4 15 0**

Thermometers, for above. .. .. See **B 47-635, B 47-675.**

The bar is 40 in. long from the head and is 1 in. square in section, with holes $\frac{3}{16}$ in. diam., drilled at intervals of 1 in. A piece of the same bar, 3 in. long, with one hole, is supplied for the determination of the cooling curve.



A 44-450.



A 44-460.

£ s. d.

A 44-450. CONDUCTIVITY APPARATUS, Lees and Chorlton (Robson: *Practical Exercises in Heat*), for the determination of the conductivity of thin layers of materials. **Without** thermometers **5 18 6**

Steam is passed through a flat cylindrical box 11·5 cm. diam. × 5 cm. deep. The bottom of the box is formed of a circular brass plate 12 mm. thick, in which a radial hole is bored to the centre. The material under test is placed between the steam box and a brass disc of exactly the same dimensions as the base of the former. The apparatus is suspended by strings fastened to the disc. Both the box and the disc are nickel-plated.

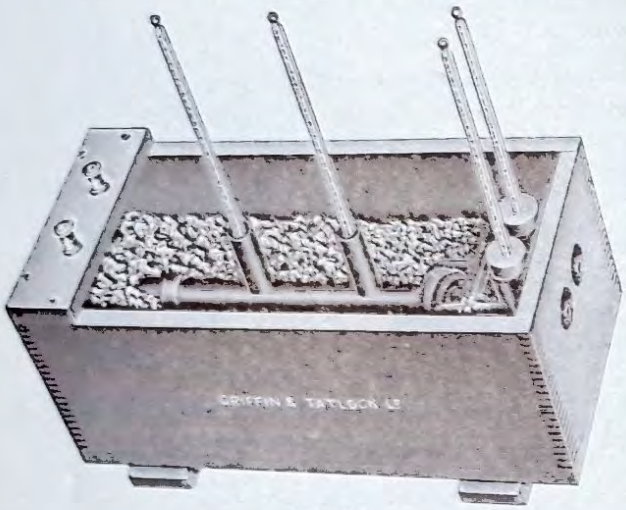
A 44-460. CONDUCTIVITY APPARATUS, Lees (Smith: *Inter. Physics*, p. 284; Allen and Moore: *Text-Book of Practical Physics*, p. 368), for determining values of badly conducting materials. Three copper discs, A, B, C, 1$\frac{5}{8}$ in. diam., are arranged in a hard asbestos-cement framework. Each disc is drilled to take a thermometer. The material to be tested, *e.g.* ebonite, cardboard, compressed cork, etc., which should be in the form of a thin disc, of the same diameter as the copper discs, is placed between A and B and the apparatus tightly clamped. Between discs B and C is an electric heating element operated from 6-volt accumulator. **Without** thermometers .. .. *r* **5 15 0**

Thermometers, for above, range −5 to 50° C. in 0·1°. .. See **B 47-675.**

The heating element is connected in series with a 6-volt accumulator, adjustable resistance and ammeter, and the apparatus left with current flowing until a steady state is attained. The readings of the thermometers and the room temperature are recorded. It is assumed that all the heat passing into and through the test disc is utilised in raising the temperature of the metal disc A, or is radiated from the exposed surface of the disc. The thermal conductivity of the test disc can be calculated by plotting the heating and cooling curves for the disc A.

THE MICROID THERMAL CONDUCTIVITY OF COPPER APPARATUS

Searle's type adapted for electrical heating



A 44-480.

The electrical heating is desirable not only for its convenience but, as the input of heat can be measured, the efficiency of the apparatus can be calculated.

SPECIFICATION

The apparatus consists essentially of a copper bar 9 in. long × 1 in. diam. An electrical heating element is embedded in one end of the bar. The standard winding is for 10 volts (65 watts). A copper worm encircles the other end of the bar and carries two pockets for thermometers. Two other thermometers are fitted to measure the temperature of the bar at two points 7·5 cm. apart. The bar is surrounded by a heavy lagging of felt and cork dust, and the whole enclosed in a wood case with removable cover.

	£	s.	d.
A 44-480. MICROID THERMAL CONDUCTIVITY OF COPPER APPARATUS, Searle's type, adapted for electrical heating, in teak case with felt lagging. **Without** thermometers ..	9	0	0

Thermometers, for above, range − 5° to 35° C., in 0·1°, **for water temperatures,** and − 5° to 105° C. in 0·2°, **for bar temperatures.** .. .. **See B 47-675.**

EXPERIMENTAL NOTES

The original apparatus as described by Searle **A 44-510** (*Phil. Mag.*, Jan., 1905) embodies a steam heater. The substitution of an electrical element in intimate contact with the copper bar is not only more convenient but provides, by measurement of heat input, a means of calculating the thermal efficiency of the apparatus. This adaptation introduces the student to the modern technique in thermal conductivity measurement such as has been elaborated in recent years at the National Physical Laboratory.

The heat supplied by the electrical element is conducted along the bar and is conveyed at the other end to water circulating in a copper worm. The inlet and outlet temperatures of the water are indicated by thermometers. Two thermometers are fitted into pockets 7·5 cm. apart, in the bar. Water is passed through the worm at such a rate that the temperature difference between inlet and outlet is 5° or 6° C. The apparatus is operated until these and the thermometers in the bar give steady indications, which are then noted. A note is also taken of the time in seconds for the passage of 250 grams of water.

If $T_4 - T_3$ is the temperature difference between outlet and inlet water, m is the mass of water collected and t the time in seconds, the rate of transmission of heat is $\frac{m(T_4 - T_3)}{t}$. Since this heat is transmitted a distance d between thermometers T_1 and T_2, then where K is the conductivity and A is the cross section of the bar in sq. cm., we have

$$K \frac{(T_1 - T_2)}{d} \times A = m \frac{(T_4 - T_3)}{t}$$

or

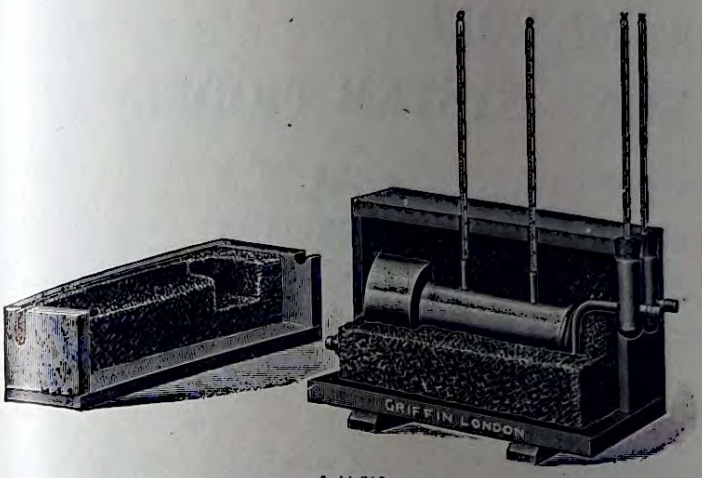
$$K = \frac{dm\,(T_4 - T_3)}{t\,(T_1 - T_2)\,A}$$

EXAMPLE

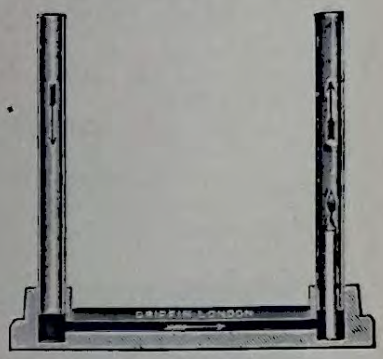
Diam. of bar = 2·55 cm.
Cross section = 5·1 sq. cm. d = 7·6 cm.
$T_1 - T_2$ = 16·3° C.
$T_4 - T_3$ = 5·74° C.
Mass of water = 250 grams.
Time for collection = 140 secs.

$$K = \frac{7{\cdot}6 \times 250 \times 5{\cdot}74}{140 \times 16{\cdot}3 \times 5{\cdot}1} = \mathbf{0{\cdot}94}\ \textbf{cals./sq. cm./sec.}$$

If at the time the water is being collected the voltage across the terminals and current in the circuit of the heating element are measured, the efficiency of the apparatus may be determined. The heat input per second in calories $= \frac{\text{volts } (E) \times \text{amps. } (C)}{4{\cdot}18}$. The output $= \frac{m(T_4 - T_3)}{t}$. The efficiency $= 4{\cdot}18 \frac{m(T_4 - T_3)}{t \times E \times C}$.



A 44-510.

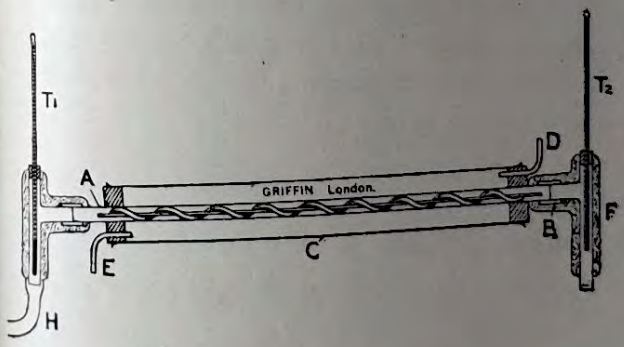


A 44-530.

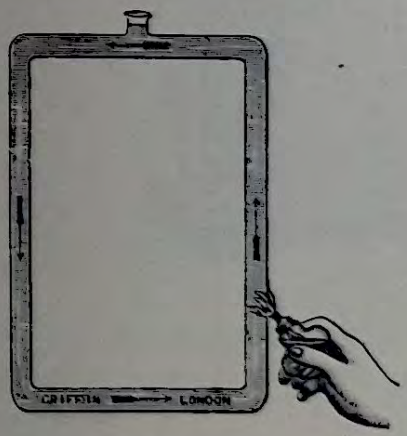
	£	s.	d.
A 44-510. THERMAL CONDUCTIVITY OF COPPER APPARATUS, Searle (*Phil. Mag.*, January, 1905 ; Noakes: *Text-Book of Heat*, pp. 334-335), packed with felt in wood case. **Without** thermometers	10	0	0
Thermometers, for above, range 0° to 50° C. in 0·2°. .. .. See B 47-675.			
Ditto, range 0° to 110° C. in 0·5°. .. .. See B 47-675.			

One end of a stout rod of copper is heated by steam, while the other end is kept cool by a stream of water flowing through a narrow copper spiral soldered to that end of the rod. Two thermometers inserted in the rod give the temperature gradient, and when the difference of temperature between the inflowing and outflowing water and also the mass of water flowing through per second are known, the conductivity of the copper can be calculated.

A 44-530. VENTILATION APPARATUS, two glass flues connected through a wood base. If a lighted candle is placed in one of the flues the convection current can be demonstrated by holding a piece of smoking paper over the other flue	0	16	0



A 44-600.



A 44-640.



A 44-650.

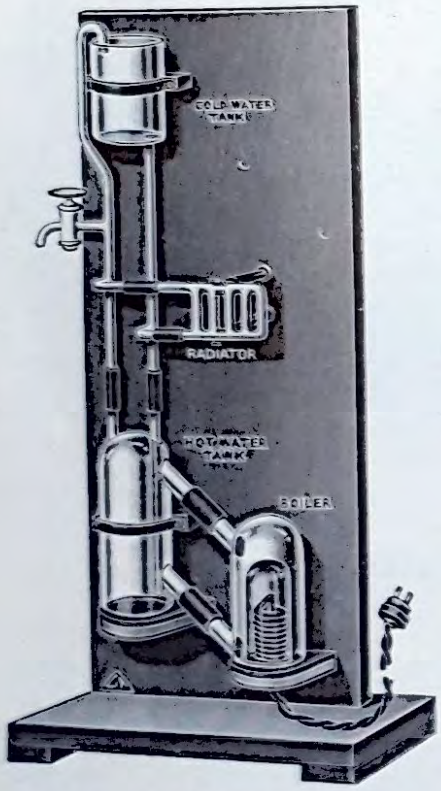
	£	s.	d.
A 44-600. CONDUCTIVITY OF GLASS APPARATUS (C. J. Smith: *Intermediate Physics*, p. 287), as illustrated, but including 2 thermometers 0° to 50° C. in 0·1°	2	12	6

A stream of water is made to flow slowly at a uniform rate through the inner glass tube A, while steam is passed through the outer tube C. When the thermometers have become constant, the rate at which heat passes through the walls of the tube A can be determined by noting the rise of temperature in a measured quantity of water in a measured interval of time.

A 44-640. CONVECTION TUBE, Glass, bent into a rectangle about 15 × 12 in., to show the convection of heat in water (**A 44-650** can be used effectively)	0	8	0
A 44-650. HEAT SENSITIVE LIQUID (Thermochromic), for convection experiments (see **A 44-720**). Gentle warming turns the colour of the liquid from pink to blue, returning to pink on cooling. By the addition of a few drops of ammonia a flocculent precipitate is formed, which streams with the flow, visually demonstrating the course of the convection current. The liquid is inflammable .. .. 1 *litre* (*bottle extra*)	0	5	6

THE MICROID DOMESTIC HEATING SYSTEM MODEL

A new apparatus providing by the use of a thermochromic liquid a vivid demonstration of convection in liquids and a working model of a Domestic Hot Water System



A 44-720.

Apparatus for use in demonstrating convection in liquids has usually been an unsatisfactory assembly of flasks, split corks, and glass tubing bends. Similarly, no well-designed apparatus has generally been available for demonstrating the design of domestic hot water systems. Both demonstrations are important in school science courses. In this new Microid Apparatus these two requirements have been combined in one apparatus which is also a working model. By the use of a thermochromic liquid, which is rose pink when cold and deep blue when hot, the progression of temperature changes is observed colorimetrically, and the movement of convection currents is made visible by the streaming of flocculated particles.

SPECIFICATION

Pyrex double-walled boiler with removable electric heater, hot water storage tank, draw-off tap, model radiator connected between flow and return pipes, overflow to cold water tank and feed to hot tank. Mounted on white enamelled stand 24 in. high × 9 in. wide; 1 litre thermochromic liquid in bottle.

	£	s.	d.
A 44-720. MICROID DOMESTIC HEATING SYSTEM MODEL, complete on white enamelled stand, with 250 watt electric heater, flex and plug, and 1 litre thermochromic liquid ..	5	15	0

Please state voltage when ordering.

Component Parts for A 44-720

		£	s.	d.
A 44-720 a.	Boiler, double-walled	0	17	6
„ „ b.	Hot Water Tank	0	12	6
„ „ c.	Cold Water Tank	0	8	6
„ „ d.	Radiator Model	0	8	6
„ „ e.	Tube with tap	0	10	6
„ „ f.	Heater, electric, spare. (*Please state voltage*)	1	12	6

EXPERIMENTAL NOTES

In this apparatus the heating boiler is represented by a hollow, double walled vessel, into which an electrical heater can be introduced. From the boiler top an upwardly inclined flow pipe is connected to the hot water tank and a downward sloping pipe provides the "return." The cold cistern (usually in the loft) is represented by a cylindrical glass vessel connected to the hot water tank by a tube which extends to the bottom of the hot tank. The hot water draw-off pipe from the top of the hot tank is provided with an overflow into the cold tank—the usual safety provision when the water boils. The thermochromic liquid is rose pink when cold and deep blue when hot. The addition

A 44-720. The Microid Domestic Heating System Model—*continued.*

of a few drops of dilute ammonia solution, precipitates flocculent particles, the large, light flakes of which stream with the convection currents.

In use, about 750 ml. of the solution are required to fill the apparatus. The solution is poured into the cistern, flows through the storage tank and thence into the boiler. The apparatus should be inclined to remove trapped air bubbles. On switching on the heater, or lighting the burner, the pink colour at the top of the boiler gradually changes to a light blue, the precipitate moves along the flow pipe into the hot tank and down through the return pipe to the boiler. Gradually the liquid in the upper part of the hot tank turns from pink to blue, displaying the temperature gradient therein, and in due course, the whole of the storage cylinder, with the exception of that part of it below the return pipe, assumes a uniform deep blue colour.

Meanwhile, expansion of the liquid in the system as a whole has taken place and the level in the cold tank is higher than at the commencement of the experiment. From the tap in the upper flow pipe (which represents either basin or bath tap) hot liquid can be drawn off, which is blue in colour and becomes pink as it cools.

Side tubes are provided on the cold water feed and on the hot water delivery tube across which a radiator grid is connected to show the construction and action of a radiator.

This model provides a realistic demonstration both of liquid convection and of a hot water supply system. It differs, in arrangement, from the usual system (in which the hot water storage tank is located in a linen cupboard on the first floor near the bath room) by having the storage tank only just above the level of the boiler on the ground floor. This system is being more widely adopted in the modern small house, and has the advantage that, the hot tank, being located in an airing cupboard on the ground floor, the door of that cupboard can be left ajar and a stream of warm air then flows into the hall, up the stairs, and warms the upper landing and bedrooms, without the installation of radiators.

The Microid Apparatus can be used equally well with water. If the thermochromic liquid is used, the apparatus should be emptied when not in use and the liquid stored in a bottle. The addition of a few drops of ammonia before re-use will precipitate more flocculent particles. On standing the precipitate tends to coagulate and does not show the streaming so well. It is a wise precaution to use the apparatus in a tray large enough to contain the thermochromic liquid (inflammable) in case of breakage.



A 45-210—215.



A 45-250—255.



A 45-260.

A 45-210. BALLS, Cast Iron, with eyes, for use in experiments on radiation.

Diam. ..	1¼	1½	2	2½	3	*in.*
	2/-	2/9	3/6	7/-	9/6	*each*

	£	s.	d.
A 45-215. STAND, for above balls, with iron claw, adjustable for height	0	9	6
A 45-250. REFLECTORS, Concave, nickel-plated copper, 18 in. diam., 6 in. deep, mounted on tripod stand .. .. *each p*	5	10	0
A 45-255. Ditto, 14 in. diam., 2½ in. deep, mounted on tripod stand .. .. *each p*	3	10	0
A 45-260. Ditto, Parabolic, polished nickel-silver, 14 in. diam., 4½ in. deep, mounted on stand .. .. *each p*	4	10	0

A 45-255 *also suitable for experiments in reflection of sound.*

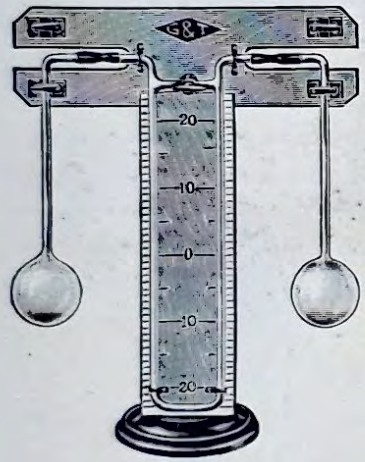


A 45-280—290.

		£	s.	d.
A 45-280.	**CUBE, Leslie,** tin, about 5 in. all faces bright	0	2	0
A 45-285.	**Ditto,** with surfaces dull black, bright black, white and bright tin	0	4	0
A 45-290.	**Ditto, Set of 3,** one bright, one black, one with two faces black	0	10	0



A 45-340.



A 45-360.



A 45-370.

A 45-340. **HEAT ABSORPTION CELL,** cylindrical, 3 in. diam., blackened inside, with glass window ; aperture at top for thermometer to be inserted into cell, and side bracket to hold thermometer outside cell. When placed in the path of radiation from a heat source it will be found that the temperature inside the cell is considerably higher than outside. May be used for elementary experiments on Diathermancy. Mounted on tripod base, **without** thermometers .. .. £ 1 17 6

A 45-360. **DIFFERENTIAL AIR THERMOMETER, Leslie,** with glass stopcock, mounted on stand with boxwood scale. The bulbs are connected by pieces of pressure tubing, and can be turned up or down .. .. £ 2 10 0

A 45-370. **THERMOSCOPE, Ether** (Noakes: *Text-Book of Heat*, p. 371), with one bulb blackened £ 0 10 0

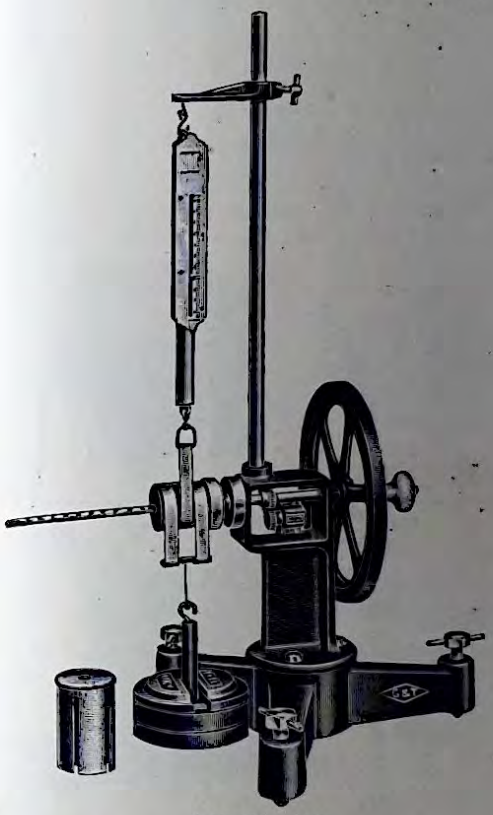


A 45-460.

A 45-460. **CARDBOARD TUBE** (Robson: *Heat*, p. 154), about 1 metre long × 5 cm. diam., having ends fitted with two corks, for rough determination of Joule's Equivalent. A thermometer is fitted through one of the corks, and the mechanical equivalent is determined from the rise in temperature of a known mass of lead shot placed in the tube and allowed to fall a number of times through the length of the tube .. .. £ 0 2 9

THE MICROID MECHANICAL EQUIVALENT OF HEAT APPARATUS

With solid metal rotating element



A 45-480—495.

The difficulty of obtaining really accurate values for " J " is well known. In designing the present model the intention was to produce an apparatus to give reasonably accurate results at a moderate price. In the course of a lengthy investigation, however, it was found that a much higher standard of accuracy than anticipated could be realised by systematic elimination of sources of error. The model now offered, therefore, combines moderation in cost with a remarkably high standard of performance and very easy manipulation.

SPECIFICATION.

A copper cylinder, bored to take a thermometer reading to 0·05° C., is rotated by a balanced handwheel. These parts are carried in a frame on a heavy tripod base with levelling screws, on which a revolution counter is mounted. The frame also carries a vertical pillar on which is fixed a bracket supporting a spring balance. A friction band encircles the copper cylinder. Its upper end is attached to the spring balance and its lower supports a heavy weight. A light metal shield envelopes the copper cylinder which is also insulated from the driving spindle by a disc of non-conducting material.

		£	s.	d.
A 45-480. MICROID MECHANICAL EQUIVALENT OF HEAT APPARATUS, Solid Rotor type, complete on base with revolution counter, spring balance, thermometer and three weights	*r*	11	5	0
A 45-485. Thermometer, 12° to 30° C. in 0·05°, marked with water equivalent	*r*	0	10	6
A 45-490. Ditto, for use in hot countries, 25° to 45° C. in 0·05°	*r*	0	12	6
A 45-495. Silk Bands, spare, for **A 45-480. Without** metal fittings	*each*	0	2	6
A 45-497. Ditto, with metal loop for attaching to spring balance and metal rod and loop for weights	*each*	0	7	0

EXPERIMENTAL NOTES

The most novel feature of the apparatus is the use of a solid cylinder of copper as calorimeter, the mass and therefore the thermal capacity of which is still further reduced by a series of longitudinal holes. Its high thermal conductivity equalises the temperature as efficiently as mechanical stirring in a water calorimeter. The heat losses are reduced to a minimum by the introduction of various devices found by experience during a lengthy investigation to be most effective. The most important of these are the shield protecting the calorimeter from the surrounding air, and the introduction of an air gap between the disc insulating the copper cylinder from the spindle and the cylinder itself. Lag between the reading of the thermometer and the temperature of the calorimeter is minimised by wrapping the thermometer bulb in copper foil to make a good fit. The bulb is dipped in oil before insertion to ensure good contact. The low thermal capacity and these provisions against heat losses enable values of " J " to within 1 per cent. to be consistently obtained. Another feature that contributes to this successful performance is the remarkably low number of revolutions necessary (about 100) to produce, say, 1° C. rise in temperature. A steady rotation and indication on the spring balance is thus easily secured.

A 45-480. The Microid Mechanical Equivalent of Heat Apparatus—*continued.*

The procedure is as follows :—

1. Fit the friction band in such a position that the spring balance may be extended to its full capacity. The band should be kept clean.
2. Place the shield carefully in position, taking care that the friction band moves freely through the slots in the shield.
3. Add sufficient weights to hanger to give a friction force of about 1500 grams, which may be varied to ensure a temperature rise of 1° to 1·2° C.
4. Dip thermometer in oil, cool in a draught and fit in calorimeter. This ensures both initial and final temperatures being read on a rising meniscus.

The readings on the spring balance may vary and the average should, of course, be taken. Where spring balance variations are ignored, error is usually less than 2 per cent.

The mass of the calorimeter, being the copper cylinder and screws, is stamped on the cylinder. The mass of the copper foil round the bulb of the thermometer should be added.

Where high accuracy is required a correction should be made for the thermal capacity of the thermometer, which is marked on each thermometer. Estimates are made by means of a reading lens to 0·1 of one division, that is, 0·005° C.

The following shows the form recommended for recording thermometer readings, D being one division of the thermometer scale (0·05° C.).

Example.

Initial temperature = 17° C. + 7 D + 0·3 D
= 17 + (7 × 0·05) + (0·3 × 0·05)
= (17 + 0·35 + 0·015) or 17·365° C.

SPECIMEN RESULT

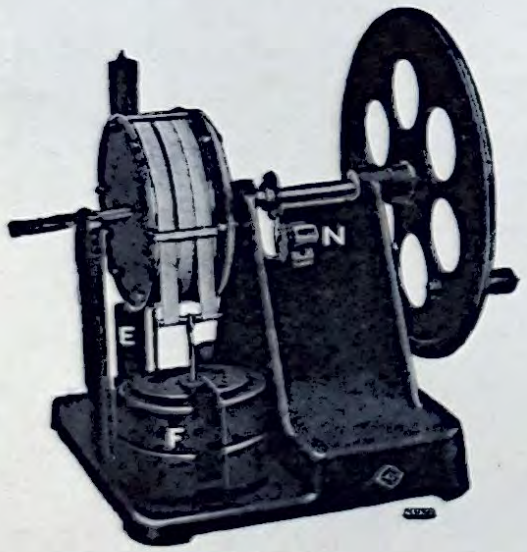
Mass of calorimeter and screws = 423 grams.
Sp. Heat of copper over range covered = 0·0920
Thermal capacity of calorimeter and screws = 38·9 cals.
,, ,, of thermometer = 0·4 cals.
Total thermal capacity = 39·3 cals
Rev. Counter 013 at beginning of experiment
113 at end of experiment
Total Revs. 100
Initial Temp. = 17° C. + 2 D + 0·7 D
= (17 + 0·10 + 0·035)° C.
= 17·135° C.
Final Temp. = 18° C. + 6 D + 0·0 D
= (18° C. + 0·30 + 0·0)
= 18·300° C.
Temp. Rise = 1·165° C.

Spring Balance, 290, 308, 287, 313, 297 grams. wt. (Not quite steady. Readings taken at end of each 20 revs.) Average, 299 grams wt.
Diameter of cylinder, 3·46 cms. (average value).
Total floating load = 2100 grams. wt.
Friction Force = 1801 grams. wt.

$$J = \frac{1801 \times 980 \times 3{\cdot}14 \times 3{\cdot}46 \times 100}{39{\cdot}3 \times 1{\cdot}165} \text{ ergs/cal.}$$

Log Numerator.		Log Denominator.	
Log 1801	= 3·2555	Log 39·3	= 1·5944
,, 980	= 2·9912	,, 1·165	= 0·0663
,, 3·14	= 0·4969		1·6607
,, 3·46	= 0·5391		
,, 100	= 2·0000		
	9·2827		
Log Denom.	= 1·6607		
,, Result	= 7·6220	Antilog 0·6220	= 4·19

J = 4·19 × 10⁷ ergs/cal.



A 45-520.

A 45-520. MECHANICAL EQUIVALENT OF HEAT APPARATUS, Callendar, complete on base with revolution counter, and hollow brass calorimeter fitted with velvet belt unequally weighted at each end. For hand operation. **With** thermometer range 10° to 30° C., and spare belt .. ..*tx* **32 10 0**

A 45-525. Ditto, complete with motor for use on 110 or 220/250 volts D.C. supply .. ..*tx* **50 0 0**

A 45-530. Ditto, complete with motor for use on 110 or 220/250 volts A.C. supply .. ..*tx* **52 10 0**

A 45-535. Thermometer, spare, 10–30° C. ..*tx* **1 0 0**

A 45-540. Ditto, 25–45° C., for use in tropical climates .. ..*tx* **1 0 0**

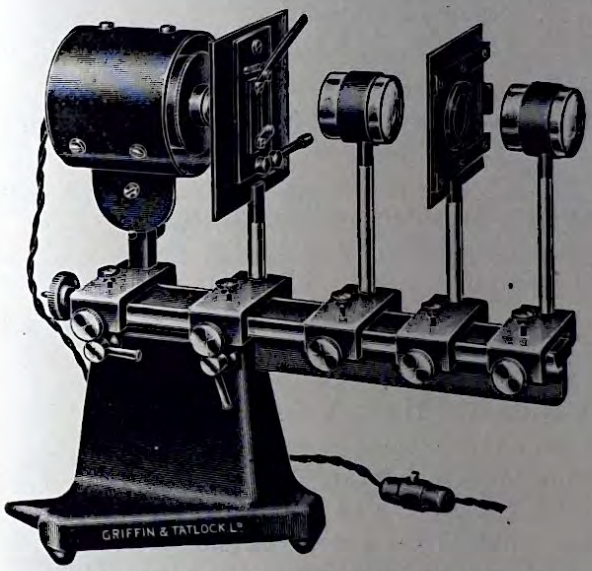
A 45-545. Velvet belt, spare, for above .. ..*tx* **0 15 0**

The name MICROID is registered by Griffin and Tatlock Limited and is used to distinguish apparatus of special interest to you.

Light

THE MICROID UNIVERSAL PROJECTOR

A comprehensive set of apparatus consisting of units which may be combined for the projection of micro-slides and animalculæ and for the demonstration of Colour Mixing, Spectra, Interference, Diffraction, Polarisation, Photoelastic and other Optical Phenomena.



A 51-120.—Assembly for Diffraction by Gauze Grating (Expt. XII).

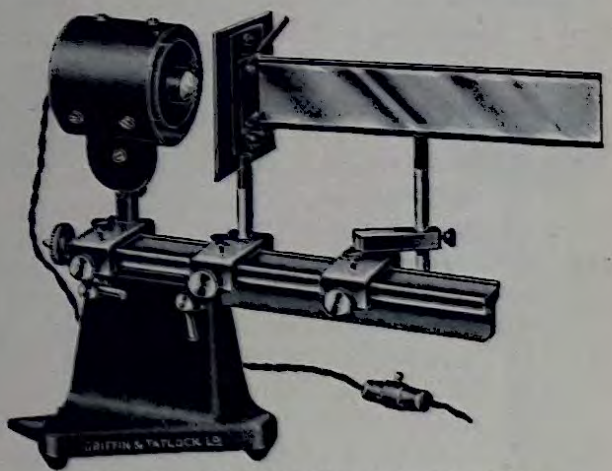
Physical optics, which provides so many experimental demonstrations of exceptional beauty, is frequently omitted from curricula or treated only mathematically. There is a general impression that the effective performance of these experiments demands expensive apparatus and high manipulative skill.

This new Microid apparatus is inexpensive, effective and easy to manipulate. Its optical system is unusually efficient and its mechanical adjustments are simple and precise. Optical phenomena are projected with remarkable definition and intensity.

The illumination is obtained from a low-voltage lamp, projected through carefully selected condenser lenses. The projector consists essentially of a base, bed and lamphouse. To it may be added as required, accessory units for the projection of micro-slides and for the demonstration of various fundamental phenomena, many of which lend themselves to quantitative interpretation.

Polarisation phenomena can be projected on the screen with good definition and of sufficient intensity for demonstration in a lecture theatre of moderate size. A brightly illuminated circle 3 ft. in diameter at a screen distance of 10 ft. is readily obtained.

The instrument was originally devised for micro-projection. In this form it meets most elementary requirements and its low cost justifies its use for that purpose alone. A small tank may be used for animalculæ. It is not too much to say that the use of the other accessory apparatus, covering many interesting and important experiments, opens up altogether new possibilities in optical demonstration.



A 51-120.—Assembly for Interference by Lloyd's Mirror (Expt. VII).

See pp. 132–141 for a description of selected experiments.

[*continued overleaf*

A 51-120. The Microid Universal Projector—*continued.*

List of Parts comprising the Series.

Part 1. Base.
Part 2. Bed, 12 in. long.
Part 3. Ditto, 18 in. long.
Part 4. Lamphouse.
Part 5. Standard Sliding Foot.
Part 6. Two Hole Foot.
Part 7. Objective Holder.
Part 8. Foot for Objective Holder.
Part 9. Slide Holder.
Parts 10, 11, 12. Objectives of various focal lengths.
Part 13. Trough, for Animalculæ or Cooling.
Part 14. Projection Mirror.
Part 25. Large Condenser.
Part 26. Achromatic Lens 10 cm. focus.
Part 27. Tripod Foot, 7½ in. high, for Part 26.
Part 28. Primary Colour Filters.
Part 29. Secondary Colour Filters.
Part 30. Tricolour Primary Filter.
Part 31. Tricolour Secondary Filter.
Part 40. Object Holder.
Part 41. Fixed Slit.
Part 42. Adjustable Slit.
Part 44. Prism 60°, dense flint glass.
Part 45. Prism 60°, hollow, cemented.
Part 46. Prism Table.
Part 47. Achromatic Lens 15 cm. focus.
Part 48. Circular Screen.
Part 49. Offset Holder.
Part 50. Spectrum Gate.
Part 51. Lens and Plate for Newton's Rings.
Parts 60-68. Diffraction Objects.
Part 69. Fresnel's Biprism.
Part 70. Lloyd's Mirror.
Part 71. Combined Slits.
Part 72. Ground Glass Screen.
Part 73. Tripod Foot, 5½ in. high, for Part 72.
Part 74. Lamphouse Aperture.
Part 75. Galvanometer Scale on stand.
Part 76. Lens, 100 cm. focus.
Part 77. Lens, auxiliary for micro-projection.
Part 78. Lens, 20 cm. focus.
Part 79. Polariser or Analyser.
Part 79a. Polariser or Analyser, Polaroid.
Part 80. Slideholder and Rotator.
Part 81. Cellophane Slides.
Part 82. Ditto, Set of 12.

Please see below for detailed specifications, illustrations and prices of above parts.

Reference to the experimental notes on pages 132 to 141 in which typical experiments are described and the parts required for each experiment are specified, will be of assistance when ordering.

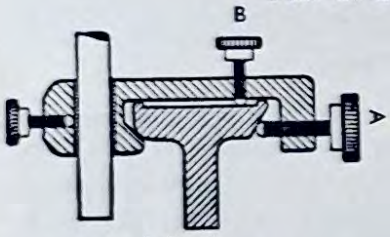
Please order by part numbers.

A 51-120. SPECIFICATIONS AND PRICES OF PARTS OF THE MICROID UNIVERSAL PROJECTOR.

£ s. d.

Part 1. Base.—A heavy iron casting having three feet on the under side and two at the end. A slot is milled in the top and two stainless steel tommy screws are fitted for clamping the bed in position .. .. *r* 1 18 0

Part 2. Bed.—12 in. long, of special T section (see fig.) plated brass bar of which the end surfaces of the arms of the T are respectively parallel and at an angle to the stem of the T. The locking screw of a sliding foot (part 5) tightens up on the sloping surface. This construction ensures precise repetition and maintenance of alignment of the parts for any experiment. The bed can be clamped in the base, either centrally or at one end. In the latter position the levelling screw in the bed in conjunction with the two feet on the end of the base enables the projector to be used in a vertical position *r* 0 19 0



A 51-120.
Section of parts 2 and 5 showing manner of assembly and screw adjustments.

Part 3. Ditto.—18 in. long .. .. *r* 1 4 0

Part 4. Lamphouse.—Two concentric metal tubes, the outer one acting as a light shield, whilst the inner one, which is adequately ventilated, carries the lamp holder and condenser. These, being mounted in tubes which slide in the inner lamphouse tube, can conveniently be adjusted for focussing. The whole lamphouse is mounted on a semi-circular plate and a stem, which, in conjunction with the sliding foot, permits of universal adjustment.

Without lamp .. .. *r* 3 17 6

Lamp for above, Class F, 6 volt or 12 volt, 24 watt, S.B.C. .. See **A 58-495.**

Part 5. Standard Sliding Foot.—Drilled with a hole into which the stem of an object is inserted and locked in position by means of a screw with milled head. The foot is of special section plated brass (see fig. above) which always locates the object supported, in the same position on the bed relative to its guiding surfaces. It is locked to the bed by means of screw A. Tilting of the foot, for alignment of the optical system, is possible by manipulation of screw B. Such tilting is of the highest importance for the accurate centring of a given arrangement of parts. Any foot may be removed from, or clamped on, the bed without disturbing the others .. .. *r* 0 11 0

Part 6. Two Hole Foot.—Similar to above but having two holes side by side for carrying attachments. The position of the holes permits, when necessary, objects to be brought closer to each other than is allowed by the standard feet .. .. *r* 0 14 0

Please order by part numbers.

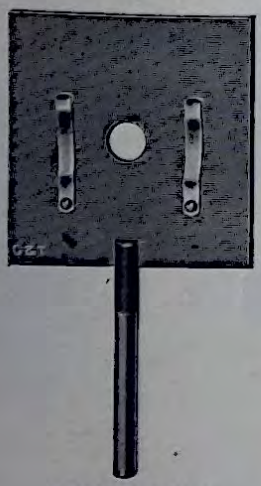
A 51-120. The Microid Universal Projector—*continued.*



A 51-120.—Parts 7 and 10.



A 51-120.—Part 8.



A 51-120.—Part 9.



A 51-120.—Part 14.

		£	s.	d.
Part 7. Objective Holder.—An inner tube, screwed R.M.S. thread at one end to take the objective, sliding in an outer sleeve supported by the usual stem. A short rod attached to the inner tube works in a spiral slot cut in the outer sleeve enabling precise adjustment of the objective to be made along its optical axis	*r*	1	10	0
Part 8. Foot for Objective Holder.—A strong tubular pillar on a sliding foot. The stem of the objective holder, part 7, slides into the pillar in which it may be adjusted for height. The whole forms a very rigid and stable mounting which permits sharp focussing to be carried out	*r*	1	2	6
Part 9. Slide Holder.—A plate 4 in. square supported on a stem. It is fitted on each face with a pair of clips which may be used for micro-slide and cooling trough respectively or cooling trough and a similar trough for animalculæ. It is carried by the standard sliding foot (part 5)	*r*	1	0	0
Part 10. Objective, Microscope.—Achromatic, 32 mm. focal length, with standard R.M.S. thread. (*See illustration part* 7.) This is made in large quantities and is offered at a specially low price	*r*	1	0	0
Part 11. Ditto.—⅔ in. focal length	*t*	2	10	0
Part 12. Ditto.—⅛ in. focal length	*t*	4	10	0
Part 13. Trough.—Mounted on 3 × 1 in. glass slide. Can be used as a cooling trough in micro-projection or filled with pond water, etc. for projection of animalculæ	*r*	0	3	0
Part 14. Projection Mirror.—For use when, with the projector horizontal, it is desired to project the image of the object on to the bench. A surface silvered mirror 3 in. square, protected by a transparent coating, mounted on a crank fitted to a standard stem. A metal sheath is provided to cover the mirror when not in use. The surface must never be cleaned with alcohol, petrol or any volatile solvent. Occasional light rubbing with soft cotton wool will suffice. The mirror is best preserved in a box containing absorbent paper impregnated with lead acetate	*r*	2	2	6



A 51-120. Part 25.

Part 25. Large Condenser for Lamphouse.—A plano-convex lens 38 mm. diam. It is mounted in a holder and replaces the standard condenser in certain experiments on colour mixing	*r*	1	0	0
Part 26. Achromatic Lens.—Convergent, 38 mm. diam., 10 cm. focal length, mounted in tubular holder on stem support	*r*	1	18	0



A 51-120. Parts 26, 47, 76, 77 and 78.

Please order by part numbers.

[*continued overleaf*

A 51-120. The Microid Universal Projector—*continued.*



A 51-120.—Parts 27 and 73.



A 51-120.—Parts 28 and 29.

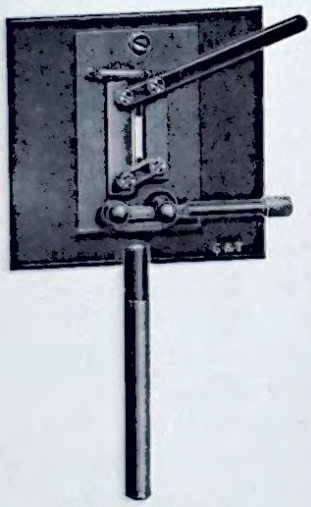


A 51-120.—Part 40.

	£	s.	d.
Part 27. Tripod Foot.—7½ in. high for supporting optical accessories at a distance from the projector .. .. *r*	0	13	6
Part 28. Primary Colour Filters.—Set of three, red, green and blue, mounted in metal tubes 2 in. long by 1⅛ in. diam., fitting over condenser mount on lamphouse (part 4) .. .. *r*	0	17	6
Part 29. Secondary Colour Filters.—Set of three, yellow, peacock blue and magenta, similarly mounted to part 28 .. .. *r*	0	17	6
Part 30. Tricolour Primary Filter.—Three overlapping filters mounted in metal tube ⅝ in. long by 1¾ in. diam. Used for subtractive colour mixing and fitting over large lamphouse condenser (part 25) .. .. *r*	0	14	0
Part 31. Tricolour Secondary Filter.—Similar to above but with yellow, peacock blue and magenta filters .. .. *r*	0	14	0
Part 40. Object Slide Holder.—Metal plate 3½ in. square, provided with 1 in. aperture and guides 2 in. apart into which the interference and diffraction accessories, parts 41 and 60 to 69, can be slipped. Mounted on stem .. .. *r*	0	19	0



A 51-120.—Part 41.



A 51-120.—Part 42.



A 51-120.—Part 45.

Part 41. Fixed Slit.—1 mm. wide on metal plate 3½ in. by 2 in. .. .. *r*	0	12	0
Part 42. Adjustable Slit.—Mounted on metal plate about 4 in. square, with stem. The slit is operated by a lever utilising the principle of the parallel ruler. It is pivoted to the plate near the top and can be rotated by means of a screw, through an arc of about 3 degrees on either side of its mean position .. .. *r*	3	0	0
Part 44. Flint Glass Prism.—Equilateral, 1¼ in. face, 1¼ in. high. Dense flint, optically worked faces $\mu_D = 1{\cdot}62$. Dispersive power C to F = 0·017. .. See **A 52-115**, p. 150.			
Part 45. Carbon Disulphide Prism, equilateral 50 mm. face, 35 mm. high. See **A 52-190**, p. 151.			

Please order by part numbers.

A 51-120. **The Microid Universal Projector**—*continued.*



A 51-120.—Part 46.



A 51-120.—Part 48.



A 51-120.—Part 50.

		£	s.	d.
Part 46.	**Prism Table.**—Circular metal plate 3 in. diam. mounted on standard stem	r 0	8	6
Part 47.	**Achromatic Lens.**—Convergent, 38 mm. diam., 15 cm. focal length, mounted in tubular holder and on stem support. (*See illustration part* 26.)	r 1	18	0
Part 48.	**Circular Screen.**—Metal, 3 in. diam. with $\frac{5}{16}$ in. hole, mounted on stem	r 0	8	6
Part 49.	**Offset Holder.**—Plated brass bar $2\frac{3}{8} \times \frac{1}{2} \times \frac{5}{8}$ in. with short metal stem for insertion into sliding foot, and hole with locking screw to take a standard stem. For use in projection of spectrum to place prism in path of beam and with Lloyd's Mirror. (*See illustrations page* 125 *and part* 70)	r 0	10	0
Part 50.	**Spectrum Gate.**—Metal plate $3\frac{1}{2} \times 3$ in. mounted on stem, with aperture $1\frac{3}{8} \times \frac{1}{2}$ in. Metal strips of various widths are included which can be clipped on the plate ..	r 1	7	6
	Skew prisms are available (*see* **A 52-180**) *for use with part* 50 *as recommended by Savage, Science Masters' Book, p.* 73.			
Part 51.	**Newton's Rings Apparatus.**—A long (100 cm.) focus lens and a glass plate 1 in. diam. are mounted together in a holder provided with a stem. The pressure between the lens and plate can be altered by means of three screws	r 1	13	0



60
A 51-120.



62
A 51-120.

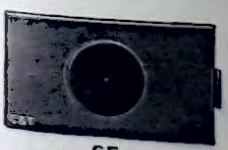


63
A 51-120.



64
A 51-120.

		£	s.	d.
Part 60.	**Single Wire Object.**—On metal plate $3\frac{1}{2} \times 2$ in., for sliding into object holder part 40	r 0	8	6
Part 61.	**Double Wire Object.**—On plate $3\frac{1}{2} \times 2$ in.	r 0	8	6
Part 62.	**Pin Object,**—On plate $3\frac{1}{2} \times 2$ in.	r 0	8	6
Part 63.	**Straight Edge.**—On plate $3\frac{1}{2} \times 2$ in., with straight edge covering half aperture in plate	r 0	8	6
Part 64.	**V Slit.**—On metal plate $3\frac{1}{2} \times 2$ in.	r 0	9	6



65
A 51-120.



66
A 51-120.



68
A 51-120.



69
A 51-120.

		£	s.	d.
Part 65.	**Circular Aperture Object.**—On metal plate $3\frac{1}{2} \times 2$ in., with aperture 0·018 in. diam. ..	r 0	8	6
Part 66.	**Gauze Grating.**—On metal plate $3\frac{1}{2} \times 2$ in. with aperture covered with 300 mesh gauze	r 0	10	6
Part 67.	**Poisson's Spot.**—On glass plate $3\frac{1}{2} \times 2$ in., with spot about 1·5 mm. diam.	r 0	5	0
Part 68.	**Zone Transmitting Plate.**—On metal plate $3\frac{1}{2} \times 2$ in., with five apertures which transmit first, first and second, etc. zones at a calculated distance from source	r 0	14	0
Part 69.	**Fresnel's Biprism.**—Mounted on metal plate $3\frac{1}{2} \times 2$ in.	r 2	2	6

Please order by part numbers.

[*continued overleaf*

A 51-120. The Microid Universal Projector—*continued.*

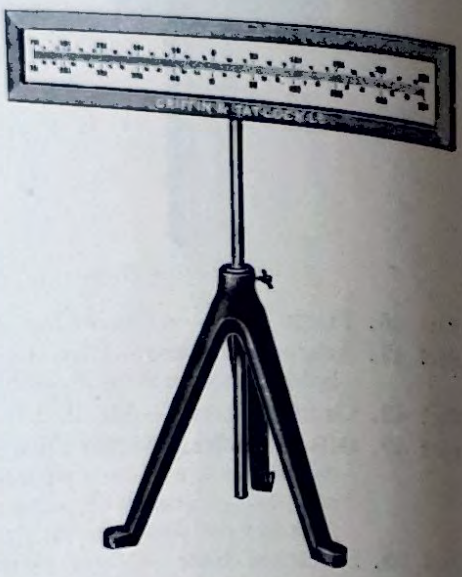


A 51-120.—Part 70—showing also Parts 5 and 49.



A 51-120.—Part 72.

A 51-120.—Part 74.



A 51-120.—Part 75.

	£ s. d.
Part 70. Lloyd's Mirror.—Aluminised surface glass mirror 9 × 2 in., mounted in metal frame on stem	r 1 7 6
Part 71. Combined Slits.—Cross, single, and double. Glass plate about 3½ × 2 in., with opaque coating ruled with cross, single, and double slits	r 0 5 0
Part 72. Screen.—Ground glass, 12 in. square, with metal frame mounted on stem	r 1 0 0
Part 73. Tripod Foot.—3½ in. high for support of part 72 (*See illustration part 27*)	r 0 13 6
Part 74. Lamphouse Aperture.—Metal tube with circular aperture 0·026 in. diam. replacing standard condenser mount on lamphouse	r 0 7 6
Part 75. Galvanometer Scale.—Translucent, graduated, with stainless steel rod on tripod	r 2 5 0
Part 76. Lens.—Convergent, 38 mm. diam., 100 cm. focal length, mounted in tubular holder and on stem support. (*See illustration part 26*)	r 0 17 6
Part 77. Lens.—Bi-concave, 38 mm. diam., about 20 cm. focal length, mounted in tubular holder and on stem support for auxiliary use with objective. (*See illustration part 26*)	r 0 17 6
Part 78. Lens.—Convergent, 38 mm. diam., 20 cm. focal length, mounted in tubular holder and on stem support. (*See illustration part 26*)	r 0 17 6

Please order by part numbers.

A 51-120. **The Microid Universal Projector**—*continued.*



A 51-120.—Part 79.



A 51-120.—Part 79a.



A 51-120.—Part 80

£ s. d.

Part 79. **Polariser or Analyser.** A pile of thin glass plates about 3 × 1¼ in. is fitted in a metal frame which, being mounted on pivots, can be inclined to the polarising angle. The frame is mounted in a metal tube provided with a milled flange about 2¼ in. diam. by which it may be rotated through 90° in a slotted outer tube supported on a stem of standard diameter. The stem is carried by the standard sliding foot (part 5). The polariser and the analyser are exactly similar .. .. *each* r 3 5 0

Part 79a. **Polariser or Analyser, Polaroid.** Polaroid film disc 1¼ in. diam., fitted in metal frame and rotatable through 90° in slotted outer tube supported on a stem of standard diameter .. .. *each* r 3 0 0

Part 80. **Slideholder and Rotator.** Designed to enable two Cellophane slides (part 81) to be supported simultaneously between the polariser and the analyser and to provide for convenient rotation of one of them with rapid interchange of either. A stem of standard (⅜ in.) diameter carries a tube about 2¼ in. diameter partially closed at one end by means of an annular ring. The ring is provided with two pairs of studs, the lines joining the pairs being mutually perpendicular. A spring clip for retaining the fixed slide is fitted. The holder for the rotating slide is of similar construction and slips into the tube supporting the fixed slide. A milled flange is attached so that the holder may easily be rotated .. .. r 3 10 0

Part 81. **Cellophane Slides.** Made from carefully selected and calibrated Cellophane and capable of use in an interesting range of experiments. The Cellophane is of uniform thickness and good transparency, giving bright and clear colours. The slides are mounted between glass plates 1¼ in. square having bound edges. They are labelled with data of path retardation for mean white light (λ = 5500 A.U.) and with directions of fast and slow axes marked. The axes are usually placed (except for slide H) at 45° to the edge of the slide, so that colours are shown when an edge of the slide is horizontal and when the vibrations in the polarised light are horizontal or vertical.

Slide ..	A	B	C	D	E	F	G	H	J	K	
Path Retardation in λ	0·25	0·30	0·40	0·53	1·1	3·1	10-step scheme each 0·30 λ		Geometrical designs		
	r 5/6	5/6	5/6	5/6	5/6	5/6	9/6	9/6	10/6	10/6	*each.*

£ s. d.

Part 82. **Ditto. Set of 12.** Comprising one each slides as in part 81, A, B, C, D, G, H, J, K, and two each E and F .. .. r 3 5 0

Please order by part numbers.

[*continued overleaf*

A 51-120. The Microid Universal Projector—*continued.*

EXPERIMENTAL NOTES

In the following notes there is described a selection of experiments which are of interest or importance in the study of light. The technique adopted is that which has been found most convenient in practice. The experiments marked with an asterisk in the list below are treated quantitatively.

Expt. I. Micro-Projection.
Expt. II. Projection of a Spectrum.
Expt. III. Additive Colour Mixing.
***Expt. IV. Projection of Newton's Rings (Reflected).**
***Expt. V. Projection of Newton's Rings (Transmitted).**
***Expt. VI. Projection of Young's Interference Fringes.**
***Expt. VII. Projection of Lloyd's Single Mirror Fringes.**
***Expt. VIII. Projection of Fresnel's Biprism Fringes.**
***Expt. IX. Diffraction by Circular Aperture (Huyghens' Zones).**
Expt. X. Dependence of Colour on Incident Light.
Expt. XI. Optical Illusion.
***Expt. XII. Diffraction by Gauze Grating (Parallel Light).**
***Expt. XIII. Diffraction by Gauze Grating (Convergent Light).**
Expt. XIV. Complementary Colours shown by Cellophane.
Expt. XV. Compensation of Path Retardation.

This list is by no means exhaustive. The user will find the Instrument adaptable to a great variety of experiments instructive to students at all stages.

For best results the 12 volt lamp should be **over-run at 14 volts** and the 6 volt at **7 volts** when a useful lamp life may be anticipated. The leads to the lamp should be kept as short as possible and the lamp filament should always be vertical. Resistances or transformers listed elsewhere in this Catalogue will be found extremely convenient. The lamp should be carefully centred.

To centre the lamp, slacken the three screws in the base plate of the lampholder, and support a plane white card about 4 in. in front of and normal to the axis of the condenser. When the filament is vertical a bright vertical rectangle will be seen with a less intense circular patch of illumination surrounding it. Adjust the lamp until the rectangle is brightest and central so that circular patch is evenly illuminated. Tighten the three screws again carefully, avoiding movement of the lamp base relative to the lamp body.

Expt. I.—Micro-Projection

A 51-120. Parts required :—1 each Nos. 1, 2, 4, 7, 8, 9, 10.
2 of No. 5.

The T-section bed should be placed centrally in position on the base and the lamphouse at the end of the bed which contains the levelling screw. A screen is provided, on one side with clips for the support of a cell which may be used either as a cooling trough or for holding animalculæ, and on the other side with clips in which the micro-slide is placed. The objective is a standard microscope objective, with R.M.S. thread.

The position of the slide-holder is regulated by the focal length of the objective employed. For long focal length objectives, *e.g.*, 32 mm., place the slide so that it is almost in contact with the condenser on the lamphouse. For short focal length objectives, *e.g.*, ⅛ in., place the slide so that the beam from the condenser converges at it. For objectives of focal lengths between those specified, use intermediate positions. Coarse adjustment of the objective is effected by moving it along the bed and fine adjustment by means of the stem running in the spiral track. The distance of projection will vary according to the nature of the preparation but 12 ft. may be regarded as a good average distance.

The condenser system is suitable for use with objectives up to ¼ in. for the resolution of fine structures.

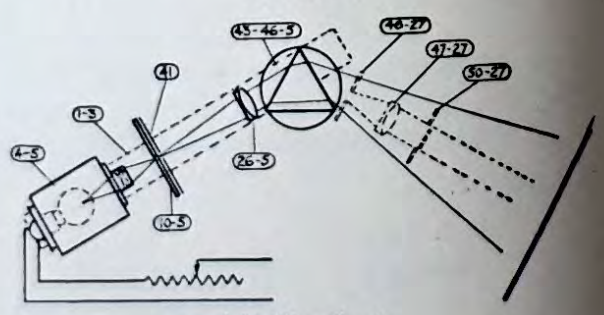


A 51 120.—Assembly for Micro-Projection.

For those who do not care to use a ⅛ in. objective, an ordinary bi-concave lens 1½ in. diam. and about 20 cm. focus, to be placed 2 to 3 in. in front of the objective in use, may be recommended. The magnification is thus increased by 30 to 40 per cent. Such a lens, mounted on the standard holder, is listed as part 77. In using this auxiliary lens care should be taken to place it so that the cone of light from the objective does not overlap the edges of the lens. After the lens is placed in position the system will of course require re-focussing. This should be done, not by moving the lens, but by adjustment of the objective.

Expt. II.—Projection of a Spectrum.

A 51-120. Parts required :—1 each Nos. 1, 3, 4, 42, 45, 46, 47, 48, 49, 50.
2 each Nos. 26, 27.
4 of No. 5.



A 51-120.—Fig. 1.

Assemble the projector with the lamp at the end of the bed. Mount a slit and an achromatic lens in sliding feet on the bed. Adjust the condenser and slit to give on the back of the slit, a real image of the filament the same size as the object. Adjust the width of the slit to about 1 mm. and turn the lamphouse to bring the image on the slit. Focus the image of the slit, by means of the achromatic

A 51-120. The Microid Universal Projector—*continued.*

lens, on to a screen placed at the same distance as that on which the spectrum is to be projected.

To get the prism into the path of the beam an offset holder and prism table mounted in a sliding foot are necessary. Refer to illustration of Lloyd's Mirror Assembly on page 125 for method of use of offset holder. A good spectrum is obtained by use of a hollow prism filled with carbon disulphide (part 45).

Place the prism on the table, rotate it into the path of the beam and the position of minimum deviation. The purity of the spectrum is improved, at the expense of some intensity of illumination, by narrowing the slit.

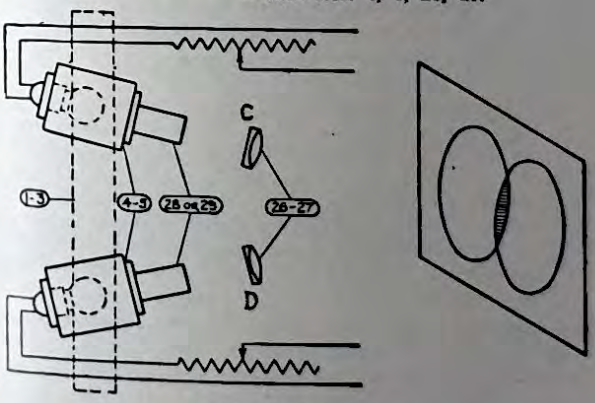
If a rheostat be included in the lamp circuit, the current passing through the filament may be gradually reduced and the colour of the light emitted will change accordingly. The order of disappearance of the spectral colours may then be noted as well as the persistence of the red when the lamp is nearly out. Filters may be tested for transmission by placing them in the path of the refracted beam.

The spectrum gate may now be employed, using the arrangement shown dotted in the figure. Place in the beam emergent from the prism, the circular screen (part 48) and the 15 cm. achromatic lens (part 47), both mounted on tripod feet. Adjust the position of the lens to illuminate the screen. Place a piece of white card in the beam. Near the lens a position will be found where a small intense spectrum is formed. Replace the card with the spectrum gate, mounted on tripod foot. By various combinations of the strips of metal of different widths supplied with the gate, any colour or colours may be removed from the spectrum. The colour of the patch on the screen then changes from white, to a colour complementary to those removed.

Skew prisms are available (see **A 52-180**) *for use with the spectrum gate as recommended by Savage,* Science Masters' Book, Series I, Part 1, *p.* 73.

Expt. III.—Additive Colour Mixing.

A 51-120. Parts required :—1 each Nos. 1, 3, 28, 29.
2 each Nos. 4, 5, 26, 27.



A 51-120.—Fig. 2.

Arrange the apparatus as in fig. 2, C and D being two 10 cm. achromatic lenses mounted on tripod feet placed about 10 cm. in front of the lamps and focussed to give overlapping circles of illumination on the screen. Fit a gelatine filter to the front of each condenser lens system. The rheostats are important where convincing results are required, although slight adjustment of intensity is possible by throwing one or other of the circles out of focus. With red and green filters it is immediately seen that, by direct addition

Red + Green = Yellow.

The particular shade of yellow may be altered by adjusting the rheostats and consequently the proportion in which the colours are mixed. The use of other filters will establish the following equations :—

Red + Blue = Magenta ; Green + Blue = Peacock Blue.

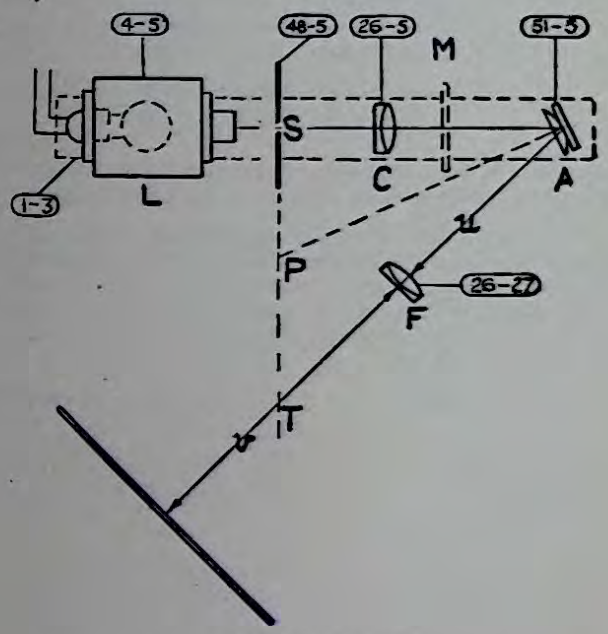
Additive mixing may be carried out using the secondary colours magenta, peacock blue and yellow, with the corresponding primary colour.

Yellow (R + G) + Blue = WHITE.
Magenta (R + B) + Green = WHITE.
Peacock Blue (G + B) + Red = WHITE.

Pure whites are always difficult to obtain in this way since gelatine filters of reasonable price are not sufficiently monochromatic and in addition high class monochromatic filters transmit too little light.

Expt. IV.—Projection of Newton's Rings by Reflected Light.

A 51-120. Parts required :—1 each Nos. 1, 3, 4, 27, 48, 51.
2 of No. 26.
4 of No. 5.



A 51-120.—Fig. 3.

Assemble the apparatus on the bed of the projector as shown in fig. 3, using the end position of the bed. Focus the lamp and move the screen S so that the beam from the condenser converges at S. Focus the lens C by means of a plane mirror M placed behind it and use the method of return rays to produce a parallel beam (see Expt. V.). Turn the lens and plate mounting A to reflect light on to the screen. Adjust the pressure screws of the lens and plate mounting to give a black central ring. Avoid unequal distribution of the pressure between lens and plate. Focus the rings on the scale or screen placed at about 2 metres or more distant, by means of the lens F which is mounted on a tripod foot.

An alternative method for the production of brighter rings and more intense illumination of the screen, may be adopted. Remove the circular aperture S and the lens C and move the lamphouse so that the beam from it converges at A. Avoid forming an image of the filament at A or the projection of it by F will tend to overpower that of the ring system.

In treating the experiment quantitatively it is necessary to know the angle of incidence on the lens A. It is sufficient for this purpose to measure with a metre rule the distances ST and SA. Thus, is obtained tan $2i$ from which $2i$ and therefore i may readily be found.

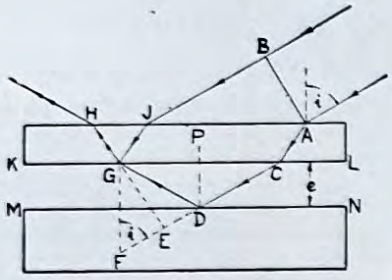
The high magnification produces rings of appreciable width. The diameter therefore of a ring of one particular colour should be measured. Red or green are suitable colours. Measure the diameter of about the fifth projected ring. Measure the distance u and v of the object and image from the lens F.

[*continued overleaf*

A 51-120. The Microid Universal Projector—*continued.*

In Newton's Rings, the central bright and dark rings are regarded as the zero bright and zero dark rings. In fringe systems, an interference band is regarded as composed of a bright and a dark band. Hence the central fringe consists of the bright band, corresponding to equality of optical paths, and the dark band on one side of it. In all formulæ this dark band is counted the zero dark band.

Theory.



A 51-120.—Fig. 4.

Since the lens has a large radius of curvature, an element of the film may be treated as being bounded by two parallel surfaces.

Let KL and MN be the surfaces of the lens and plate respectively, separated by a distance e, the thickness of the film. AB is a plane wave front incident on the plane face of the lens. A ray incident at A is refracted to C, reflected at D and emerges along GH, along which also a ray from the portion B of the wave front, is reflected at G after refraction at J.

Draw GE perpendicular to CD produced. Draw GF perpendicular to MN. Then $P\hat{D}C = G\hat{F}D$ and CD = DG = DF and GF = $2e$.

Light reaches E from A and G from B simultaneously. Thus the difference of path at G is DG — DE which equals EF.

$$EF = GF \cos G\hat{F}E. \qquad EF = 2e \cdot \cos i.$$

A phase difference of π, equivalent to a path difference of $\lambda/2$ is introduced, since the reflection at G is in glass from air and that at D is in air from glass.

The whole path difference is thus $2e \cos i + \lambda/2$. Where the lens is in contact with the glass, $e = 0$ and for a small distance around, a dark ring is formed. Moving outwards light and dark rings are found, due to changes in e.

The zero ring therefore occurs when $2e \cos i + \lambda/2 = \lambda$.
The first ,, ,, ,, ,, $2e \cos i + \lambda/2 = 2\lambda$.
The nth ,, ,, ,, ,, $2e \cos i + \lambda/2 = (n + 1)\lambda$.

$$\therefore 2e \cos i = (2n + 1)\lambda/2 \quad . \quad . \quad . \quad (1)$$

The ring system on the screen is magnified by the lens **F** (fig. 3). The size of the rings is obtained by application of the formula

$$\frac{i}{o} = \frac{v}{u} \text{ or } o = \frac{iu}{v} \quad . \quad . \quad . \quad . \quad (2)$$

If R be the radius of curvature of the plano-convex lens and r the radius at A (fig. 3) of the ring measured on the scale, r being equal to o in equation (2), then :—

$$e = \frac{r^2}{2R} \text{ (see Expt. V)} = \frac{i^2u^2}{2v^2R}. \quad . \quad . \quad (3)$$

The condition for a bright ring is $2e \cos i = (2n + 1)\lambda/2$.

$$\therefore \lambda = \frac{4e \cos i}{(2n + 1)} \quad . \quad . \quad . \quad . \quad (4)$$

and substituting for e in (4) from (3)

$$\lambda = \frac{2i^2u^2 \cos i}{v^2 R (2n + 1)} \text{ cm.}$$

Specimen Result.

To find angle of incidence AS = 23 cm. (fig. 3).
ST = 13·58 cm.
$\therefore$ Tan $2i$ = 0·5904 $\quad 2i = 30° 36'$ $\quad i = 15° 18'$.
Radius of curvature of the lens at A (fig. 3) .. (R) = 104·4 cm.
Distance of lens A from projection lens F .. (u) = 10·5 cm.
Distance from lens F to screen .. .. .. (v) = 220·0 cm.
Mean radius of 3rd projected ring, red .. .. (i) = $3{\cdot}4_5$ cm.

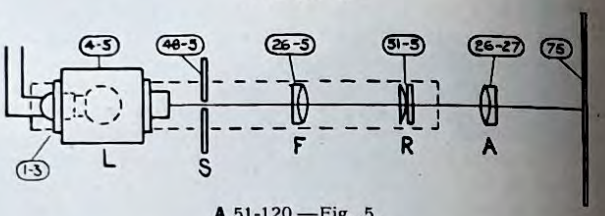
$$\lambda = \frac{2 \times (3{\cdot}4_5)^2 (10{\cdot}5)^2 \times \cos 15° 18'}{(220)^2 \times 104{\cdot}4 \times 7}.$$

λ (mean red) = $7{\cdot}2 \times 10^{-5}$ cm.

From Kaye & Laby; *Tables of Physical and Chemical Constants.* $\lambda = 7{\cdot}1 \times 10^{-5}$ cm. for mean red.

Expt. V.—Projection of Newton's Rings by Transmitted Light.

A 51-120. Parts required :—1 each Nos. 1, 3, 4, 27, 48, 51, 75.
2 of No. 26.
4 of No. 5.



A 51-120.—Fig. 5.

Mount the lamphouse **L**, circular aperture **S**, achromatic lens **F** and the combined lens and plate **R** in sliding feet on the bed of the projector. Adjust the lamphouse until the aperture **S** is strongly illuminated. A parallel beam is required from the lens **F**. Support a piece of plane mirror behind **F** and adjust the position of **F** until a sharply focussed image of **S** is formed at the side of the aperture. A parallel beam of light now falls on the plano-convex lens and plate **R**.

View **R** from the side nearer **F** and adjust the screws in the mounting of **R** until, with as little pressure as possible on the lens, the system of reflected rings is seen with a dark centre. Focus the system of transmitted rings on to the screen or a galvanometer scale by means of the lens **A** (10-15 cm. focal length) which should be mounted on a tripod foot.

It should be noted that—

(*a*) It is important to see that the surfaces of the lens and plate which are in contact are clean. They are readily cleaned by a piece of soft cloth moistened with alcohol.

(*b*) The pressure screws on the lens mounting should not be screwed up more than is just sufficient to provide a dark centre to the ring system. Further, they should be screwed up to transmit the pressure evenly. Unequal tightening distorts the series of complete circles of which the rings should consist.

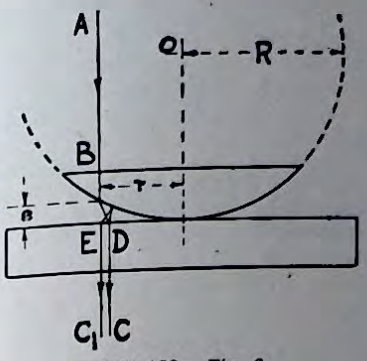
It is interesting to note that although, normally, the transmitted ring system is much less intense than the reflected system yet the rings projected as described are visible in dull daylight and in a room illuminated not too brightly by artificial light. In a totally darkened room, the rings are not improved very much in intensity.

For **quantitative** results, sufficient light is available for an approximate measurement of the wavelength of, for example, red light. The central ring is usually white when the lens **R** has a radius of curvature of about 1 metre, but with rings of higher order the red becomes more pronounced. If any difficulty be experienced in deciding the number of a ring a red filter fitted to the lamphouse, although it will reduce the intensity of illumination so far that actual diameters cannot be measured, yet will be of considerable assistance in deciding the number of the ring.

Better results may be obtained for demonstration purposes by omitting the lens **F** and concentrating as much light as possible from the condenser of the lamp, through the aperture **S** on to the lens **R**. Even better results may be obtained by replacing **F** by a $\frac{1}{2}$ in. objective, mounted in special objective holder such as is used on the micro-projector assembly. (**Expt. I.** Parts 7, 8, 11.)

A 51-120. The Microid Universal Projector—*continued.*

Theory.

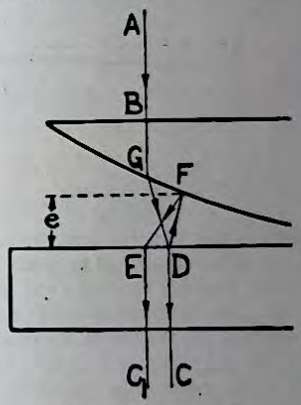


A 51-120.—Fig. 6.

In fig. 6 let O be the centre of curvature of the back surface of the lens and R its radius of curvature. Let r be the radius of the interference ring and e the thickness of the air film at the point of incidence.

Consider the case when light is incident normally on the plane surface of the lens.

Of any incident ray AB, a portion emerges along DC and a portion along EC_1. Since the thickness e of the film is small, DC can be considered as being a continuation of AB. Similarly the portion emerging along EC_1 can be considered as coincident with the directly transmitted portion DC.



A 51-120.—Fig. 7.

Dependent upon the additional length of path DFE travelled (see fig. 7), this reflected ray may be in or out of phase with the portion DC. Since the film is very thin we may write $DF = e$. Then extra path travelled by $EC_1 = 2e$.

By geometry $r^2 = e(2R - e) = 2Re - e^2$.

We may neglect e^2 as being a small quantity of the second order.

$$\therefore e = \frac{r^2}{2R} \quad .. \quad .. \quad .. \quad (1)$$

Since there are two similar reflections at D and F (fig. 7) in the path of the ray EC_1 in travelling from B to C_1 any difference of phase can alter the effective length of path only by λ and not by any odd multiple of $\lambda/2$. Hence for the

zero bright ring $2e = 0$
first ,, ,, $2e = \lambda$
nth ,, ,, $2e = 2n\lambda/2$ .. .. (2)

Now the ring system at R (fig. 5) is magnified by the lens A. The actual radius of the ring may be found by application of the usual lens formula

$$\frac{i}{o} = \frac{v}{u}$$

$$\therefore o = \frac{iu}{v}, \text{ where } o \text{ corresponds to the } r \text{ in fig. 6 and equation (1)} \quad (3)$$

From (1) and (2) $\frac{2r^2}{2R} = 2n\lambda/2$ and from (3) $\lambda = \frac{i^2u^2}{v^2Ru}$.

Specimen Result.

Radius of curvature of lens (Spherometer).

Let C be radius of circumcircle of the legs of the spherometer, h the movement of the central leg and R the radius of curvature of the lens, then $R = \frac{C^2 + h^2}{2h}$.

By measurement $C = 1{\cdot}77$ cm. and $h = 0{\cdot}015$ cm.

$$R = \frac{(1{\cdot}77)^2 + (0{\cdot}015)^2}{2 \times 0{\cdot}015} = 104{\cdot}4 \text{ cm.}$$

To find the diameter (2r) of the rings.

No. of Ring.	Scale Reading cm.		Diameter. cm.
	Left.	Right.	
1	$4{\cdot}1_0$	$1{\cdot}4_5$	$2{\cdot}6_5$
2	$4{\cdot}3_7$	$1{\cdot}1_5$	$3{\cdot}2_2$
3	$4{\cdot}6_1$	$0{\cdot}8_7$	$3{\cdot}7_4$
4	$4{\cdot}8_5$	$0{\cdot}6_5$	$4{\cdot}2_0$

Radius of 4th Projected ring (i) .. .. = $2{\cdot}1_0$ cm.
Distance from lens R to lens A (u) .. .. = 14·8 cm.
Distance from lens A to screen (v) .. .. = 182·5 cm.

$$\lambda = \frac{(2{\cdot}1_0)^2 \times (14{\cdot}8)^2}{(182{\cdot}5)^2 \times 104{\cdot}4 \times 4} \text{ cm.}$$

λ (mean red) $= 6{\cdot}9 \times 10^{-5}$ cm.

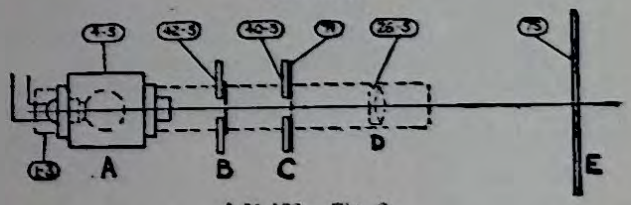
Kaye & Laby give $7{\cdot}1 \times 10^{-5}$ cm. for mean red.

Expt. VI.—Projection of Young's Interference Fringes.

This experiment is of historical importance as being associated with the development of the Wave Theory of light and its acceptance, with the ultimate overthrow of the Emission Theory.

In its original form the experiment was performed by Young in 1807, but the method adopted here is simpler and is Rayleigh's modification described in 1893. Even with this apparatus, however, it is difficult to pass sufficient light through the narrow slits which must be used, to project convincing fringes at a distance greater than 1-2 metres. It is, therefore, suggested that no attempt should be made to project fringes visible to a whole class, but to confine the demonstration to groups of about half a dozen or so at one time.

A 51-120. Parts required :—1 each Nos. 1, 3, 4, 26, 40, 42, 71, 75. 4 of No. 5.



A 51-120.—Fig. 8.

Mount the lamphouse A, adjustable slit B and double slit C in object holder, on the bed of the projector. Place a translucent galvanometer scale E at the projection distance recommended above. If quantitative results are not required, a ground glass screen should be used. Centre the lamp carefully (see p. 132). Adjust the distance of the slit to produce an image of the filament, the same size as the object, on the rear of the jaws. A distance of 5-10 cm. between B and C is suitable.

Place the receiving screen about 20-30 cm. from the double slit C and effect parallelism of B and C, observing the image on the screen meanwhile. Adjust the opening of the jaws of B until the fringes

[*continued overleaf*

A 51-120. The Microid Universal Projector—*continued.*

come into best definition. The screen E can now be moved to a distance of 1-2 metres, depending upon the intensity of the fringes and slight final adjustments can be made.

If a voltage in excess of the recommended lamp voltage (14 volts) is available, a rheostat can be included in the circuit and the lamp still further over-run at 15 volts for the few minutes while measurements are being taken.

In some experiments, the central fringe appears white and colour appears in the bright fringe on either side. If a green filter be then placed on the condenser, it will be found that although the general illumination is low, yet the fringes can be located with a greater degree of certainty than is possible with white light. The fringes having been identified and the first feeble green having been recognised as (in this case) the second bright fringe, it is possible to measure the total width of 6-10 fringes without the necessity of using the green filter. In adopting this method it should not be overlooked that the central white fringe should be counted in with the green fringes.

The distance apart of the double slits may be measured by a vernier microscope. Alternatively, since a scale is already set up, a convenient and instructive method is to insert a convex lens D (part 26) of 10 cm. focal length, between C and E and to use the relationship $\frac{i}{o} = \frac{v}{u}$. The green filter may be used for this and the illumination will be sufficiently great to enable the screen to be placed at 3-4 metres from the slits.

Theory.



A 51-120.—Fig. 9.

Let S_1 and S_2 represent the two slits, at a distance d apart and PP_1 the screen, distant y from S_1S_2.

Let OP be the perpendicular bisector of S_1S_2.

Disturbances in phase at S_1 and S_2 reach P in phase since they travel over equal paths S_1P and S_2P.

The effect at P_1 depends upon the path difference $S_2P_1 - S_1P_1$.

If this difference be an integral number of wavelengths, *i.e.*, λ, 2λ, ... $n\lambda$, the waves from S_1 and S_2 reinforce and there is a bright band at P_1.

If, however, $S_2P_1 - S_1P_1$ be an odd number of half wavelengths, *i.e.*, $\lambda/2$, $3\lambda/2$, . . . $(2n + 1)\lambda/2$, $(n = 0, 1, 2 . . . . n)$, the waves interfere and there is a dark band at P_1.

In the following, P_1 is treated as the position of the first bright fringe, P_1P the combined width of one bright and one dark fringe and $S_2P_1 - S_1P_1 = \lambda$. From the figure :—

$$(S_2P_1)^2 = y^2 + \left(x + \frac{d}{2}\right)^2 \quad \text{and} \quad (S_1P_1)^2 = y^2 + \left(x - \frac{d}{2}\right)^2$$

i.e. $(S_2P_1)^2 = y^2 + x^2 + xd + \frac{d^2}{4}$ and $(S_1P_1)^2 = y^2 + x^2 - xd + \frac{d^2}{4}$

By subtraction

$$(S_2P_1)^2 - (S_1P_1)^2 = 2xd$$

and

$$S_2P_1 - S_1P_1 = \frac{2xd}{S_2P_1 + S_1P_1}.$$

Since x and d are small compared with y, we may write

$$S_2P_1 + S_1P_1 = 2y.$$

Hence

$$S_2P_1 - S_1P_1 = \frac{xd}{y} = \lambda.$$

$$\therefore \lambda = \frac{\text{fringe width} \times \text{slit width}}{\text{distance of projection}}$$

The distance between the fixed slits, using a convex lens, is as given above, $o = \frac{iu}{v}$ where $o = d$.

Hence

$$\lambda = \frac{\mathbf{x \,.\, i \,.\, u}}{\mathbf{yv}} \text{ cm.}$$

Specimen Result.

Width of 7 bright and 7 dark fringes	..	..	= 1·1$_2$ cm.
Width of 1 bright and 1 dark fringe	(x)	..	= 0·16 cm.
Distance of projection	.. ..	(y)	.. = 62·0 cm.
Width of image of slits	.. ..	(i)	.. = 0·45 cm.
Distance of object	.. .. ..	(u)	.. = 5·0 cm.
Distance of image	.. .. ..	(v)	.. = 118·0 cm.

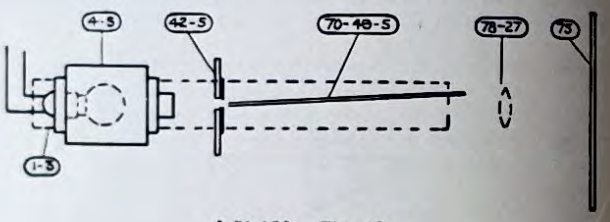
$$\lambda = \frac{0{\cdot}16 \times 0{\cdot}45 \times 5}{62 \times 118}.$$

$$\lambda \text{ mean green} = \mathbf{4{\cdot}9 \times 10^{-5}} \text{ cm.}$$

Kaye & Laby give $5{\cdot}50$ to $4{\cdot}92 \times 10^{-5}$ cm. for green light.

Expt. VII.—Projection of Lloyd's Single Mirror Fringes.

A 51-120. Parts required :—1 each Nos. 1, 2, 4, 27, 42, 49, 70, 75, 78, 3 of No. 5.



A 51-120.—Fig. 10.

This assembly is illustrated on page 125. Mount the lamphouse and the adjustable slit on the bed of the projector. Focus the lamp so that an image of the filament the same size as the object, falls on the back of the slit. Use an offset holder to support the Lloyd's mirror in a sliding foot and set the mirror approximately parallel to the axis of the bed : the offset holder is used to obtain a condition of grazing incidence of the beam from the slit on the mirror. The distance between the slit and its image must be small—a few hundredths of a centimetre only. (Fringe systems other than the true Lloyd's system may be obtained when this distance is large.)

To adjust the distance between the slit and its image, turn the mirror either about its stem or about the stem of the offset holder, or both, until, to an eye placed approximately normally to the slit, the slit and its image are seen side by side. They will not then necessarily be parallel. Rotate the slit until the two appear to be parallel. It may then be necessary to readjust the mirror so that the correct distance of separation given above, is obtained between the slit and its image.

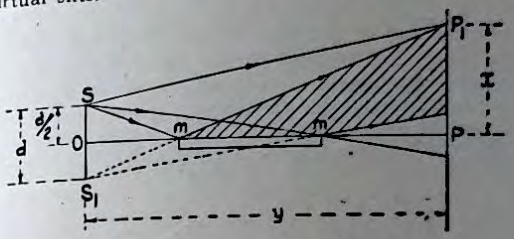
Little difficulty should now be experienced in identifying the interference pattern, after which the slit may be opened until fringe definition is just beginning to be affected. The fringes should be visible on a translucent screen, the projection distance recommended being between 1 and 2 metres. An additional change of phase occurs, equivalent to a path difference of half a wavelength, due to reflection and the half interference pattern is correspondingly displaced.

For **quantitative** results, the white light fringes are sufficiently definite to enable direct measurements to be taken without the necessity for the introduction of a filter. A translucent galvanometer scale forms a convenient graduated screen for projection. A simple technique is to set one of the gradations of the screen on one side of a green fringe. Regarding this as the fiducial point, the distance to the corresponding point on the second or third fringe should be

A 51-120. The Microid Universal Projector—*continued.*

read off on the scale as accurately as possible, at the same time recording the projection distance.

To find the distance between the real and virtual sources a convex lens (shown dotted in fig. 10) is used in conjunction with a green filter to give a magnified image at a distance of 3 to 4 metres. The lens part 78 is suitable. The image of the real slit will probably be more distinct than that of the virtual one. The distance measured should be that between the centres of the two green images. Application of the usual lens formula $\frac{i}{o} = \frac{v}{u}$ gives the distance between the real and virtual slits.



A 51-120.—Fig. 11.

Let S and S_1 be the real and virtual sources respectively distant d apart.

Let P be the point at which the perpendicular bisector OP of SS_1 meets the screen PP_1.

Let MM be the mirror

The general condition for interference at P_1 is, as in Expt. VI, that $S_1P_1 - SP_1 =$ any odd number of half wavelengths, *i.e.*, $\lambda/2, 3\lambda/2, 5\lambda/2$, etc. . . . . (1)

Now although the path from S to P_1 via the mirror is geometrically the same as that from S_1 to P_1 ($SM = S_1M$) it is not optically the same for the rays reflected at MM suffer a change of phase of π equal to a path difference of $\lambda/2$.

Equation (1) above then becomes $S_1P_1 - SP_1 = 0, \lambda, 2\lambda$, etc. which is the condition for reinforcement at P_1.

Hence when $S_1P_1 - SP_1 = \lambda$ we have a bright band at P_1 and the band is displaced by half the interval of a band width from the mirror edge.

From the figure :—

$$(S_1P_1)^2 = y^2 + \left(x + \frac{d}{2}\right)^2 \text{ and } (SP_1)^2 = y^2 + \left(x - \frac{d}{2}\right)^2$$

$$\therefore \quad (S_1P_1)^2 - (SP_1)^2 = 2xd$$

and

$$S_1P_1 - SP_1 = \frac{2xd}{S_1P_1 + SP_1}.$$

Since x and d are small compared with y we may write

$$S_1P_1 + SP_1 = 2y.$$

Hence $S_1P_1 - SP_1 = \frac{xd}{y} = \lambda$ (taking into account the phase change on reflection)

$$\therefore \lambda = \frac{\text{fringe width} \times \text{slit width}}{\text{distance of projection}}.$$

The distance between the real and virtual slits using a convex lens is as given above, $a = \frac{iu}{v}$ where $a = d$.

$$\text{Hence } \lambda = \frac{x \cdot i \cdot u}{yv} \text{ cm.}$$

Probably the greatest source of error in the above is the measurement of i. With care, however, the demonstration value for λ can be obtained sufficiently closely to the accepted value, for the experiment to be convincing.

Specimen Result.

Width of 2 green and 2 dark fringes ..	..	=	0·59 cm.
Width of 1 green and 1 dark fringe (x)	..	=	$0{\cdot}29_5$ cm.
Distance of projection .. .. (y)	..	=	149·0 cm.
Width of image of slits .. .. (i)	..	=	0·38 cm.
Distance of object .. .. (u)	...	=	25·1 cm.
Distance of image .. .. (v)	..	=	344·0 cm.

$$\lambda = \frac{0{\cdot}295 \times 0{\cdot}38 \times 25{\cdot}1}{149 \times 344}$$

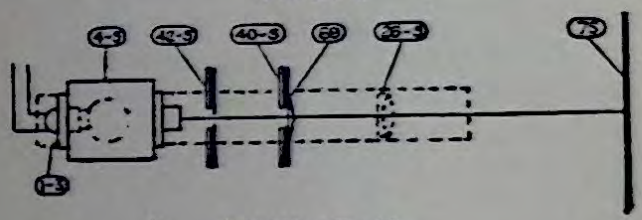
$$\therefore \lambda \text{ (mean green)} = 5{\cdot}5 \times 10^{-5} \text{ cm.}$$

Kaye & Laby give $5{\cdot}2 \times 10^{-5}$ cm. for mean green.

Expt. VIII.—Projection of Fresnel's Biprism Fringes.

This experiment was devised by Fresnel to meet the objectors to Young's experiment who said that the properties of the light passing through the pinholes which Young used were modified and that interference fringes were not obtained. The experiment is described quantitatively and values for λ can be obtained to an accuracy of about $\pm$ 5 per cent. Greater accuracy is possible, but this, involving the use of a micrometer eyepiece, is less convincing to young students than the fringes seen on a screen by the eye.

A 51-120. Parts required :—1 each Nos. 1, 3, 4, 26, 40, 42, 69, 75. 4 of No. 5.



A 51-120.—Fig. 12.

Mount the lampnouse, adjustable slit, and biprism in object holder, on the bed of the projector. See that the lamp is centred (see p. 132 for this adjustment) and move the slit so that an image of the filament about the same size as the object, is focussed on the back of the slit.

Place the eye on the axis of the system and slide the biprism in the object holder so that the beam from the slit strikes the apex of the biprism symmetrically. The most important adjustment is that of setting the biprism and slit parallel. Adjust the screw on the slit until, on moving the eye from side to side, the whole length of the image of the slit disappears simultaneously. The slit is now parallel to the apex of the refracting angle of the biprism and its width should be adjusted to bring the fringes into best definition, it is described in standard text books that the central fringe is white. In the course of experiments conducted with this and other more elaborate apparatus, a white central fringe has not always been obtained. No explanation of this hitherto undescribed phenomenon is yet forthcoming.

It may be found that, even though the fringes are well defined, a student 20 feet away will not see them as clearly as he would if they were less well defined and were made brighter by opening the slit. In such cases it must be left to the lecturer to effect a compromise giving the best general results.

For quantitative measurements a translucent galvanometer scale placed about 150 cm. from the biprism will be found convenient. A filter should be placed over the condenser mount. The width of as many fringes as possible should be read off on the scale, estimating to the smallest convenient fraction of a millimetre.

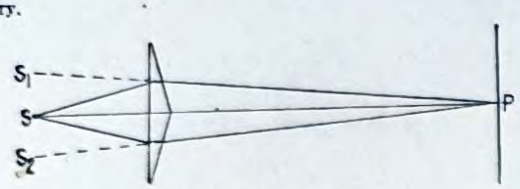
Measurement of the distance between the virtual slits is most conveniently accomplished by means of a convex lens shown dotted in fig. 12, inserted between the biprism and the galvanometer scale

[*continued overleaf*

A 51-120. The Microid Universal Projector—*continued.*

removed to 4-6 metres. The distance between the slit and biprism must not be altered. By application of the usual lens formula $\frac{i}{o} = \frac{v}{u}$ the distance o can readily be evaluated.

Theory.



A 51-120.—Fig. 13.

The biprism has a very small refracting angle. Light diverges from the slit S (fig. 13) through both parts of the prism and appears to come, after refraction, from S_1 and S_2. S_1 and S_2, therefore, follow the changes of phase of S and are, therefore, two similar sources—one of the conditions for interference between them. The presence of the biprism can now be ignored and the problem treated as a special case of Young's interference (Expt. VII). In Fresnel's experiment, interference takes place between two **virtual** slits.



A 51-120.—Fig. 14.

Referring to fig. 14 :—

Let x = width of one dark + one bright band.
d = Distance between S_1 and S_2.
y = Distance of projection.

Then $(S_2P_2)^2 = y^2 + \left(x + \frac{d}{2}\right)^2$ and $(S_1P_1)^2 = y^2 + \left(x - \frac{d}{2}\right)^2$.

$$(S_2P_2)^2 - (S_1P_1)^2 = 2xd$$

$$S_2P_2 - S_1P_1 = \frac{2xd}{S_2P_2 + S_1P_1}$$

and since x and d are small compared with y, we may write

$$S_2P_2 + S_1P_1 = 2y.$$

$$\therefore S_2P_2 - S_1P_1 = \frac{xd}{y}$$

Also, since x equals one complete fringe width,

$$S_2P_2 - S_1P_1 = \lambda$$

$$\therefore \lambda = \frac{xd}{y}.$$

The distance between the virtual slits using a convex lens is, as given above, $d = \frac{iu}{v}$ where $i = d$.

$$\therefore \lambda = \frac{x \cdot i \cdot u}{yv} \text{ cm.}$$

Specimen Result.

Width of 5 green + 5 dark fringes	..	..	=	0·81 cm.
Width of 1 green + 1 dark fringe (x)	..	..	=	0·16 cm.
Distance of projection	..	.. (y)	..	= 150·0 cm.
Width of image of slits	..	.. (i)	..	= 1·55 cm.
Object distance	..	.. .. (u)	..	= 10·4 cm.
Image distance	..	.. .. (v)	..	= 331·0 cm.

$$\therefore \lambda = \frac{0{\cdot}16 \times 1{\cdot}55 \times 10{\cdot}4}{331 \times 150}$$

λ (mean green) = $5{\cdot}2 \times 10^{-5}$ cm.

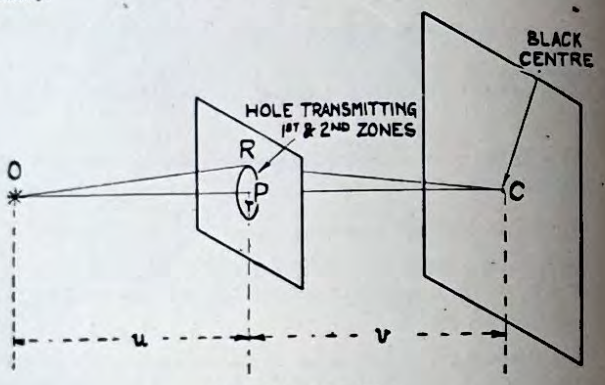
Keys & Leahy give λ (mean green) = $5{\cdot}10$ to $4{\cdot}92 \times 10^{-5}$ cm.

Expt. IX.—Diffraction by Circular Aperture (Huyghens' Zones).

A 51-120. Parts required :—1 each Nos. 1, 3, 4, 5, 27, 40, 68, 72, 73, 74.

Remove the condenser lens system from the lamp body and replace it by a diaphragm (part 74) with a small aperture which should be as close to the lamp as possible. Place the zone plate (part 68) in the object holder (part 40) supported on tripod foot (part 27) and about 250 cm. from pinhole source. The sizes of the holes transmitting the first and subsequent zones are calculated for these distances. Place a ground glass receiving screen (part 72) about 250 cm. from the zoneplate and adjust it to obtain clearest fringes. It may be found that little difference in the result is observable for a movement of 10 cm. and it might therefore be thought that the adjustment would be more critical if a monochromatic filter were interposed. This has been tried but it is found that the intensity is then so much reduced that the Huyghens' Zone cannot be located within 50 or more cm. Thus white light must be used and a mean value of λ calculated.

Theory.



A 51-120.—Fig. 15.

Let u = Distance from source to aperture (OP).
,, v = Distance from aperture to screen (PC).
,, r = Radius of hole transmitting 1st and 2nd zones (PR).

Then $OR^2 = u^2 + r^2$

$$OR = u\left[1 + \frac{r^2}{u^2}\right]^{\frac{1}{2}}.$$

Expanding by the binomial theorem and neglecting higher powers of r than r^2 :—

$$OR = u\left[1 + \frac{r^2}{2u^2}\right]$$

$$\text{Similarly } RC = v\left[1 + \frac{r^2}{2v^2}\right]$$

$$\therefore OR + RC = u + \frac{r^2}{2u} + v + \frac{r^2}{2v}$$

$$\text{and } OP + PC = u + v$$

$$\therefore (OR + RC) - (OP + PC) = \frac{r^2}{2u} + \frac{r^2}{2v} = \frac{r^2}{2}\left[\frac{1}{u} + \frac{1}{v}\right]$$

Now when the 1st and 2nd zones are transmitted

$$(OR + RC) - (OP + PC) = \lambda. \quad \text{Hence } \lambda = \frac{r^2}{2}\left[\frac{1}{u} + \frac{1}{v}\right]$$

or $$\lambda = \frac{d^2}{8}\left[\frac{1}{u} + \frac{1}{v}\right] \text{ cm. where } d = 2r.$$

Specimen Result.

The diameter of the circular aperture was determined by means of a vernier microscope reading to 0·002 cm.

Reading of vernier microscope at one side of aperture	= 4·724 cm.
Reading of vernier microscope at other side of aperture	= 4·490 cm.
Diameter of aperture	= 0·234 cm.

A 51-120. The Microid Universal Projector—*continued.*

Distance from source to aperture (u) = 260 cm.

Distance from aperture to screen (v) = 210 cm.

$$\therefore \lambda = \frac{(\cdot 234)^2}{8}\left[\frac{1}{260} + \frac{1}{210}\right] = \frac{(\cdot 234)^2}{8}\left[\cdot 00385 + \cdot 00476\right]$$

$$= \frac{(\cdot 234)^2}{8}\left[\cdot 0086\right].$$

$$\therefore \lambda = 5 \cdot 9 \times 10^{-5} \text{ cm.}$$

Expt. X.—Dependence of Colour on Incident Light.

A 51-120. Parts required :—1 each Nos. 1, 3, 4, 5, 28.

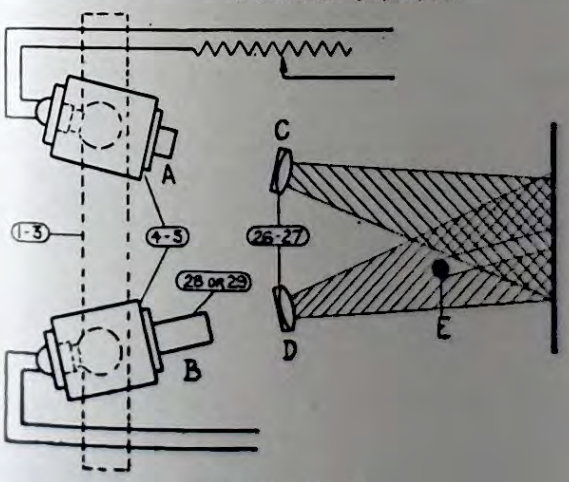
This experiment is often performed with Holmgren's coloured wools. The following is an amusing variation which is therefore likely to be retained in the student's memory.

Prepare on drawing paper a picture of a face in which the outlines are brought out in strong black lines and the natural colouring represented by water colours. Fasten this to the screen. Arrange the projector with a red filter and a 10 cm. achromatic lens to cast a circle of illumination on the figure. The whole appears of one uniform colour except the black outline. Now replace the red filter by a blue one, when the colour of the figure appears to be that of a negro or Eurasian on a blue field or background. While vivid impressions remain, the fact should be emphasised that the white paper appears of the same colour as the light with which it is being illuminated.

This may be followed up by pointing out that the red portions appear red in either red or white light, and in all other lights either black or brown. Finally, it may be stressed that bodies have no colour of their own but merely reflect certain components of the light incident on them. The spectacular aspect of an experiment of this nature varies with the purity of the gelatine filters and the water colours used.

Expt. XI.—Optical Illusion.

A 51-120. Parts required :—1 each Nos. 1, 3, 28.
2 each Nos. 4, 5, 26, 27.



A 51-120.—Fig. 16.

Mount two lamp bodies on the bed of the projector as shown in fig. 16. Use the central position of the bed on the base. Include a rheostat in the circuit of the lamp A. Place two 10 cm. achromatic lenses C and D carried on tripod feet in front of A and B respectively and adjust them to throw overlapping white circles on to the screen. Place a red gelatine filter, mounted in a tube, on the condenser of B and place between D and the screen a rod E. A illuminates the shadow of E which is cast on the screen by B.

Switch on B. The red illuminated circle is crossed by the dark shadow of the rod. Switch off B and switch on A, noting that the former shadow of the rod cast by B now receives only white light from A. Switch on B again. The shadow now appears peacock blue. Adjust the rheostat so that the colour difference is as distinct as possible.

Similar experiments can be carried out using filters of other colours.

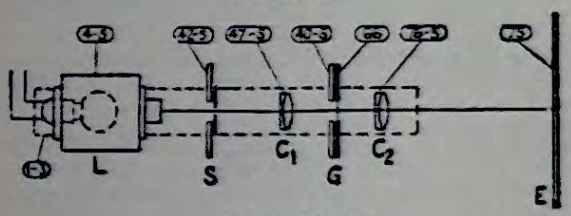
The explanation of these effects is as follows :—

The components of white light are red and peacock blue (see Expt. III). The red background stimulates those parts of the eye which respond to red and an appropriate signal is sent to the brain. When white light falls on the black shadow, the eye, already stimulated to the red, notes specially the peacock blue component by contrast.

An interesting variation on this experiment can be performed as follows : From a piece of three-plywood cut out a rectangle slightly smaller in dimensions than the shadow of the rod. Cover the wood with white drawing paper and use this as the screen with the shadow of the rod covering the aperture. Observations conducted from the front of the screen will result in the colour of the shadow being named as the complementary colour of the filter in the lamp B. Observers at the back of the screen, however, will in every case correctly name the colour as white since in this case the judgment is not biased by the surrounding illumination.

Expt. XII.—Diffraction by Gauze Grating with Parallel Light.

A 51-120. Parts required :—1 each Nos. 1, 3, 4, 40, 42, 47, 66, 75, 76.
5 of No. 5.



A 51-120.—Fig. 17.

This assembly is illustrated on page 125.

Mount the apparatus on the bed of the projector as shown in fig. 17. Focus the image of the filament on the rear of the jaws of the adjustable slit S. Adjust the lens C_1 (part 47) by a piece of mirror, using the method of return rays, to produce a beam of parallel light which is incident normally on the gauze grating G mounted in the object holder (part 40). Focus the diffraction images by means of the long focus lens C_2 (part 76, f = 100 cm.) on to a galvanometer scale about 1 metre distant.

With a wide slit, several orders of image are received on the scale; narrowing the slit brings those of the first order into prominence. A purple filter, which transmits red and blue, interposed between the lamp and slit, results in the central direct image becoming purple and the first order spectra on each side of it becoming red and blue.

Measure the distance between the centres of the first red or blue diffracted images on each side of the central image. Measure the distance from lens C_2 to the screen. The distance between the diffracted images having been measured, $\tan \theta$ may thus be found, θ being the angle of diffraction. With a long focus lens C_2 and the small diffraction of the gauze employed $\sin \theta = \tan \theta$ (approx.).

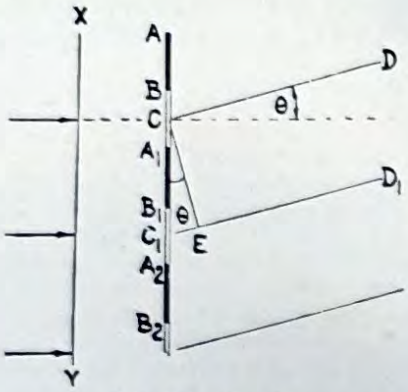
To find the width of the grating elements, remove lens C_2 and slit S and place the object holder and grating G between the lamp-house and the lens C_1.

Adjust the latter to project a magnified image of the gauze on the scale placed 4-5 metres away. Measure the total width of about 20 of the wires and spaces and determine the size of the grating from the formula $\frac{i}{o} = \frac{v}{u}$. In this formula o, the object, is equal to d, the grating element.

[continued overleaf

A 51-120. The Microid Universal Projector—*continued.*

Theory.



A 21-120.—Fig. 18.

Let a plane wave XY be incident normally on the grating. Light enters the apertures which, according to Huyghens' principle, become the source of secondary wavelets diverging in all directions.

Consider rays CD, C_1D_1, in any one direction—*i.e.*, parallel rays, making an angle θ with the normal. Then all the rays from any one space have a resultant which has the same phase as the ray from the midpoint of that space. They can be considered as replaced by this resultant. It is then necessary only to compound a number of parallel rays CD, C_1D_1, etc., from a number of equidistant points C, C_1, etc.

Draw CE perpendicular to CD. The common difference between any consecutive pair of rays is C_1E which is equal to $CC_1 \sin C_1\hat{C}E$ and if d be the width of a combined wire and space or, in the case of a ruled grating, a ruling and space, then $C_1E = d \sin \theta$.

Now if $C_1E = (2n + 1)\ \lambda/2$ the rays CD and C_1D_1 interfere to produce a contribution of zero amplitude. If, however, $C_1E = 2n\lambda/2$ CD and C_1D_1 reinforce and all such parallel rays can be brought to a focus by means of a lens, to produce a bright image in the direction θ.

If $n = 0$ we have the first undeviated central image, sin θ being 0 also. If $n = 1$, $d \sin \theta = \lambda$, which gives the first diffracted image on each side of the central image.

The size d of the grating is obtained from the formula

$$o = \frac{iu}{v} \text{ where } o = d \text{ (width of grating element).}$$

$$\textbf{Hence } \lambda = \frac{iu}{v} \sin \theta \text{ cm.}$$

Specimen Result.

Scale reading of centre of 1st order red image LHS .. .. = 21·0 cm.
Scale reading of centre of 1st order red image RHS .. .. = 19·3$_6$ cm.
∴ Distance of separation of two 1st order images = 1·6$_4$ cm.

Diffraction of 1st order image .. .. .. = 0·8$_2$ cm.
Distance from lens C_2 to screen .. .. = 109·7 cm.

$$\text{Sin } \theta = \tan \theta = \frac{0{\cdot}8_2}{109{\cdot}7},$$

Scale reading of 20 magnified grating spaces and wires (20 × d).
Left 20·0 cm., Right 17·0$_8$ cm., Difference .. = 2·9$_2$ cm.
Distance of object (u) = 10·8 cm.
" image (v) = 177·0 cm.

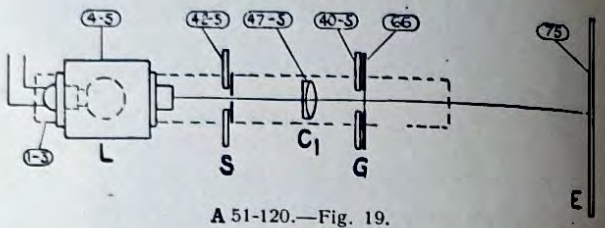
$$\therefore \lambda = \frac{2{\cdot}9_2 \times 10{\cdot}8 \times 0{\cdot}8_2}{20 \times 177 \times 109{\cdot}7} \text{ cm.}$$

$$\lambda \text{ (mean red)} = \mathbf{6{\cdot}7 \times 10^{-5}} \text{ cm.}$$

Rays A Laby give λ (mean red) = $7{\cdot}1 \times 10^{-5}$ cm.

Expt. XIII.—Diffraction by Gauze Grating with Convergent Light.

A 51-120. Parts required :—1 each Nos. 1, 3, 4, 40, 42, 47, 66, 75. 4 of No. 5.



A 51-120.—Fig. 19.

Mount the lamphouse and adjustable slit on the bed of the projector, using the bed in the end position and place the slit so that an intense image of the filament is received on the rear of the slit. Mount an achromatic lens C_1 (part 47, $f = 15$ cm.) in front of the slit so that it produces a well-defined image of the slit on the scale which is placed 2-3 metres away. Insert the object holder in a sliding foot and the gauze grating in the object holder.

Look through the scale towards the source. Several orders of spectra will be seen, the number depending very largely on the width of the slit. For **quantitative** work it is recommended to close the slit so that the first order only is seen. If the room be totally darkened, the graduations on the scale are difficult to read; it is therefore advisable to work in dull daylight or in the light of a low power lamp.

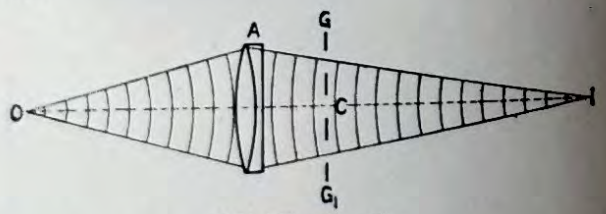
Insert now a purple filter between the condenser and slit. Such a filter transmits red and blue, which are its constituent colours. The central image then becomes purple and the first order diffracted image on each side breaks up, enabling separate red and blue images to be seen. The blue is diffracted least and is nearer to the central image.

The spectra should be examined carefully, since, due to the spacing of the grating not being perfectly uniform, " ghosts " may sometimes be observed.

Measure the distance between the centre of the first red or blue diffracted image on each side of the central image as in Expt. XII.

The grating space is determined as in Expt. XII or a travelling microscope may be employed.

Theory.



A 51-120.—Fig. 20.

Using an achromatic lens, a point source emitting white light has an image formed which is a replica of the object, *i.e.*, it is uncoloured.

Consider now spherical waves diverging from O as centre. When these waves pass through the lens their curvature changes and they converge at I, the image. But fig. 20 shows that the extremities of the converging waves fall first on the gauze. The secondary wavelets which originate as the waves pass through the gauze are not in phase as they are in the diffraction grating when a plane wave is employed. This difference of phase, however, is just sufficient to compensate for the path difference, *i.e.*, the retardation, between marginal and paraxial rays (by Fermat's Principle the paths of the ray OAI and a paraxial ray OI being optically equivalent). The waves from all the apertures therefore arrive in phase at I and the formula obtained in Expt. XII is applicable.

Hence $$\lambda = \frac{iu}{v} \sin \theta.$$

A 51-120. The Microid Universal Projector—*continued.*

Specimen Result.

Scale reading of centre of 1st order, red image
LHS .. .. = $26{\cdot}4_0$ cm.
Scale reading of centre of 1st order, red image
RHS .. .. = $21{\cdot}0_0$ cm.

$\therefore$ Distance of separation of two 1st order images = $5{\cdot}4_0$ cm.

$\therefore$ Diffraction of 1st order image .. .. .. = $2{\cdot}7_0$ cm.
Distance from grating to screen .. .. .. = 524 cm.

$\therefore$ [Sin θ = tan $\theta = \frac{2{\cdot}7_0}{524}$

20 magnified grating spaces and wires $(20 \times i)$ = 7·70 cm.
Distance of object (u) = 10·4 cm.
Distance of image (v) = 310·0 cm.

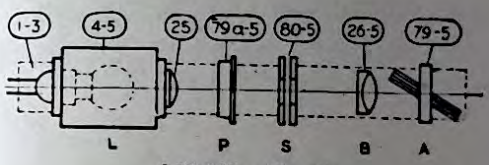
$$\therefore \lambda = \frac{7{\cdot}70 \times 10{\cdot}4 \times 2{\cdot}7_0}{20 \times 310 \times 524}$$

$$\therefore \lambda \text{ (mean red)} = 6{\cdot}7 \times 10^{-5} \text{ cm.}$$

Kaye & Laby give λ (mean red) $7{\cdot}10 \times 10^{-5}$ cm.

Expt. XIV.—Complementary Colours shown by Cellophane.

A 51-120. Parts required :—1 each Nos. 1, 3, 4, 25, 26, 80.
2 No. 79, or 2 No. 79a, or 1 each Nos. 79 and 79a.
5 No. 5.



A 51-120.—Fig. 21.

Mount the lamphouse L containing the large condenser (part 25), at the end of the 18 in. bed (part 3), using the central position of the bed. Adjust the focussing of the condenser to give a wide parallel beam to the screen about 10 ft. away.

Mount the polariser P, the rotating slideholder S, the projection lens B and the analyser A each on a sliding foot. One of the pair of Polaroid discs (part 79a) is shown in fig. 21 used as polariser P in place of the pile of glass plates; but if it is used as analyser A the reflected image in complementary colours is not obtained. For demonstration it is instructive to interchange P and A. Adjust the height of each unit of the optical system, so that the centre of the beam passes through its centre. Complete the alignment by means of the tilting screw with which each sliding foot is provided, bearing on the top of the bed.

Rotate the sleeve carrying the pile of plates in A until the axis of the plates is vertical. Turn the plates to the polarising angle (about 57° to the normal). Arrange that the transmitted image is received on the screen and the reflected image on a second screen (cardboard or paper) so placed that an angle of about 104° is included between the two screens. The second screen is then normal to the beam reflected from the analyser. The two screens should preferably be equidistant from the analyser to ensure the simultaneous focussing of both images, though some latitude is permissible. Now rotate the polariser to bring about extinction of the transmitted beam.

Place the slide G (part 81) in the fixed side of the slideholder and focus an image of the vertical steps of the echelon on to the screen. The transmitted image, at a screen distance of about 10 feet, will be 3-4 feet in diameter. It will be delineated in bright colours and the reflected image, polarised in the plane at right angles, will be of equal intensity and in colours complementary to those of the transmitted image. The system is now set up and adjusted.

The slide G may now be removed and the slides A-F placed in turn in the fixed side of the slideholder. The complementary colours will appear on the screens and can be interchanged by rotation of the polariser through 90°. If the analyser be rotated the reflected image moves. It is, therefore, preferable to demonstrate the effects by rotation of the polariser. The change in colour as the progression of slides A-F is inserted successively in the slideholder, a change identified with increasing phase difference as the thickness of Cellophane increases, will be noted. The slide G may now again be introduced to show in one image the effect of gradual increase of the thickness of Cellophane on the colour. The succession observed for this slide, naming the colours in order of thickness of Cellophane increasing by steps of 0·3λ and commencing at the least thickness, is :—white, canary yellow, purple, sea green, yellow, reddish purple, green, beige, pink, yellowish green.

Expt. XV.—Compensation of Path Retardation.

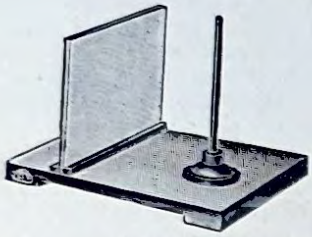
A 51-120. Parts required :—As for Expt. XIV.

With the same arrangement of apparatus as in Expt. XIV the important principle, applied extensively in photoelastic measurements of compensation of path retardation, may be demonstrated with slides E or F.

Place one slide E (1·1λ) in the fixed side of the slideholder, part 80, and note the complementary colours, yellow and blue on the screens. Rotation of the polariser results in interchange of the positions of the two colours. Place the second slide E in the rotating side of the slideholder, so that its axes are parallel to those of the first slide. The complementary colours are now red and green, due to a thickness of Cellophane equivalent to a path retardation of 2·2λ. Rotate the second slide E in its holder until its axes are perpendicular to those of the fixed slide, *i.e.* so that the fast axis of the one slide is superimposed on the slow axis of the other and the slides are "crossed." The image now appears with a central black square, surrounded by 4 segments each *blue* in colour. This experiment, repeated with the slides F, shows the central black square surrounded by *green* segments. This principle is applied extensively in photoelasticity for measurements of the stress in complex mechanical structures in which mathematical calculation of the stress is difficult or even impossible.

A celluloid model of the structure is first made. Now celluloid under stress acquires a fast axis in the direction of stress. By crossing the portion of the model under investigation with the echelon slide H, it is known that where black areas appear in the image, the path retardation in the model is equal to that in the portion of the echelon with which it is crossed and, the retardation in the echelon being known, it follows that the retardation in the model is also known. From a knowledge of the stress-optical coefficient C of celluloid, defined as $r = CTd$ brewsters, where r = path retardation per thickness d of celluloid under tension T, the stress may be evaluated.

The various assemblies of the MICROID UNIVERSAL PROJECTOR described on pages 125 to 141 do not exhaust the possibilities of the series. The user will find the apparatus adaptable to a great variety of experiments instructive to students at all stages.



A 51-260.



A 51-270.



A 51-290.

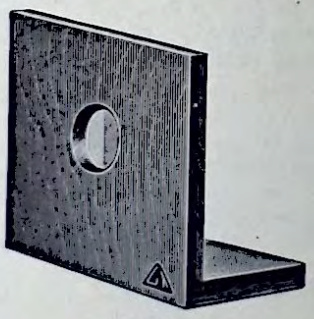
	£	s.	d.
A 51-260. PHOTOMETER, Rumford, ground glass screen, on wood base, and rod on metal foot	0	8	0
A 51-270. PHOTOMETER, Bunsen, Grease Spot, 63 mm. diam., mounted in brass holder, with brass stem $\frac{3}{8}$ in. diam.	0	12	6
A 51-275. Ditto, on stand **A 51-415**	1	5	0
A 51-280. Grease Spot Disc, only, unmounted	0	1	0

A 51-290. PHOTOMETER HEAD, Bunsen Grease Spot (Houstoun: *Treatise on Light*, p. 317), grease spot disc mounted on wood stand with two plane mirrors inclined at such an angle that the images of the two sides of the disc are visible simultaneously to the eye of an observer in the plane of the disc 0 17 6

Bunsen Photometer Head mounted on metal stem for use as an optical bench accessory, see **A 53-345.**



A 51-310.



A 51-315.

	£	s.	d.
A 51-310. PHOTOMETER, Paraffin Wax, Joly, two paraffin wax blocks 4 × 2 × 2 cm., separated by sheet of tinfoil	0	9	6

Two similar blocks of wax, separated by a thin sheet of tinfoil, are illuminated on opposite sides by the sources to be compared. The light is scattered by the wax, and the sources are adjusted until the blocks appear equally luminous when observed from the ends.

A 51-315. PHOTOMETER, Paraffin Wax (Clay: *Practical Exercises in Light*, fig. 108), two pieces of paraffin wax about 2·5 cm. square × 10 mm. thick, having a piece of tinfoil placed between them. Fitted on wood frame, with aperture about 12 mm. diam. 0 12 6

LIGHT SOURCES, see pages 211-221.


Front View.



A 51-325. Rear View.


A 51-340.


A 51-345.

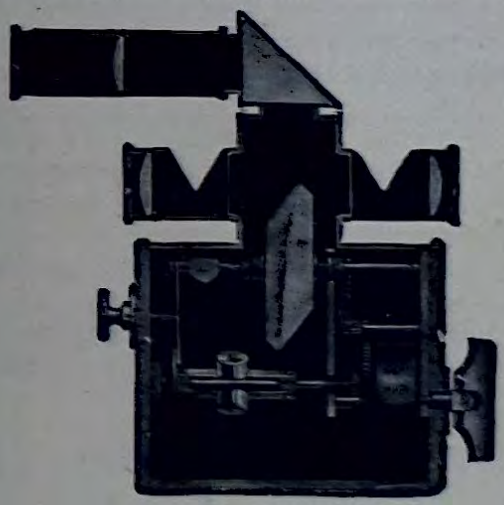

A 51-355.

	£	s.	d.
A 51-325. PHOTOMETER, Paraffin Wax, Joly (Allen & Moore: *Text-book of Practical Physics*, p. 307 ; Edser: *Light for Students*, p. 12). Pair of paraffin blocks separated by sheet of tinfoil as **A 51-310**, mounted on brass stem with metal screen to shield the observer's eyes from direct rays of the illuminating sources	1	15	0
A 51-340. CANDLE HOLDER, for 4 candles, on brass stem ⅜ in. diam.	0	11	6
A 51-345. Ditto, for 1 candle	0	5	6
A 51-355. ELECTRIC LAMP HOLDER, bayonet type (*Lamps, see pp.* 211-213)	0	10	6
A 51-360. Chimney, metal, for above, with round hole or slot	0	15	0



A 51-410.


A 51-415.


A 51-450.

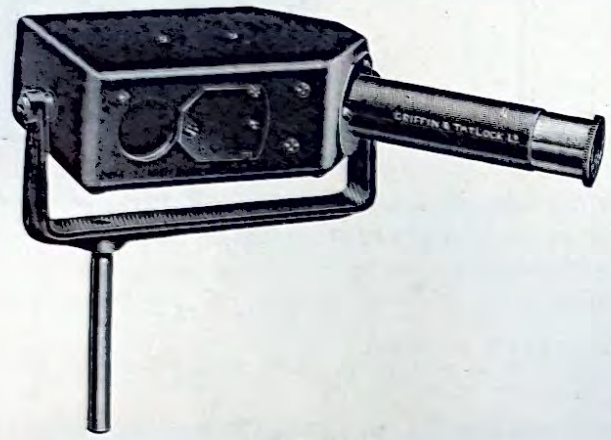
	£	s.	d.
A 51-410. STAND, Iron, with hollow brass stem, made to take any of the rod mounted fittings **A 51-270** to **A 51-355**	0	12	6
A 51-415. STAND, hollow brass stem on hardwood base with centre line, made to take any of the fittings **A 51-270** to **A 51-355**, for use on optical benches	0	12	6
A 51-450. PHOTOMETER, Flicker (Worsnop and Flint: *Advanced Practical Physics*, 2nd Edn, p. 383), for comparing lights of the same or of widely differing colours	† 18	2	3

In this instrument the light is focussed on a revolving white wheel, the edge of which is bevelled on each side, the ridge between the bevels running spirally round the wheel. The edge of the revolving wheel is viewed through an eye-piece, and unless the illumination on both sides of the ridge is equal there is a flickering effect. The disc is caused to revolve by a spring motor which is mounted within the housing and fitted with a governor and brake.

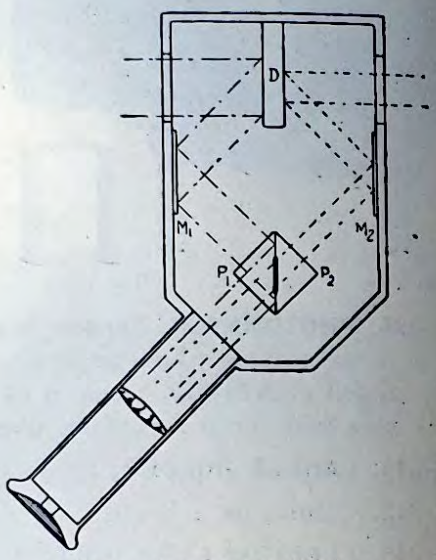
Fittings A 51-270, A 51-325—355 are made with a brass stem ⅜ in. diam. to fit Photomster Bench A 51-490.

THE MICROID LUMMER-BRODHUN PHOTOMETER

A simple accurate model



A 51-470.



A 51-470.—Diagram of Optical System.

The most convenient form of photometer is the Lummer-Brodhun. From the educational point of view its high cost has been a serious drawback. The optical system of the Microid Lummer-Brodhun photometer has been simplified, with the result that an accurate photometer at a low price is now available.

SPECIFICATION.

The optical parts are mounted in a metal case 6 × 3½ × 2 in., provided with a cradle and ⅜ in. diam. stem for support on optical bench, and two shutters which should be kept closed when the instrument is not in use.

A diagram of the optical system is shown above. D is a plaster disc with a uniformly matt surface. M_1 and M_2 are plane mirrors and P_1 and P_2 are two right-angled prisms with their hypotenuses in optical contact over a small circular patch in the centre.

When the intensity of illumination on the two sides of the disc D is unequal, the field of view seen through the telescope is a light or dark circle surrounded by a dark or light annular ring. When the intensities are equal an evenly illuminated field is seen.

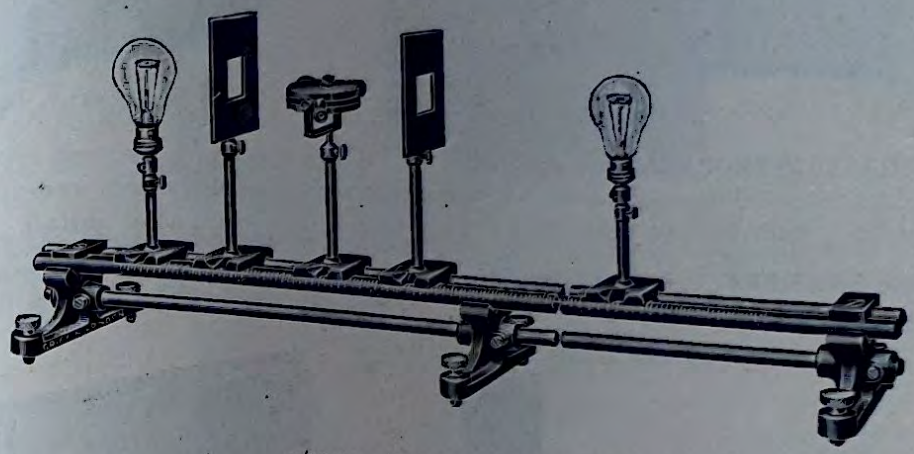
	£	s.	d.
A 51-470. MICROID LUMMER-BRODHUN PHOTOMETER, in metal case with telescope, and cradle and stem support	7	10	0



A 51-480

A 51-480. PHOTOMETER, Lummer-Brodhun (Worsnop and Flint: *Adv. Pract. Physics*, p. 384), with true Lummer-Brodhun optical system having optically worked Lummer-Brodhun cube and two total reflection prisms in place of the mirrors used in the model **A 51-470.** The opaque white screen can be turned through 180° by means of the milled head. The metal case, about 4 in. diam., has two limiting diaphragms of equal size fitted to the apertures, and is mounted on a cradle with stem ⅜ in. diam. for stand or photometer bench 16 10 0

THE MICROID PHOTOMETER BENCH



A 51-490—495.—Showing extra Lamp.

SPECIFICATION.

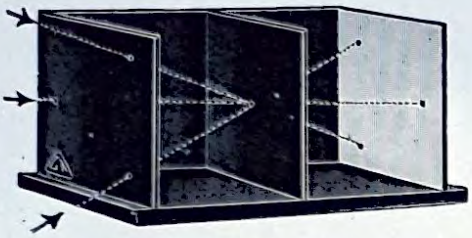
The bench is 2¼ metres long and is composed of two stainless steel rods, ¾ in. diam., one of which is engine divided into mm. up to 2 metres. The rods are supported in three cast iron cradles fitted with levelling screws, those at each end being provided with clamps to secure the rods firmly and the centre one being so designed that the sliding feet of the fittings pass freely over it. The sliding feet, 5 of which are supplied with the bench, are of iron and make geometric contact with the rods by means of a flat on one side and two vees on the other.

The three long rods can be easily and quickly taken out, materially reducing the space required for storage purposes. With the exception of the steel rods, all parts are finished a matt optical black to prevent reflection (*vide* Houstoun: *Treatise on Light*).

	£	s.	d.
A 51-490. MICROID PHOTOMETER BENCH, 2 metres long, one rod engine divided in mm., with five iron sliding feet. **Without** photometric fittings .. .. *r*	18	0	0
A 51-495. Fittings, Optical, for above, Lummer-Brodhun Head **A 51-480,** two screens with rectangular apertures, 100 volt sub-standard Lamp **A 58-170,** with N.P.L. certificate, and two electric lampholders **A 51-355** .. .. *t*	23	0	0

(When ordering please state candle power of Lamp.)

The MICROID PHYSICAL SERIES is a range of distinctive designs in Apparatus for the demonstration of Physical Principles. These special models have been developed in our own Technical Department and in collaboration with independent authorities expert in their various subjects.

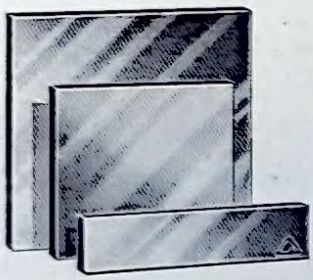


A 51-530.

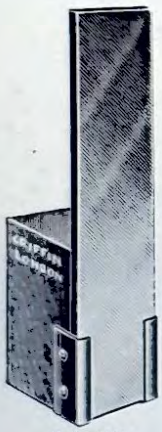


A 51-540.

	£	s.	d.
A 51-530. RECTILINEAR PROPAGATION APPARATUS. Three sheet metal screens approx. 12·5 cm. high mounted on wood base ; left screen with three pinholes, centre screen with central pinhole, both finished dead black ; right screen with matt white surface ..	1	1	0
A 51-540. PINHOLE CAMERA, two brass tubes, 1½ in. diam., extending 4 to 6½ in., with ground glass screen	0	10	0



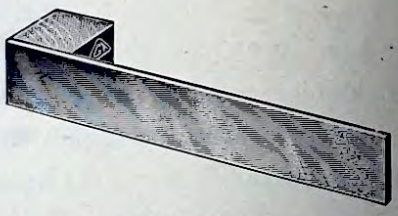
A 51-595—605.



A 51-620.



A 51-625.



A 51-630.

	£	s.	d.
A 51-590. PLATE GLASS, Unsilvered, 8 × 6 × 1 in. thick, edges polished ; for showing images by reflection from both back and front surfaces	1	1	0

A 51-595. MIRRORS, Plane, unmounted, silvered on back surface and protected.

Dimensions ..	3 × 1	6 × 1	4 × 3	5 × 5	6 × 4	6 × 6	*in.*
	3/-	4/-	6/6	13/-	12/6	18/-	*dozen*
	4d.	5d.	8d.	1/3	1/3	1/8	*each*

A 51-605. MIRRORS, Plane, Surface-Aluminised, plane glass plates on which a film of aluminium has been deposited by evaporation. These mirrors have higher reflectivity than ordinary back silvered mirrors, the surface is hard, durable and untarnishable. They can also be used as back-surfaced mirrors. **Unmounted.**

Dimensions ..	3 × 1	6 × 1	4 × 3	5 × 5	6 × 4	6 × 6	*in.*
	5/-	7/-	12/-	16/-	16/-	20/-	*each*

A 51-610. Ditto, with optically worked surfaces .. .. *Prices on application.*

A 51-620. MIRROR STRIPS, Plane, 6 × 1 in., mounted vertically on small wood feet 1 in. wide in such a way that the mirror reaches down to the table level. Mirror removable from mount. .. .. *each* **2/-** ; *dozen* **1 1 0**

A 51-625. Ditto, Plane, 6 × 1 in., mounted horizontally .. .. *each* **2/-** ; *dozen* **1 1 0**

A 51-630. Ditto, Plane, 6 × 1 in., mounted on 1 in. wood cube so that mirror may be placed vertically or horizontally. Mirror not removable from mount .. *each* **1/3** ; *dozen* **0 13 0**



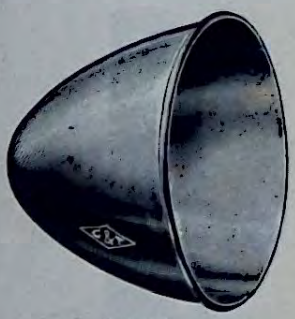
A 51-640—650.
A 51-680—690.



A 51-660—665.



A 51-710.



A 51-740.

MIRRORS, Concave or Convex, not optically worked, unmounted, intended for use as a range of mirrors for students' exercises. These are not precision mirrors but focal lengths stated are reasonably accurate.

Cat. No.	Diameter.	FOCAL LENGTH *cm.*							
		Concave.				Convex.			
		10	15	20	30	10	15	20	30
A 51-640	50 mm.	2/-	2/-	2/-	2/-	2/-	2/-	2/-	2/-
A 51-645	75 mm.	2/6	2/6	2/6	2/6	2/6	2/6	2/6	2/6
A 51-650	100 mm.	—	4/-	4/-	4/-	—	4/-	4/-	4/-

MIRRORS, Concave or Convex, not optically worked, in metal mount with boss and screw for fixing on a rod ⅜ in. diam. Foci as above. (*Please state focus required when ordering.*)

Diam.	75	100 *mm.*
A 51-660. Concave	r 12/6	16/- *each*
A 51-665. Convex	r 12/6	16/- *each*

MIRRORS, Concave or Convex, optically worked, highest quality, heavily silvered, unmounted.

Cat. No.	Diameter.	FOCAL LENGTH *cm.*									
		Concave.					Convex.				
		7·5	10	15	20	30	7·5	10	15	20	30
A 51-680	50 mm.	6/6	5/-	5/-	4/6	4/-	6/6	5/-	5/-	4/6	4/-
A 51-685	75 mm.	—	9/-	8/-	8/-	8/-	—	9/-	8/-	8/-	8/-
A 51-690	150 mm.	—	—	—	—	30/-	—	—	—	—	30/-

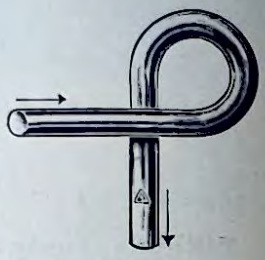
	£	s.	d.
A 51-710. **MIRROR, Cylindrical, metal,** both sides nickel-plated and polished, 3 in. radius, 3 in. high; to show a caustic curve	0	10	6
A 51-715. **MIRROR, Cylindrical, Concave,** glass, silvered, 3 in. radius, 1½ in. high	0	4	6
A 51-720. **Ditto, Convex**	0	4	6

A 51-740. **MIRRORS, Parabolic,** accurately constructed of copper, with reinforced edge, silver plated inside.

Focal length	10	20	30 *mm.*
Diam. × depth	10 × 6	14 × 6	14 × 4 *cm.*
	12/6	14/6	13/6 *each*


A 51-790.


A 51-815.


A 51-830.

	£	s.	d.
A 51-790. DESIGNOSCOPE, an improved form of **kaleidoscope** showing applications of laws of reflection and formation of multiple images. With rotating disc $4\frac{1}{2}$ in. diam. on which flowers, leaves, pieces of silk, etc., may be placed. When viewed from above these give remarkable changes in design as the disc is rotated. Complete in box	0	5	6
A 51-815. MODEL SEXTANT, 8 in. radius, light metal frame with scale to 120° and vernier reading to 10 minutes of arc. With handle	3	5	0
A 51-830. TOTAL INTERNAL REFLECTION LOOP, Perspex (Sutton: *Demonstration Experiments in Physics*, p. 384). Light from a strong source entering one end of the rod is internally reflected around the loop with little loss and emerges at the other end. Int. diam. of loop $3\frac{1}{4}$ in. Diam. of rod 1 in., both ends polished .. .. *p*	2	10	0


A 51-900.


A 51-905.


A 51-910.


A 51-915.


A 51-920.


A 51-925.

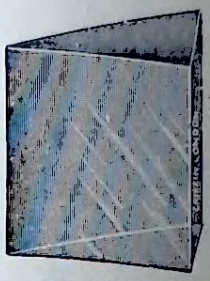

A 51-930.


A 51-935.


A 51-945.

BLOCKS, Perspex, for refraction experiments, polished, clear, white backed, free from striae and bubbles, edges slightly bevelled. British made.

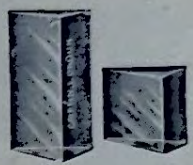
A 51-900. Rectangular	$4\frac{7}{16} \times 2\frac{7}{8} \times \frac{3}{4}$	$7\frac{15}{16} \times 5\frac{15}{16} \times \frac{3}{4}$	*in.*	
	9/-	24/-	*each*	
A 51-905. Triangular, nominal angles 90°, 60°, 30°, $4\frac{7}{16} \times 2\frac{7}{8} \times \frac{3}{4}$ in. thick			*each*	0 9 0
A 51-910. Triangular, nominal angles 90°, 45°, 45°, $4\frac{7}{16} \times 3 \times \frac{3}{4}$ in. thick			*each*	0 9 0
A 51-915. Trapezoidal, with two prisms, nominal angles 45° and 60°, base 4 in., length of sides 2 in. and $1\frac{5}{8}$ in., $\frac{3}{4}$ in. thick			*each*	0 9 0
A 51-920. Circular, $3\frac{7}{8}$ in. diam., $\frac{3}{4}$ in. thick			*each*	0 13 6
A 51-925. Semicircular, $3\frac{7}{8}$ in. diam., $\frac{3}{4}$ in. thick			*each*	0 8 0
A 51-930. Biconcave, length $5\frac{1}{2}$ in., radii 7 in., $\frac{3}{4}$ in. thick			*each*	0 17 6
A 51-935. Biconvex, length $5\frac{1}{2}$ in., radii 7 in., $\frac{3}{4}$ in. thick			*each*	0 17 6
A 51-940. Biconcave, length $5\frac{1}{2}$ in., radii $3\frac{7}{8}$ in., $\frac{3}{4}$ in. thick			*each*	1 0 0
A 51-945. Biconvex, length $5\frac{1}{2}$ in., radii $3\frac{7}{8}$ in., $\frac{3}{4}$ in. thick			*each*	1 0 0



60°, 60°, 60°.
A 51-960.



90°, 45°, 45°.
A 51-965.



90°, 60°, 30°.
A 51-970.

PRISMS, A 51-960—995, are for students' use. They are non-optically worked, with polished faces, edges slightly bevelled, angles approximating to the nominal angles. British made of white plate glass, refractive index $n_D = 1{\cdot}523$ approx.

A 51-960. PRISMS, Glass, Equilateral, not optically worked, nominal angles 60°, 60°, 60°.

No.	1	2	3	
Size of face, approx.	50	70	83	*mm.*
Height, approx.	40	50	57	*mm.*
	r 10/-	12/6	15/-	*each*

A 51-965. PRISMS, Glass, Right-angled, not optically worked, nominal angles 90°, 45°, 45°.

No.	1	2	3	4	
Length of hypotenuse, approx.	27	33	43	64	*mm.*
Height, approx.	30	42	43	64	*mm.*
	r 4/6	5/-	8/6	13/6	*each*

A 51-970. PRISMS, Glass, not optically worked, nominal angles, 90°, 60°, 30°.

No.	1	2	3	
Length of hypotenuse, approx.	52	70	106	*mm.*
Height, approx.	40	25	60	*mm.*
	r 7/6	8/6	15/-	*each*



A 51-975.



A 51-980.



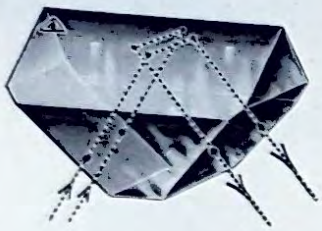
A 51-985.

	£	s.	d.
A 51-975. PRISMS, Glass, not optically worked, nominal angles 75°, 60°, 45°, face 39 × 28 × 35 mm., height 39 mm. .. .. *pair* r	0	10	0

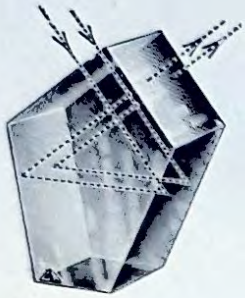
A 51-980. CUBES, Glass, polished faces.

Side, approx.	32	52 *mm.*
	r 7/-	13/- *each*

A 51-985. CONE, Glass, with well polished surface, but not optically worked, for demonstrating the formation of the rainbow, base about 55 mm. diam., 50 mm. high .. .. .. r 0 12 0



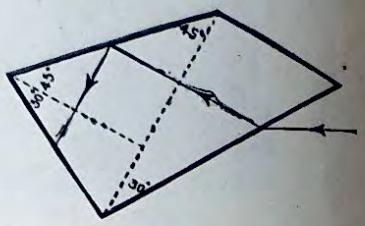
A 51-990.



A 51-995.



60°, 60°, 60°.
A 52-105—125.



A 52-155.

£ s. d.

A 51-990. PRISM, "Roof Edge" (Johnson: *Practical Optics*), length of top (90°) edge, 60 mm.; overall height, 40 mm. Deviates the rays 90° and inverts them. The principle is adopted in many forms of prisms which are employed in telescope systems required to give an erect image of the object .. .. *r* 0 7 6

A 51-995. PRISM, Pentagonal (Johnson: *Practical Optics*; Gleichen: *The Theory of Modern Optical Instruments*). Nominal angles 90°, 110°, 110°, length of top edge, 30 mm.; overall height, 55 mm. Deviates the ray 90° without producing either inversion or reversion. For practical purposes the two 45° faces of the prism are silvered; in this demonstration prism they are unsilvered. A plane mirror can be placed against each 45° face of the prism *r* 0 10 6

The above prisms are replicas in polished white plate glass, of optically worked prisms of high quality optical glass, extensively used for war-time requirements, *e.g.* Roof-edge Prisms in artillery sighting telescopes, Pentagonal Prisms used as window prisms in range finders.

PRISMS, optically worked, angles 60°.

Cat. No.	Type	Refractive Index for D	Mean Dispersion, C to F	Dimensions (Face × Height)	
				1 × 1 in.	1¼ × 1¼ in.
				£ s. d.	£ s. d.
A 52-105	Crown Glass	1·52	0·0086	0 18 0	1 5 0
A 52-110	Light Flint Glass	1·58	0·014	1 0 0	1 7 6
A 52-115	Dense Flint Glass	1·62	0·017	1 1 0	1 10 0
A 52-120	Very Dense Flint Glass ..	1·65	0·019	1 5 0	2 0 0
A 52-125	Extra Dense Flint Glass ..	1·74	0·026	2 0 0	2 10 0

A 52-140. PRISMS, Plate Glass, optically worked, angles 60°.

Face	1	1¼	1¼	1¼	*in.*
Height	2	1¼	2½	3	*in.*
	15/-	15/-	23/-	£1 10 0	*each*

A 52-145. PRISMS, Quartz, angles 60°, with two sides worked and the refracting edge perpendicular to the optic axis, so that a ray passing through the prism in the position of minimum deviation is parallel to the optic axis.

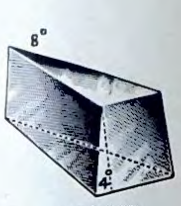
Face	20	25	30	35	*mm.*
	£1 15 0	£2 2 6	£2 7 6	£3 10 0	*each*

A 52-150. PRISMS, Crown Glass, optically worked, right angled, 90°, 45°, 45°, for total reflection. The faces containing the right angle are square.

Side of square faces	¾	1	1¼	1½	1¾	*in.*
	16/-	18/6	£1 5 0	£1 12 6	£2 0 0	*each*

£ s. d.

A 52-155. PRISM, Glass, Constant Deviation, optically worked, producing a 90° deviation for all wave-lengths, as used in Constant Deviation Spectrometers, of very dense flint glass, refractive index for D = 1·65; longest side 1⅜ in., height 1 in. **2 5 0**



A 52-180.


A 52-190.


A 52-320.

A 52-180. PRISMS, Skew (Savage: *Science Master's Book, Series I, Pt.* 1, pp. 73, 246). For colour mixing experiments. Refracting angle 8°, the two faces containing the refracting angle inclined at an angle of about 4°. Optically worked.

Dimensions, length × width ..	20 × 6	20 × 9	20 × 13 *mm.*
	r 6/6	7/6	8/6 *each*

A 52-190. PRISMS, Hollow, glass, equilateral, for determining refractive indices of liquids. Generally filled with carbon disulphide to form a prism of high dispersive power. Made of selected plate glass and sealed with cement which is unaffected by heat or acids. With filling tubulure and stopper.

Face	35	50	75	60 *mm.*
Height	35	35	35	60 *mm.*
	£1 10 0	£2 2 0	£2 5 0	£2 17 6 *each*

£ s. d.

A 52-320. REFRACTION TROUGH, 24 × 8 × 4 in. high, of plate glass, cemented into strong angle-iron frame, with legs 2 in. high .. .. r 4 10 0

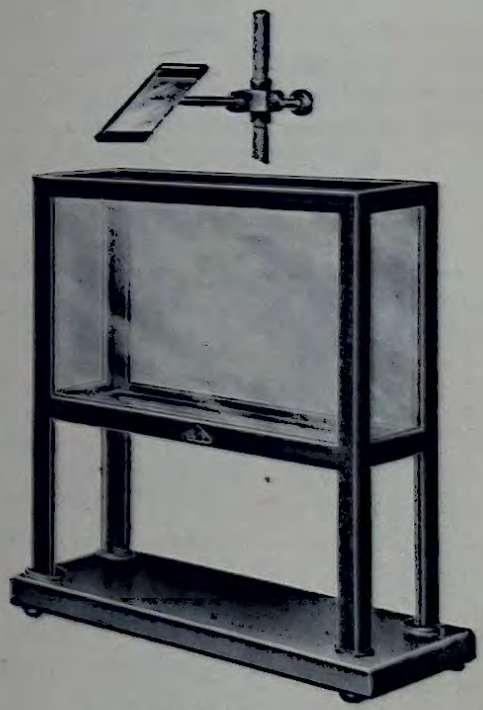
A long, narrow trough of this kind is useful for wave-making as well as for refraction experiments. It is also convenient for use in carrying out Tyndall's beautiful experiment which illustrates the redness of the sky at sunset (or in fog) and the blueness of the sky, by the slow deposition of colloidal sulphur from a weak $Na_2S_2O_3$ solution acidified with HCl (*vide School Sci. Rev.*, 1932, **13**, 283).

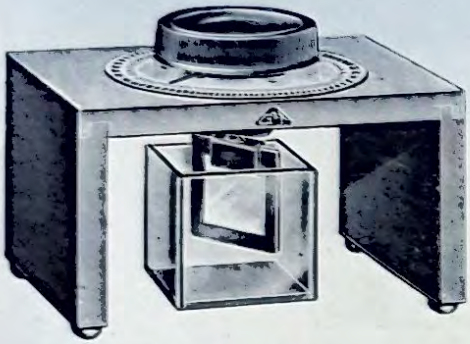
A 52-330. REFRACTION TROUGH, (Sutton: *Demonstration Experiments in Physics*, p. 384) 14 × 4½ × 9 in. high, of plate glass, cemented into strong angle iron frame, with legs 6 in. high, mounted on wood base 16 × 6 in. Plane mirror 4 × 2¾ in. in metal frame, adjustable for angle and height with clamp and retort stand 24 in. high .. r 5 15 0

£ s. d.

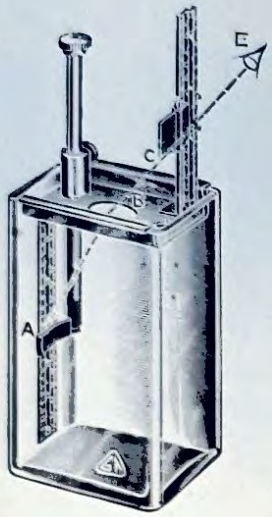
The trough when filled with water containing a little fluorescein serves to demonstrate refraction and total internal reflection. The adjustable mirror is used to reflect the beam from a conveniently placed lamphouse in to any part of the trough. A mirror strip may be placed on the bottom.

It is worthy of note that by covering the open top by a sheet of glass, the trough may be used as a smoke box, and it may be advantageous to use the trough in this manner, even where it is partially filled with water, as the rays are then visible in their passage through the air.


A 52-330.



A 52-360—370.



A 52-390.



A 52-420.



A 52-435.

£ s. d.

A 52-360. CRITICAL ANGLE APPARATUS, Improved design (Clay: *Practical Exercises in Light*, fig. 30 ; Allen & Moore: *Text-Book of Practical Physics*, p. 243). A glass cell comprising two parallel glass plates sealed to enclose a thin air film, is fitted to a vertical spindle and can be rotated about a vertical axis by means of a large diam. knob incorporating a **slow motion device.** The angle of rotation is read from a pointer and circular graduated scale. The air cell, knob and dial are mounted on a wood bridge with rubber feet, so that the air cell dips into a cubical cemented glass cell having sides of parallel plate glass **2 7 6**

A 52-365. Air Cell, only, for above **0 5 0**

Glass Cell, Cubical, only, for above, 50 mm. side .. .. See **A 55-230.**

A 52-390. REFRACTIVE INDEX APPARATUS, real and apparent depth. A metal frame, fitted on a glass box 7 × 4 × 3 in., carries two stainless steel rules, one of which projects vertically above the box whilst the other is immersed in the liquid in the box. Both rules carry adjustable sighting indexes and the frame has a circular aperture fitted with a cross-wire **2 5 0**

The glass box is filled with water or other liquid until the liquid just touches the cross-wire. The index A is set to any required depth, the eye placed on a level with the lower edge of index C, which is then adjusted so that the image of the upper edge of A, the cross-wire B and the lower edge of C appear to be collinear. The real and the apparent depths are then read from the scales and the refractive index is evaluated. By measurement of distances of scales from B, i and r can be determined and $\frac{\sin i}{\sin r}$ used as a check on the previous value.

1 2 3



A 52-430.
(Half Size.)

A 52-420. MICROID LUMINOUS PINS (*Science Masters' Book, Series II, Pt. I*, pp. 105–6), 6 watt festoon lamp **A 58-295—297** on base with pin, and leads with tags .. .. *each* r **0 8**]**0**

In use the lamps are stuck into the drawing board like ordinary pins; they are particularly effective for demonstrating the formation of images by lenses and mirrors, because they are practically line sources and can be moved about at will.

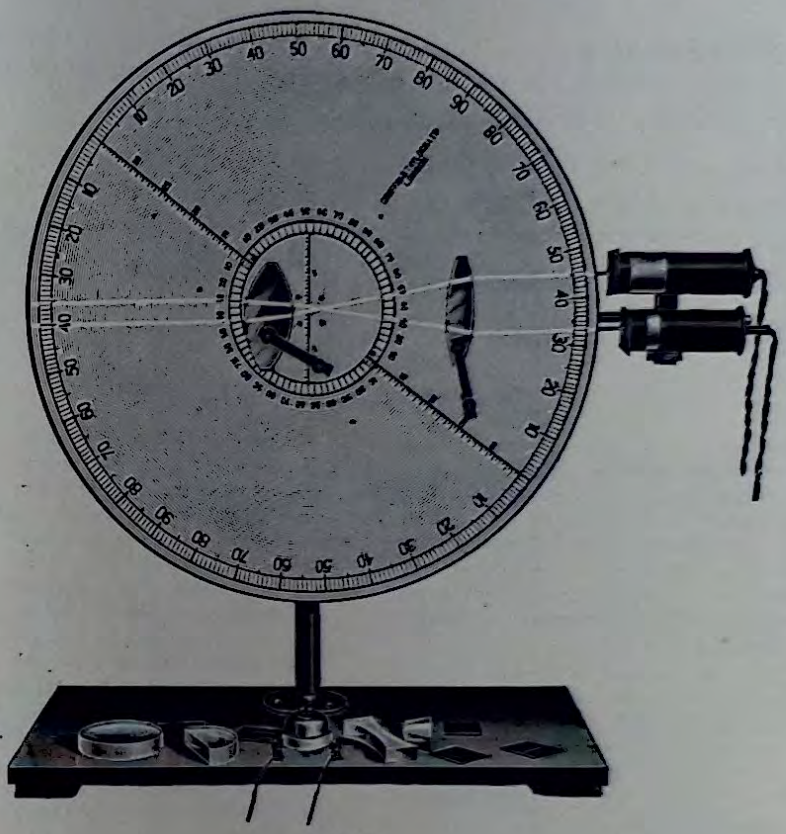
A 52-430. PINS, stout.

Length	2	2½	3	*in.*
	3/6	6/-	7/-	*gross*

A 52-435. MICROID RAY BOX, for use in ray-tracing. Ventilated wood box 7 × 3 × 3 in., fitted S.B.C. lampholder, window for colour filters, mirror reversible at 45° to reflect light through single slit or 5 slits at sides, with 1 yard flex and tags. **Without Lamp A 58-495** .. .. r **1 0 0**

THE MICROID OPTICAL DISC

A new large scale demonstration model



A 52-460.

This apparatus incorporates several important new features. The disc is 30 in. diameter, enabling experiments to be followed in detail by a large class. It may be used as an Optical Board. The light sources are mounted co-axially with the disc and give beams of sufficient intensity to be visible in daylight. It is provided with a centre disc rotating independently of the outer one so that the apparatus can be used as a demonstration spectrometer. Two clamps of special design enable the optical parts to be fixed and interchanged with speed and ease.

SPECIFICATION

The apparatus consists of two concentric discs having a matt white surface clearly graduated in degrees. These are mounted to rotate freely about a horizontal axis fixed to a vertical pillar which carries the whole apparatus, and is screwed to a firm wooden base. The discs can, however, be clamped in any position, or locked to each other as desired, for various experiments.

On the same horizontal axis as the discs is mounted a balanced arm carrying the light sources which can be used in daylight to produce a variety of different rays. This co-axial mounting, and the graduation of both discs, enables quantitative measurement to be performed with maximum efficiency. Since the locking clamps are behind the discs, the demonstrations are not obstructed by manipulation of the apparatus.

The light sources.—These are supplied in a variety of voltages to suit individual needs. The use of two lamps, the directions of which can be altered, greatly increases the range of possible experiments. The lamps have slide carriers in front, so that different types of beams can be produced, and experiments on colour can be done by using filters.

The optical elements.—An attempt has been made to keep down the number of these as far as possible, but the set comprises a trapezoidal slab with two prism angles, two right angle prisms, two convex and one concave

[*continued overleaf*

A 52-460. The Microid Optical Disc—*continued.*

lenses and one each plane, convex and concave mirrors, a semi-circular block for refraction, and a circular slab for rainbow experiments. These are described on p. 148 and can easily be supplemented from usual laboratory equipment, ordinary glass blocks, prisms, diffraction gratings, etc., being quite suitable.

£ s. d.

A 52-460. MICROID OPTICAL DISC, with disc 75 cm. (30 in.) diameter, complete on stand, with two projectors, seven slits for different beams, and three different coloured screens.
Without projector lamps and prisms, etc. .. .. r 27 0 0

Lamps, Projector, Class F, 6 volt or 12 volt, 24 watts, S.B.C. .. see **A 58-495.**

Trapezoidal block, two right angled prisms, two different convex lenses, one concave lens, semi-circular block for refraction, circular block for rainbow, for use with above, see **A 51-900—945.**

Plane Mirrors, for use with above .. .. *see page* 146

Convex and Concave Mirrors, for use with above .. .. .. *see page* 147

EXPERIMENTAL NOTES

The Lamps.—One of the lamps gives a more powerful beam, and the other, having a long focus lens, gives one which is less intense, but more parallel. The latter should be used for quantitative work, but both should be used together for demonstration purposes to get a wide beam. Before any experiments are tried, the battery or mains should be connected to the terminals on the instrument. **It is imperative** that the **filament** be then adjusted so that it is **at right angles to the plane of the disc**. This can be tested by focussing it on a distant wall by means of the draw tube.

If one of the slides is now placed in front of the lens, an intense ray should appear on the disc. The most intense illumination will be obtained if the lamp is tilted a little towards the disc, and any further adjustments for parallelism can then be made. Convergent or divergent beams can be obtained by altering the focussing, and for work on shadows, the lens tubes should be removed altogether.

The simple experiments on mixing two colours are performed by using the coloured glasses to produce overlapping beams of light, or for colour subtraction, by holding one in front of the other.

Objects.—The objects should be handled carefully to prevent the chipping of the enamelling on the back, which serves to show up the paths of the rays inside the medium. They are easily clamped to the disc in any desired position by the clamps on the front.

The Disc-Locking Clamps.—Three locking clamps are provided. The first clamps the two discs (inner and outer) together, and the second and third clamp the inner and outer discs respectively to the stand. The discs may, therefore, be rotated as one, either may be rotated while the other is fixed or both may be fixed. The lamps are not clamped but, being held by a balanced arm, may be rotated independently.

DEMONSTRATIONS

Many more experiments than those outlined below will suggest themselves. This is an apparatus for general school use in optics, but can easily be adapted to the teaching of Physical Geography, Astronomy, etc. It can also be profitably employed in demonstrating the theory of the Spectrometer, Refractometer, Sextant, etc. Experiments with a refraction tank, diffraction grating, and with polarized light are other possibilities. Indeed, Optics cannot be satisfactorily taught without the help of such an instrument.

LIST OF EXPERIMENTS

1. Shadows: Umbra, Penumbra. (With Lens Tubes removed.)
2. Reflection from a plane mirror.
3. Reflection from a concave mirror.
4. Reflection from a convex mirror.

(With parallel, convergent or divergent rays.)

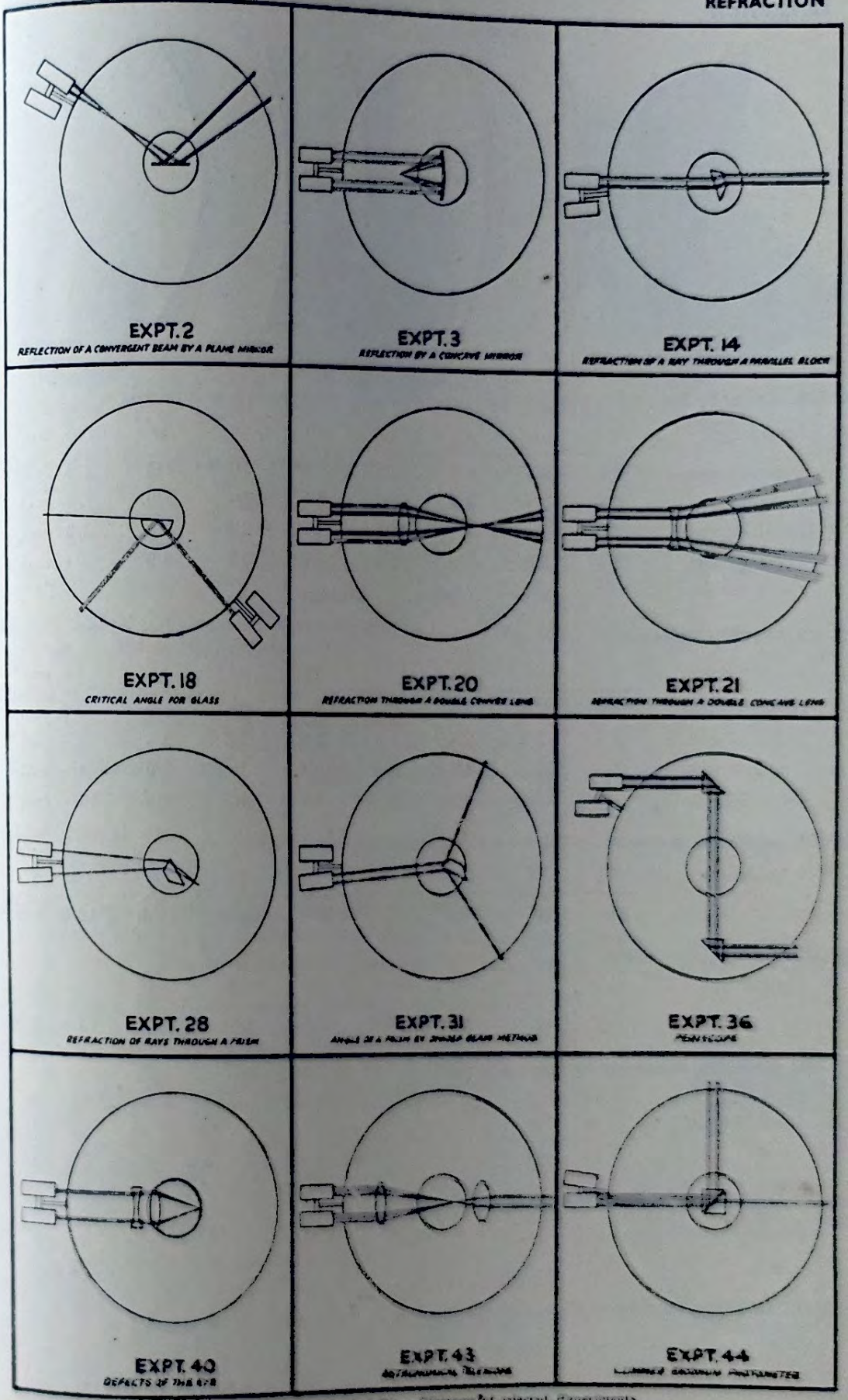
5. Angle of reflection equals angle of incidence.
6. Reflected ray moves through twice the angle of mirror.
7. Reflection of rays from mirrors at an angle; production of images in same. (Use a convergent beam.)
8. Multiple reflection between parallel mirrors.
9. Internal reflections in a slab.
10. Focal length of convex mirror.
11. Focal length of concave mirror.

(Direct method and with auxiliary lens.)

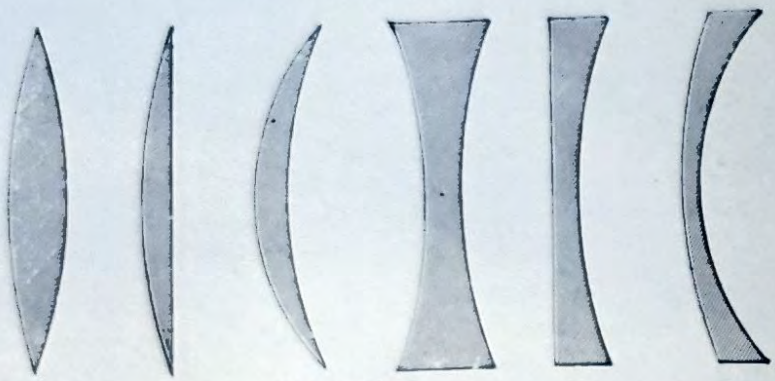
12. Normal incidence on convex mirror.
13. Normal incidence on concave mirror.
14. Refraction through a parallel sided slab; lateral displacement and parallelism of incident and emergent rays.
15. Partial reflection and refraction at a surface.
16. Measurement of index of refraction sin *i*/sin *r*.
17. Total internal reflection.
18. Critical angle (hence refractive index).
19. Spherical aberration of a thick lens (lens tube removed from light source).
20. Refraction through a double convex lens.
21. Refraction through a double concave lens.
22. Measurement of focal length of convex lens.
23. Measurement of focal length of concave lens.
24. Measurement of focal length of concave lens with auxiliary lens.
25. Measurement of focal length of convex lens with auxiliary mirror.
26. Measurement of radius of curvature of surface of concave lens.
27. Demonstration of caustic curve.
28. Refraction of rays through a prism.
29. Measurement of angle of a prism (Gauss method).
30. Measurement of angle of a prism (Rotating beam method).
31. Measurement of angle of a prism (Divided beam method).
32. Variation of deviation with angle of incidence.
33. Measurement of angle of minimum deviation.
34. Total internal reflection in a prism.
35. Reversal of rays by a prism.
36. Prism Binoculars or Periscope effect.
37. Formation of rainbow (Primary.)
38. Formation of rainbow (Secondary).
39. Principle of Refractometer.
40. Defects of the Eye (long sight).
41. Defects of the Eye (short sight).

(Sheet of card represents pupil.)

42. Passage of rays through a lens system.
43. The Astronomical Telescope.
44. Principles of Lummer-Brodhun Photometer.
45. Variation of focal length of a lens with colour.
46. Production of simple Spectrum.
47. Absorption of filters; different deviations.
48. Experiments in additive colour mixing.
49. Refraction of liquids, using a tank (extra).
50. Study of Diffraction Phenomena, using a grating (extra).



A52-460.—Microid Optical Disc—Diagrams for selected Experiments.



A 52-520—565.

A 52-520. LENSES, Bi-convex, good quality glass accurately worked, with ground edges.

Focal length ..	5	10	15	20	26	30	50	100	*cm.*
Diam. 25 mm. ..	3/6	2/-	1/9	1/6	1/6	1/3	1/3	1/3	*each*
Diam. 38 mm. ..	8/-	3/-	2/6	2/3	2/3	2/-	1/9	1/9	*each*
Diam. 51 mm. ..	10/6	5/-	4/-	3/-	3/-	2/6	2/6	2/6	*each*
Diam. 63 mm. ..	13/-	8/6	5/-	4/6	3/9	3/9	3/9	3/-	*each*

Shorter focal lengths, see **A 52-550.**

A 52-525. Ditto, Bi-concave.

Focal length ..	5	10	15	20	26	30	50	100	*cm.*
Diam. 25 mm. ..	3/9	2/6	2/3	2/-	2/-	2/-	1/9	2/6	*each*
Diam. 38 mm. ..	8/6	3/3	3/-	2/6	2/6	2/3	2/-	3/-	*each*
Diam. 51 mm. ..	11/-	6/-	4/6	3/6	3/3	3/-	2/9	4/-	*each*
Diam. 63 mm. ..	—	10/-	6/-	5/-	4/-	4/-	4/-	10/-	*each*

A 52-530. LENSES, Bi-convex, 38-40 mm. diam., with unground edges.

Focal length ..	5	10	15	20	26	30	50	100	*cm.*
	40/-	30/-	17/6	15/-	14/-	14/-	12/6	12/6	*dozen*

A 52-535. Ditto, Bi-concave.

Focal length	5	10	15	20	26	30	50	*cm.*
	45/-	32/6	25/-	21/-	15/-	15/-	13/6	*dozen*

A 52-550. LENSES, Plano-convex, ground edges.

Diam.	10	17	25	25	25	51	63	63	63	63	*mm.*
Focal length ..	30	8	8·5	4	5	21·5	15	20	26	30	*cm.*
	4/-	4/6	7/-	6/6	5/6	5/6	7/6	4/6	4/-	4/-	*each*

A 52-560. LENSES, Plano-concave, ground edges, 63 mm. diam.

Focal length	20	26	30	*cm.*
	7/6	7/-	6/6	*each*

A 52-565. LENSES, Condenser, Plano-convex, about 6 in. focal length, unmounted.

Diam.	4	4½	*in.*
	9/-	11/-	*each*



A 52-580.



A 52-590.



A 52-625.

A 52-580. **LENSES, Achromatic, Plano-convex,** two lenses cemented together, ground edges, unmounted.

Diam.	12	12	38	38 *mm.*
Focal length	3·2	6·4	10	15 *cm.*
	15/-	13/-	22/-	22/- *each*

£ s. d.

A 52-590. **LENSES, Cylindrical, Plano-convex,** 49 × 43 mm., focal length about 15 cm., suitable for use with ray boxes .. .. *each* 0 4 6

A 52-600. **LENSES, Spectacle,** 47 mm. diam.:—bi-convex, bi-concave, plano-convex, plano-concave, convexo-concave, concavo-convex .. .. *set of six* 0 12 6

A 52-610. **LENSES, Specimen,** 50 mm. diam.:—bi-convex, bi-concave, plano-convex, plano-concave, convexo-concave, concavo-convex; ground edges .. .. *set of six* 1 15 0

A 52-620. **TRIAL SET,** 48 lenses, 36 mm. diam., 24 bi-convex and 24 bi-concave of different focal lengths from 8·5 to 400 cm., in polished wood case .. .. *p* 9 10 0

A 52-625. **Ditto, 114 lenses,** 36 mm. diam., 35 bi-convex and 35 bi-concave spherical, focal lengths from 5 to 400 cm., and 22 each plano-convex and plano-concave cylindrical, focal lengths 16·7 to 400 cm., in case with hinged lid .. .. *p* 12 10 0

A 52-640. **LENS MEASURE,** watch form, reading to + 15D on red scale and − 15D on black scale .. .. *p* £ s. d. 1 13 0

The lens measure consists of a dial 41 mm. diam. with wide graduations and red (+) and black (−) scales for easy reading. Unbreakable glass front, two hardened fixed pins and centre moving pin, one of the former being adjustable for zero-setting. The case has two convenient finger grips.

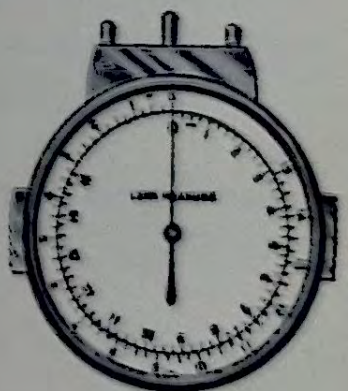
When the measure is applied to a curved surface, either convex or concave, movement of the centre pin actuates a coupling device which rotates the pointer to a figure which expresses the dioptric value of the curved surface. The focal length of a lens in cm. is obtained from the expression :—

$$f = \frac{100}{\text{Dioptric value}}$$

It should be borne in mind that the curvature of both faces of the lens should be taken into account. Thus if the lens is bi-convex and the dioptric value of each surface is 5 dioptres the focal length of the lens is 10 cm.

The dial is calibrated for crown glass ordinary lens glasses and is calculated assuming the refractive index is 1·523.

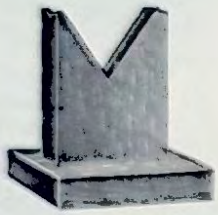
The lens measure may clearly be applied to the determination of curvatures other than those of lens faces.



A 52-640.



A 52-750.



A 52-755.



A 52-760.



A 52-765.



A 52-775.



A 52-780.

	£	s.	d.
A 52-750. LENS HOLDER, Wood, to take lenses from 38 mm. to 100 mm. diam.	0	3	6
A 52-755. LENS HOLDER, Wood, with V slot to hold lens, fitted on base *each* **2/6** ; *dozen*	1	7	6
A 52-760. LENS HOLDER, bronzed brass, to take lenses 38 to 51 mm. diam. *each* **9d.** ; *dozen*	0	8	0
A 52-765. LENS HOLDER, brass spring clip on wood base with index mark ; takes lenses up to 63 mm. diam. .. .. *each* **2/6** ; *dozen*	1	7	6

A 52-775. HOLDERS, lens, mirror, ground glass screen, etc., brass, circular with retaining ring, on brass stem ⅜ in. diam., suitable for optical benches **A 53-120, A 53-185.**

Internal diam.	38	51	63	102	150	*mm.*
	6/-	**7/-**	**8/-**	**11/6**	**15/-**	*each*

	£	s.	d.
A 52-780. HOLDER, lens, mirror ; adjustable, for any diameter up to 100 mm. Brass stem ⅜ in. diam., suitable for optical benches **A 53-120, A 53-185**	1	7	6



A 52-815.

	£	s.	d.
A 52-810. LUMINEX MAGNIFIER, Fixed Focus Model, magnification × 10, with lamp and battery. In soft leather case .. .. *ea*	1	8	6

A 52-815. Ditto, Adjustable Focus Models, with lamp and battery. The × 20 is fitted with an achromatic lens, giving a field of view free from aberration. In soft leather case.

Magnification	× 10	× 15	× 20	
ea	**£1 10 6**	**£1 13 6**	**£4 2 6**	*each*

	£	s.	d.
A 52-820. LUMINEX MAGNIFIER Scale Model, magnification × 10, adjustable focus, with lamp, battery and one scale, to be selected from list below. In soft leather case. (*Please state scale required when ordering*) .. .. *ea*	2	18	6

Accessories for A 52-810–820

		£	s.	d.	
A 52-820 a.	**Scale only,** 1 in., divided into 10ths, 50ths and 200ths of an inch .. .. .. *ea*	1	3	6	
" " b.	Ditto, 10 mm., divided into 0·01 mm. .. .. *ea*	1	3	6	
" " 2.	Ditto, with cross, 1/8 or 1 mm. squares over the whole field .. .. .. *each*	1	3	6	
" " 6.	**Extra Lamp** .. .. *each*	0	0	5	
" " 7.	**Extra Battery** .. .. *each*	0	0	6	



A 52-850. Triple.



A 52-865. Triple.



A 52-855.

A 52-850. **LENSES, Pocket,** $\frac{7}{8}$ in. diam., mounted in vulcanite case.

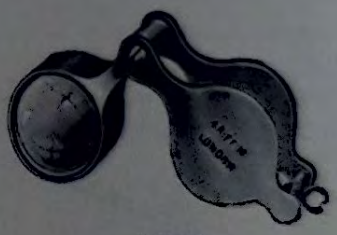
Type	Single.	Double.	Triple.	
	2/3	3/6	4/6	*each*
A 52-855. Ditto, $1\frac{1}{4}$ in. diam.	3/6	7/-	9/6	*each*

A 52-865. **EYE GLASSES, Watchmakers',** 1 in. diam., in vulcanite mount, focal length 2, 3, 4 in.

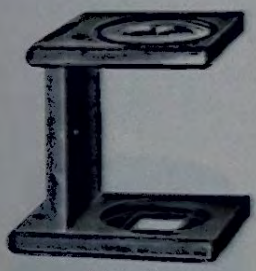
	£	s.	d.
(*When ordering please state focal length*) .. .. *each*	0	1	9



A 52-885.



A 52-895.



A 53-910.

A 52-885. **LENS MAGNIFIERS, Pocket,** doublet lens, not fully corrected for spherical aberration and achromatism, but giving a tolerably flat field almost free from colour. Lenses, aperture 17 mm., in vulcanite mount folding into a nickel-plated case.

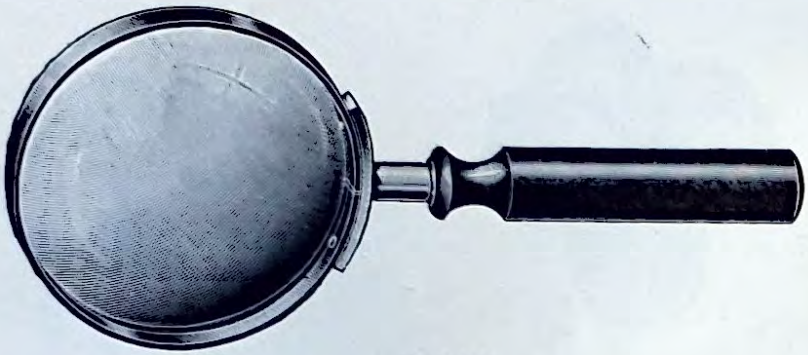
Magnification	× 5	× 8	× 10	
	7/6	8/-	9/-	*each*

A 52-895. **LENS MAGNIFIERS, Achromatic, Pocket,** giving a flat field of view, free from distortion and colour; in nickel-plated mount with cover, complete in chamois leather case.

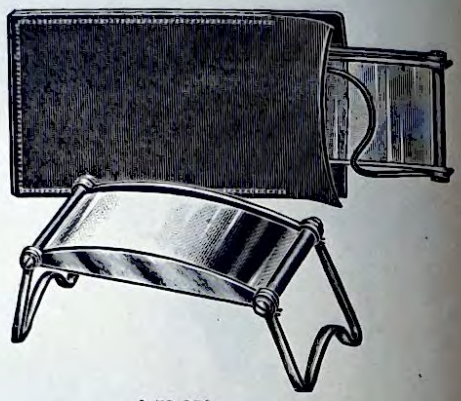
Diam. of lens	1 in.	$\frac{3}{4}$ in.	$\frac{1}{2}$ in.	
Magnification	× 5	× 12	× 20	
	£1 7 6	£1 7 6	£2 2 6	*each*

	£	s.	d.
A 52-900. Ditto, double form, with lenses $\frac{3}{4}$ and $\frac{1}{2}$ in. diam., and magnifications × 10 and × 20	2	15	0

A 52-910. **COUNTING GLASSES (Linen Provers),** folding metal frame with $\frac{1}{2}$ in. square aperture, students' quality 0 4 0



A 52-940.



A 52-950.

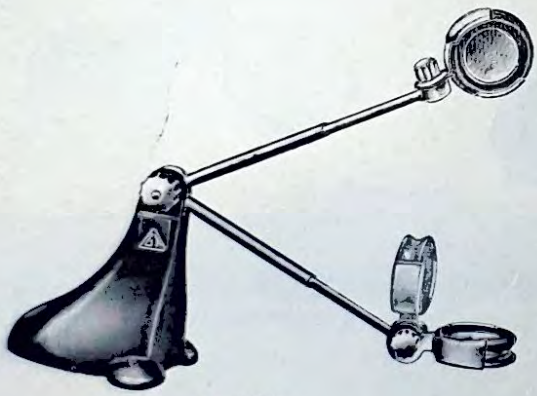
A 52-940. LENSES, Reading, circular, with polished metal mounts and screwed black handles.

Diam.	$2\frac{1}{2}$	3	$3\frac{1}{2}$	4	*in.*
	9/-	**11/6**	**17/6**	**25/-**	*each*

	£	s.	d.
A 52-945. Ditto, rectangular, lens approx. $2\frac{1}{2} \times 1\frac{5}{8}$ in. .. .. *each*	**1**	**5**	**0**
A 52-950. LENS, Reading, rectangular, spherical-cylindrical giving flat field without distortion, in folding metal frame, in leather case. Lens approx. $3\frac{1}{4} \times 1\frac{3}{8}$ in.	**1**	**17**	**6**



A 52-970—975.



A 52-985.



A 52-990.

	£	s.	d.
A 52-970. LENS, Tripod, clear aperture $1\frac{1}{16}$ in. diam., magnification × 5, in plastic mount. Gives wide, undistorted field of view. Can be used in the hand, or in the plastic tripod stand as illustrated, which is of correct height for the focus of the lens and requires no adjustment. Can be used also on the adjustable stand **A 52-985**	**0**	**10**	**6**
A 52-975. Lens only	**0**	**7**	**6**
A 52-985. LENS STAND, Adjustable, to take lens **A 52-975.** Heavy base $4\frac{1}{2}$ in. high, black crackle finish, with nickelled telescopic arm extending to 7 in., friction adjustments and milled head locking nuts hold the lens rigidly in any position from bench level to vertical. The lens is held in a spring clip from which it can easily and quickly be detached. Particularly suitable for reading manometer and thermometer scales, verniers, balance scales, etc., and the examination of small objects. (Also suitable as a dissecting lens for biology.) **Without** lens	**1**	**2**	**6**
A 52-990. LENS MAGNIFIER (Pocket Microscope), fountain pen pattern, with clip for waistcoat pocket, 5 in. long, $\frac{3}{4}$ in. diam., magnification × 25, with focussing arrangement, nickelled brass .. .. *p*	**0**	**7**	**6**

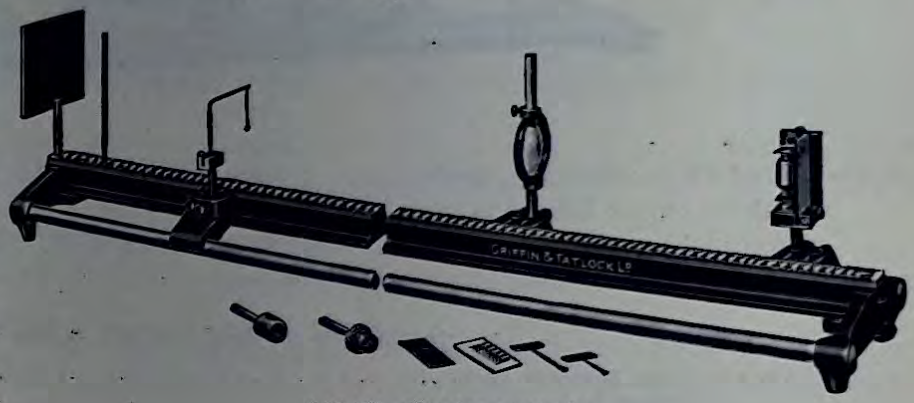
THE MICROID OPTICAL BENCH MODEL A

An improved metal bench for two concurrent experiments

Registered Design No. 786743

The need for a low priced metal bench of robust construction, and capable of giving accurate results, has long been recognised. Such a bench should also be capable, when occasion requires, of use for interference and diffraction experiments.

In designing the Microid Optical Bench Model "A," these considerations have been borne in mind. The outstanding feature is a double track which enables mirror and photometer experiments to be carried out with greater ease, and independent work to be performed by two students simultaneously.



A 53-120.—Showing accessories.

SPECIFICATION.

The bench, one metre in length, is formed by two substantial end supports carrying two ⅜ in. diam. rods and a **T**-section bar. The sliding feet are heavy iron castings and each has two holes and clamping screws for holding accessories. They are geometrically supported by means of a double **V** bearing at the front resting on one of the rods and a toe at the rear resting on the lower part of the **T**-bar. An engraved index line is provided for each hole on the sliding feet.

The scale, which is graduated 0–100 cm. in both directions, is secured both to the end supports and to the **T**-bar. At each end of the bench a hole is drilled to take a standard stem, such as that of a screen, and a series of smaller holes in which a rod may be fitted to form a Rumford Photometer.

Suitable accessories for use with the bench are listed below.

	£	s.	d.
A 53-120. MICROID OPTICAL BENCH, MODEL A, metal, one metre long, with three sliding feet. **Without** optical fittings	4	15	0

Component Parts of Optical Bench A 53-120

		£	s.	d.
A 53-120 a.	**Sliding Feet,** heavy cast iron, with two ⅜ in. diam. holes and clamping screws *each*	0	6	6
„ „ **b.**	**Pinholder,** on ⅜ in. stem, with clamp for supporting pins, etc. Will also support screens **A 53-120 g-k**	0	6	6
„ „ **c.**	**Pins,** set of 3 for above, long, short and inverted (see illustration), mounted on brass bases	0	8	0
„ „ **d.**	**Lens holder,** on ⅜ in. stem, to accommodate lenses up to 51 mm. diam.	0	8	0
„ „ **e.**	**Screen,** metal, 4 × 2½ in., on stem, with rod for photometer experiments	0	4	6
„ **f.**	**Lampholder,** on ⅜ in. stem, to carry festoon lamp in clips mounted in ebonite plate with terminals and ground glass screen 3 × 1 in.	0	19	6
	Lamp, tubular, for above. .. .. See **A 58-295—297.**			
„ „ **g.**	**Crosswires Screen,** 3 × 1 in.	0	4	6
„ „ **h.**	**Screen,** translucent, 3 × 1 in., with scale in millimetres	0	5	0
„ „ **k.**	**Screen,** opaque, 3 × 1 in., with scale in millimetres, for use as an image screen ..	0	4	6
„ „ **m.**	**Candle-holder,** on ⅜ in. stem	0	3	0
„ „ **n.**	**Lampholder,** small bayonet type, on ⅜ in. stem, to carry 12 volt high wattage lamp	0	5	0
	Lamp, for above, Class F, 12 volt, 24 watt. .. .. S.B.C. See **A 58-495.**			

EXPERIMENTAL NOTES

Optical bench technique is so well known that there will be indicated here only the various standard experiments which the student should perform and for which this bench is particularly suitable.

I. Plane and Convex Mirrors.

Relation between image and object by parallax: Focal length, etc., of convex mirror, using auxiliary lens, lamp and screen.

II. Concave Mirrors.

Relation between image and object: Curvature and magnification by screen and by parallax methods.

III. Lenses.

Focal lengths of lenses by formula and by using auxiliary mirrors. Magnification of lenses.

IV. Lens Combinations.

Determination of Principal points. Telescope, microscope, and their magnifying powers.

V. Photometry.

Inverse square law. Comparison of candle powers. Determination of candle power.



A 53-140.

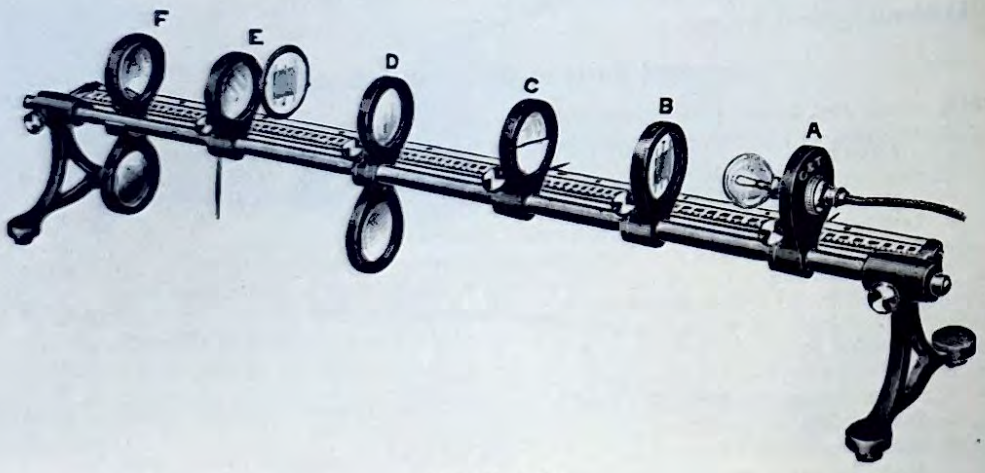
	£	s.	d.
A 53-140. OPTICAL BENCH, Simple (Clay: *Practical Exercises in Light*, fig. 48), wood board with metre rule divided in mm.; zinc screen with two holes (one hole being fitted with cross wires), and bent to take card; image screen; four lens holders; needle; grease spot disc; and single candle holder on stands	3	15	0

Component Parts of Optical Bench A 53-140

	£	s.	d.
A 53-140 a. **Zinc Screen**, on stand	0	10	6
„ „ b. **Image Screen**, on stand	0	6	6
„ „ c. **Lens Holder**	0	5	6
„ „ d. **Needle**, on stand	0	3	6
„ „ e. **Grease Spot Disc**, without stand	0	1	0
„ „ f. **Candle Holder**, single	0	3	6

THE MICROID OPTICAL BENCH MODEL A.1

Components not easily removable produce a bench ready for immediate use in an exceptionally wide range of optical experiments



A 53-160—165.

The ideal design of optical bench suitable for use by elementary students has long been sought. It should be robust, should be designed so that accessory parts cannot easily be mislaid and should require the minimum of time to set up and to adjust. The images, particularly of pins, should be easy to locate.

The Microid Optical Bench Model A.1 has been designed with these ends in view. It has been subjected to searching tests in the hands of students before being marketed. It is a simple design that has been found most effective for its purpose. By a judicious combination of optical parts it fulfils all requirements in optics to the School Certificate stage. The addition of one accessory, carries the scope of the instrument to the H.S.C. and Scholarship stages. Particular attention has been paid to the illumination of the pins so that the experienced will recognise in the apparatus a distinct advance on optical benches formerly available.

A 53-160.—The Microid Optical Bench Model A.1—*continued.*

SPECIFICATION

The optical components are carried in special lens holders adjustable along a stainless steel rod about 1 metre in length mounted on supports provided with rubber feet. One double and four single holders are supplied, lettered A-E respectively, and carrying, in order, the following components:—

A. Lampholder, s.b.c., flex and spade terminals. Pin on boss.

B. Frosted glass scale ruled with black lines 2 mm. apart, centre line capped by a black solid circle for use as a pin object.

C. Top, clear glass semicircle; lower, plane glass semicircle silvered on side facing scale B, backed by white ivorine semicircle ruled with black lines 2 mm. apart. Pin on boss.

D. Concave mirror 10 cm. *f.*, biconvex lens 15 cm. *f.*

E. Plane silvered mirror. Metal disc attached to face of lens holder can be swung aside to expose mirror. Attached to disc is white ivorine circle ruled with black lines 2 mm. apart. Centre line as in A above. Pin on boss.

F. Biconcave lens 30 cm. *f.* Convex mirror 30 cm. *f.* The boss of this lens holder is specially slotted so that it may easily be removed from the optical bench. *It is not included in the standard equipment but is extra.*

Engraved on the boss of each lens holder is a line from which measurements may be taken.

A wood rule, graduated in mm. and numbered at each cm., is mounted in spring clips on the supporting feet. The rule is easily removable to allow the components to be rotated when the experiment requires it.

All pins are of stainless steel. Special attention has been paid to illumination of the pins which in optical experiments are notoriously difficult to see.

The following arrangements can be employed as desired:—

(*a*) Pin showing black against a light background.

(*b*) Dark line object on a matt background.

(*c*) Object pin showing bright by reflected light.

	£ s. d.
A 53-160. MICROID OPTICAL BENCH MODEL A.1. Stainless steel rod, supporting feet, and components in holders A-E enumerated above. Metre rule .. .. *r*	5 10 0
Lamp for above, Class F, 12 volt, 24 watt, S.B.C., ... *see* **A 58-495.**	
A 53-165. Extra Component, F, double lens holder with slotted boss, bi-concave lens, 30 cm. *f.*, convex mirror 30 cm. *f.*, for use in Expts. XVIII-XXVI .. .. *r*	0 16 0

EXPERIMENTAL NOTES

In setting up the apparatus for the first time, care should be taken to see that all the accessories are arranged in the order shown in the illustration and as described above. As the bench is a compact apparatus it will pack into a small space without being taken to pieces.

Measurements of the distances between the pins, scales or lenses, may be made by a metre rule. The rule may be held in the hand, or placed in the spring clips on the supporting feet, and used in conjunction with a standard distance rod. Any suitable rod may be employed for this purpose. If a distance rod be used errors due to non-coincidence of optical centres of the lenses with the engraved lines on the lens holder bosses are avoided.

The bench should always be used with lamp at the right and the metre scale at the back.

REAL IMAGE EXPERIMENTS (CONVEX LENS).

Expt. I. Focal length of a convex lens using distant object.—Place the screen E and the lens D about 15 cm. apart and direct the system at a bright distant object. Adjust the distance of separation of E and D until the image is sharply in focus. The focal length of D is the distance between the screen and the lens.

Expt. II. Focal length of a convex lens by parallax at focus.—Erect lens D and the pin on the holder C and look in the direction CD towards a distant object, keeping the eye about 2 ft. from the pin. Move the eye from side to side and adjust the distance between C and D until no relative motion of the image and the pin takes place. The distance between C and D is then the focal length of the lens. The adjustment for elimination of parallax between the pin and the image of the distant object is readily carried out by remembering that whichever of these is farthest from the eye moves with the eye.

Expt. III. Focal length of a convex lens by reflection of parallel rays back to the object.—Erect the plane mirror E, the lens D and the pin on the lampholder A. Switch on the lamp to illuminate the pin and adjust the distance between A and C to about 15 cm. The distance between D and E is not material and may be any convenient value. The eye is then placed about 2 ft. behind the pin and the distance AD adjusted until parallax is eliminated between the pin and its inverted image. The distance AD is the focal length of the lens.

Expt. IV. Focal length by measurement of distance of object and its real image.—Erect the lamp A, the object B, the lens D and the

[*continued overleaf*

A 53-160.—The Microid Optical Bench Model A.1.—*continued.*

screen E. Separate B and E each from D by about 28 cm. Switch on the lamp to illuminate the object and adjust the screen until a sharply focussed image of B is produced on E. The distances of separation from the lens should then be measured (if necessary by the use of the standard distance piece) and the values of u and v recorded. The distance of the object B from the lens can now be increased progressively and other values found for u and v. If desired, a graph may be plotted showing the relationship between $\frac{1}{u}$ and $\frac{1}{v}$.

Expt. V. Focal length by measurement of distance of object and its real image using parallax.—Erect the pin on E, the lens D and the pin on A at distances as in Expt. IV. With the eye on the left (E) side look into the lens at the image of A. If necessary, illuminate A by switching on the lamp and adjust the position of the image-finding pin E until parallax is eliminated. Proceed then as in Expt. IV and record results in a similar manner.

Expt. VI. Focal length by the minimum distance (4 f) method.—This method depends upon the fact that when the distance between object and image exceeds 4 f, a real image can be formed with the lens in either of two positions. The experiment is carried out so that the distance between these two positions is gradually diminished until they coincide. The distance from object to image is then the minimum at which the lens can form a real image and equals 4 f.

Arrange the apparatus as in Expts. IV or V. Let the distance from B to E be about 80 cms. Find the two positions of the lens at which parallax is eliminated between the real pin and the image of the object. Let these two scale readings of the lens be x and y. Set the lens at the position $\frac{x+y}{2}$. Now move pin A towards the lens until parallax is again eliminated between the real pin and the image of the object. Next move the lens to find the second position at which, for these positions of object and image pin, the second real image can be formed. These two positions are then $\frac{x+y}{2}$ and z. Move the lens to $\frac{1}{2}\left(\frac{x+y}{2}+z\right)$. In a few repetitions of these operations, the distance between the object pin and the image pin is soon reduced to the minimum, at which it equals 4 f. Since the method necessitates the measurement of one large distance only, it is probably one of the most accurate methods.

Expt. VII. Focal length by measuring distance of object and its real image, using a plane mirror.—Erect the lens D about 35 cm. from the pin A and about 30 cm. from the mirror E. Illuminate the pin by switching on the lamp. Place the eye about 2 ft. behind the pin and observe the image of the pin. Move the eye from side to side and decrease the distance between A and C until parallax is eliminated between the pin and its image. As the two are coincident when parallax is eliminated, they can be seen separately only in positions on either side of the final position of the pin. Repeat for other distances.

In this experiment an inverted image of A is formed by the lens. If the distance from lens to mirror is so adjusted that the image falls on the surface of the mirror then it will be reflected back and after refraction through the lens will form an image coincident with the object. The formula $\frac{1}{v}-\frac{1}{u}=\frac{1}{f}$ can now be applied, with v, the distance from the image (on the mirror) to the lens, negative.

Expt. VIII. To verify by pin and distance method Newton's formula $fq = f^2$. Newton's formula may be verified by inserting $(p + f)$ for $-u$ and $(f + q)$ for v in the formula $\frac{1}{v}-\frac{1}{u}=\frac{1}{f}$. The experiment may then be conducted as in Expts. V, VI, or VII, except that the two distances, p and q respectively, are measured from the two foci, which are found as in Expts. II or III.

This method, while not of great interest for thin lenses (to which the formula $\frac{1}{v}-\frac{1}{u}=\frac{1}{f}$ can directly be applied), is used extensively for thick lenses or for combinations of lenses, where the focal planes, from which u and v are measured, do not coincide with the surfaces of the lenses.

Expt. IX. Focal length of a lens by method of Magnification by Lamp and Screen.—Erect the screen E, the lens D, object B and lamp A. Separate B and D by about 50 cm. and adjust E to receive a sharp image. Measure the magnification m. Displace the lens through a distance d to give a second sharp image. Let the magnification here be m'. Then $f=\frac{d}{(m-m')}$.

The method is discussed theoretically in Houstoun: *Treatise on Light*, p. 73, and in other text books.

Expt. X. Focal length of a lens by Abbé Method of magnification.—Arrange the apparatus as in Expt. IX but now displace E a distance d from the lens and move B until focus is again obtained and let the magnification be m'. Then $f=\frac{d}{(m-m')}$.

VIRTUAL IMAGE EXPERIMENT (CONVEX LENS).

Expt. XI. Half mirror method.—Erect the pin A, the half mirror C, the lens D and the pin E. Illuminate the pin A. Looking from A towards E the image of A can be seen in the half mirror, and the image of E, through the lens D and the clear glass semicircle, above the half mirror. By adjustment of the distances the two images may be made apparently collinear and parallax between them eliminated. The observations are facilitated if the eye is some distance (2 ft.) from E. In an experiment, the actual distance u from the pin on E to the lens surface was 4·5 cm. The actual distance from the tip of the pin on A to the mirror surface was 13·7 cm. and the distance from mirror surface to lens was 5·8 cm. Since the distance of the image from a plane mirror is equal to that of the object, the image in the plane mirror was formed 13·7 cm. behind the plane mirror, which brought it (13·7 — 5·8) cm. behind the lens. Thus u = 4·5 cm. and v is virtual and is 7·9 cm.

REAL IMAGE EXPERIMENTS (CONCAVE MIRROR).

Expt. XII. To determine the focal length of a concave mirror by elimination of parallax between a pin and the image of a distant object.—This experiment is not easy to perform as the observer's head usually constitutes an obstruction. Erect the concave mirror D and the pin on C. Select a suitable distant object and direct the bench towards it so that an angle is included between the normal at the centre of the mirror and a line from the object to the same point. Rotate the holder C until the axis of the pin makes an angle with the horizontal. The most suitable value must be found by trial. With the head placed to one side of the bench, the image of the distant object can usually be seen in such a position that the pin can be superimposed on it and parallax between the two eliminated.

Another method is to direct the axis of the optical bench towards the object and then, with its plane vertical, to interpose between the object and pin, a piece of plane, unsilvered glass, turned about a vertical axis to an angle of 45° to the bench. This glass reflects sufficiently to enable the parallax adjustment to be effected easily. The focal length is the distance between the concave mirror and the pin. An easy modification of this experiment is to form a real image of the distant object on the scale on the back of the half mirror E.

Expt. XIII. To find the centre of curvature of a concave mirror.—Erect the mirror D and the illuminated pin A. Adjust the distance (about 20 cms.) between the two until parallax is eliminated between the object and its image. The eye should be placed about 2 ft. away from the pin. The measured distance is the radius of curvature r which is equal to $2f$.

A 53-160.—The Microid Optical Bench Model A.1.—*continued.*

Expt. XIV. Focal length of concave mirror by measurement of the distance of an object and of its real image, using parallax.—Erect the mirror D, and the pins A for the object and C for use in image finding. Place C at various distances from D and find the position of the image by eliminating parallax between the image and the pin A. For example if C be placed at about 14·5 cm. from D, A will be at about 32 cm. from D. The measured distances u and v are then both positive.

Expt. XV. Focal length of concave mirror by measurement of the distance of an object and of its real image.—Erect the mirror D, the half mirror C, the screen B, and the lamp A. Make the distance DC about 16 cm. and DB about 28 cm. Observe the images of the pin and measure the various values of u and v as in Expt. XIV.

Expt. XVI. Verification of Newton's formula.—The position of the objects and the image are found as in Expts. XIV or XV, but the distances p and q are measured from the focus which is first found by the method of Expt. XI. This is an important method of finding the focal length of a thick mirror and is suggested here as a useful exercise.

VIRTUAL IMAGE EXPERIMENT (CONCAVE LENS).

Expt. XVII. Half Mirror Method.—Erect the mirror D, the half mirror C, and the illuminated pin A. A value for DC is 7·5 cm. corresponding to a value for DA of about 30 cm. On looking along the bench, the image of the scale will be seen in the concave mirror and of the pin in the plane mirror. Eliminate parallax between the two images, measure v and u and apply the formula $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$ to obtain f.

EXPERIMENTS INVOLVING THE USE OF THE EXTRA COMPONENT F.

Expt. XVIII. Focal length of a convex mirror.—Place the component F on the optical bench between C and D. Erect the illuminated pin A and the half mirror C. The experiment is to arrange the positions of the components so that the image of A in C coincides with the image in the convex mirror F of the scale on the back of the half mirror D. Approximate distances of separation are FC 8·5 cm., FA 25 cm. Adjust so that parallax is elimnated between the two images. Then, since the image is as far behind the plane mirror as the object is in front, the position of the image in F is located. Measure the distances and apply the formula to find f.

Expt. XIX. Focal length of a convex mirror by combination with a convex lens.—Place on the bench between D and C the convex mirror in the component F. The mirror should face the lens D and be placed as close to it as possible. (The error caused by the distance of separation is negligibly small and is ignored.) The combination functions as a concave mirror of focal length $\frac{1}{F} = \frac{2}{f_{\text{mir.}}} + \frac{1}{f_{\text{lens}}}$. The focal length of the convex mirror being positive and that of the lens negative, the combination has a long focal length which may be determined using the pin E by the method of Expt. XIII.

Expt. XX. Focal length of convex mirror by centre of curvature method using auxiliary convex lens.—Erect the object screen E and the illuminated pin A about 80 cm. apart.

Erect the lens D and adjust its position so that parallax is eliminated between the pin and the image of E. Place the mirror F on the optical bench between E and D and adjust its position until parallax is again eliminated between the pin A and its image seen in the mirror. The distance FE is the length of the radius of curvature of the convex mirror and is $2f$. Light from A in this experiment is reflected back along its own path and must therefore have been incident normally on the convex mirror.

A modification of the experiment is to dispense with the use of the screen E. This experiment is carried out as described above; then, with the pin A and the lens D unmoved, the mirror is moved away from D until an erect image is seen in parallax with the pin. The mirror F then replaces exactly the screen E. This modification is difficult to carry out because the image is so nearly behind the pin that it cannot easily be seen.

Expt. XXI. Focal length of a convex mirror.—Erect the mirror F at about 3 cm. scale reading, the pin E at 28 cm., the lens D at 41 cm. and the illuminated pin A at 61 cm. From about 1 ft. distant observe A and adjust it to eliminate parallax with the image in the convex mirror, of the object pin E seen through the lens.

The distance of the mirror from the object pin E is u and can be measured. The pin E has a corresponding image distance v in the convex mirror and it is this image which produces the real image at A through the lens D. In order, therefore, to find v, the scale readings are noted, the mirror F removed, and the pin E withdrawn from D until parallax is eliminated between its image and the pin A. Pin E is now in the same position as its former image in the convex mirror. The distance v is now the difference between the scale reading of F and the new reading of E and is negative.

Expt. XXII. Focal length of a convex mirror using real images on screens.—The methods used in Expts. XIX and XX can be extended by the use of the lamp A, the half scale C, and the object screen E.

Expt. XXIII. Focal length of a biconcave lens using the silvered half mirror.—Erect in order the pin E, the concave lens on the accessory F, the half mirror C and the illuminated pin A. Observing from A towards E an image of A will be seen in C and an image of E will be seen through F. Approximate scale readings for the parts are:—E 20 cm., F 26·5 cm., C 36·5 cm. and A 55 cm. Adjust their positions until parallax is eliminated between the two images and calculate the focal length as in Expt. XI.

Expt. XXIV. Focal length of a biconcave lens by combination with a biconvex lens of shorter focal length.

Erect the lens D and place on the bench the biconcave lens F as close as possible to D. The resulting combination has a focal length F given by the formula $\frac{1}{F} = \frac{1}{f_{\text{——}}} + \frac{1}{f_{\text{——}}}$ where $f_{\text{——}}$ is negative. With the lenses employed here $\frac{1}{f_{\text{——}}}$ is greater than $\frac{1}{f_{\text{——}}}$ so that the combination is negative and equivalent to a $f_{\text{——}}$ convex lens. The focal length is best determined by the method of Expt. III.

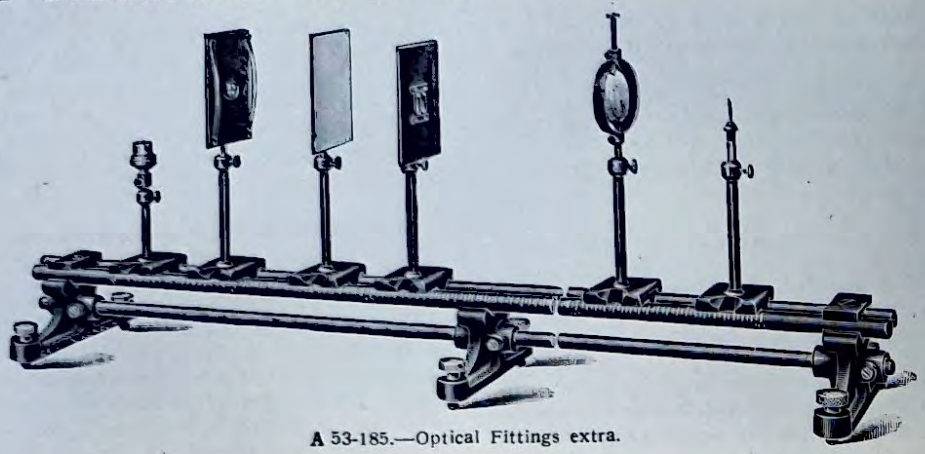
Expt. XXV. Focal length of a biconcave lens by combination with a convex lens by parallax methods

Erect the pin E, lens F, lens D and illuminated pin A at scale readings in order of about 19 cm., 40 cm., 60 cm. and 95 cm.

Rays from the object E, which is actually distant u from F, appear, after traversing F to come from a point v cm. behind F. They then fall on the biconvex lens D and form a final real image which can be located by parallax with the pin A. The distance u is measured, the reading of F noted and F then removed. Now withdraw pin E to about 12 cm. from D and eliminate parallax between the image of E and the pin A. The distance v from F to E can now be found and the focal length determined by application of the formula.

Expt. XXVI. Focal length of a biconcave lens.—Expt. XXV can be repeated, using screen E, lenses F and D and the lamp A. First measure the distance u when a real image is formed on the screen. Then determine v by noting the position of the concave lens and of the screen when a real image is obtained with the lens removed.

THE MICROID OPTICAL BENCH MODEL B



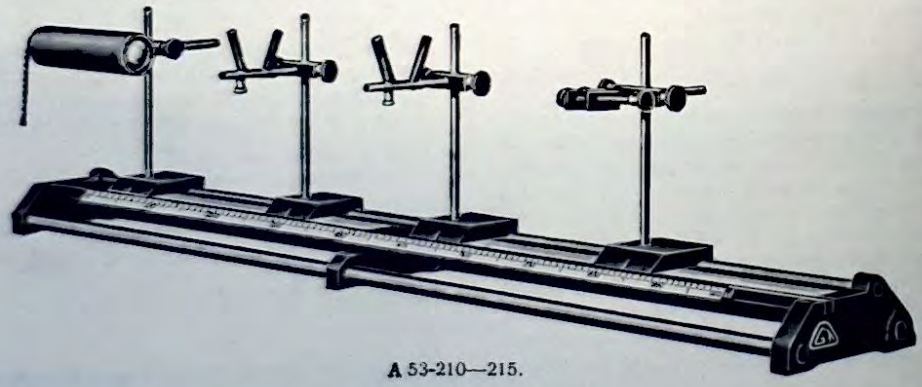
A 53-185.—Optical Fittings extra.

SPECIFICATION

The bench is about 2¼ metres long and is composed of two **stainless steel** rods, one of which is **engine divided** into mm. up to 2 metres. The rods are supported in three cast iron cradles fitted with levelling screws, the cradles at each end being provided with clamps to secure the rods firmly and the centre cradle being so designed that the sliding feet of the fittings pass freely over it. The sliding feet, 6 of which are supplied with the bench, are of iron and make geometric contact with the rods by means of a flat on one side and two vees on the other. The three long rods can be easily and quickly taken out, thus materially reducing the space required for storage purposes.

	£	s.	d.
A 53-185. MICROID OPTICAL BENCH, MODEL B, 2¼ metres long, two rods of stainless steel, one being engine divided in mm., with six iron sliding feet. **Without** optical fittings *r*	18	0	0
A 53-190. Extra Sliding Feet, with brass holder .. .. *each r*	0	17	6
A 53-195. Ditto, with heavy brass holder to take the heavier of the fittings **A 53-300—345,** if greater stability is required .. .. *each r*	1	10	0

Any of the Optical Bench Fittings **A 53-300—345** *will fit the above.*



A 53-210—215.

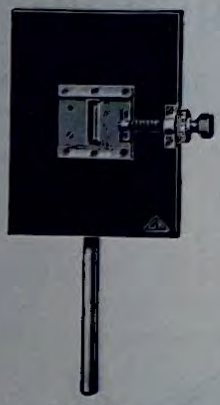
OPTICAL BENCHES, designed for school and college use. In two lengths, 100 cm. and 150 cm., of rigid construction, with accurately worked slides to give easy movement along the bed. Sliding feet are stable enough to eliminate clamps and are provided with a positioning mark in the same vertical plane as the lens holders, to read against the metal graduated scale. The lens holders are adjustable to take lenses and mirrors from 2 in. to 4 in. diam. A clamp is supplied for holding pin objects, etc. The lamphouse is of simple construction with low voltage straight filament lamp and single condenser to give parallel beam.

	£	s.	d.
A 53-210. Optical Bench, 1 metre long, with graduated scale, four sliding feet, lamphouse, lamp and condenser, two lens holders and clamp for pin objects, as illustrated	15	15	0
A 53-215. Ditto, 150 cm. long	18	18	0

Prices on application for opal diffuser, accurate pinhole, crosswires for attachment to lamphouse, and of ground glass screens, graticules, etc.


A 53-300.


A 53-305.


A 53-310.


A 53-315.

OPTICAL BENCH FITTINGS, a standard brass stem $\frac{3}{8}$ in. diam. is supplied with all the following fittings, making them suitable (and interchangeable) for use on Optical Benches **A 53-120** and **A 53-185**.

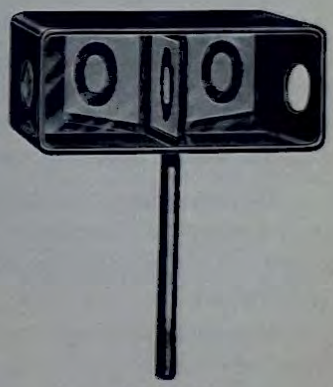
	£	s.	d.
A 53-300. **Image Screen**, paper, 6 × 4 in., stretched on metal frame	0	15	0
A 53-305. **Object Screen**, metal, 6 × 4 in., with $\frac{1}{2}$ in. aperture, cross wires and spring clips ..	0	15	0
A 53-310. **Slit, Adjustable**, with one fixed jaw and the other in a mechanical slide operated by micrometer screw and read by divided drum ; on metal screen 6 × 4 in. ..	3	17	6
A 53-315. **Iris Diaphragm**, on metal screen 6 × 4 in.	1	10	0


A 53-325.


A 53-330.


A 53-335.


A 53-340.


A 53-345.

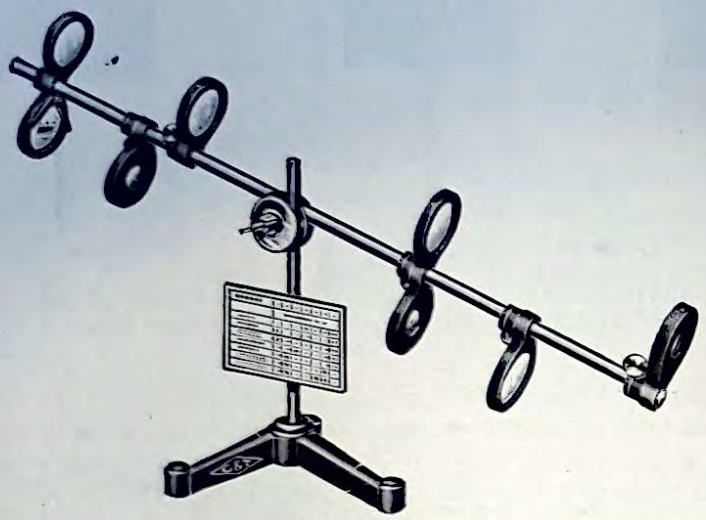
	£	s.	d.
A 53-325. **Pin Object**	0	5	6
A 53-330. **Standard Distance Rod**, 20 cm. including holder, to determine the index error of the bench	0	10	6
A 53-335. **Ramsden Eyepiece**, with micrometer scale 10 mm. × 0·1 mm., in focal plane ..	3	0	0
A 53-340. **Collimator**, with adjustable slit, for obtaining a parallel beam of light. The objective is an achromatic lens of about 22 mm. aperture and about 18 cm. focal length. With rack and pinion, in holder	9	0	0
A 53-345. **Photometer, Bunsen**, with 2 inclined mirrors, 2½ × 2½ in.	0	17	6

Additional Optical Bench Fittings will be found on the following pages:—

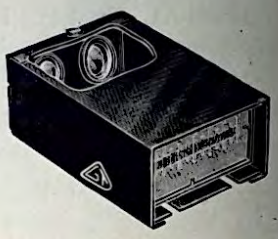
Holders for Lenses, Mirrors, Ground Glass Screens, etc.	*see page* 158
Gas Burner, incandescent	*see* A 58-220
Gas Burner, sodium	„ A 59-185
Gas Burner, fish-tail	„ A 58-230
Electric Lamp Holder	*see page* 143
Candle Holder, for 1 candle	„ „ 143
Candle Holder, for 4 candles	„ „ 143
Photometer, Lummer Brodhun	„ „ 144
Interference Apparatus, Young	„ „ 186
Interference Prism, Fresnel	„ „ 188

THE MICROID TELEMICROSCOPE

A universal assembly for the rapid erection of fifteen different types of telescope or microscope



A 53-520.



A 53-525.

This new apparatus has been specially designed to exhibit clearly and simply the optical systems of well-known forms of telescope and microscope and the improvements which result from the use of compound eyepieces.

The need for the apparatus has been made evident by consideration of a large number of answers in recent examinations. It is believed that a student who has once compared the small field of view obtained in a Galilean system, with the corresponding large field obtained with the astronomical telescope, using compound eyepieces, will never experience any difficulty by confusing the two arrangements.

The apparatus includes in its range provision for the erection of a Galilean telescope, a simple astronomical telescope, an astronomical telescope with a simple field lens, or with a Huyghens or a Ramsden eyepiece. As a microscope it may have either a simple objective or a Wollaston doublet and these may be used with any of the above five types of eyepieces.

The Microid Image Comparator is a unique accessory developed for use with the Telemicroscope to manifest the differences between a relaxed and an accommodated eye. It is believed that it is the only available device which permits the determination of magnification when the final image is at the least distance of distinct vision.

SPECIFICATION

A heavy tripod foot with a stainless steel rod about 10 in. long is fitted with a universal bosshead supporting a stainless steel rod about 27 in. long. Stops are fitted to each end of the rod to prevent removal of the lens holders.

The lenses are mounted in special holders, adjustable along the rod, and can be clamped in any position. They are neither removable nor reversible except by intent. Four single and two double lens holders are supplied. Each is numbered (1, 2, 3A, 3B, 4, 5, 6A, 6B) and is provided with a white line, engraved on the screw boss, from which measurements may be taken. The focal length of each lens is stamped upon its holder. Lens holders Nos. 2 and 6B are each provided with a pair of clips in which an image screen may be supported. The holder 6B is fitted with a plane glass disc engraved with a millimetre scale for use as object in determining magnifications. A distance piece is provided on the rod between lenses 4 and 5 for use in some experiments to keep the lenses a fixed distance (7·5 cm.) apart.

In order to assist in the erection of any required system a chart mounted on the vertical rod is supplied with each instrument. It states the components and their approximate distances of separation for any selected arrangement.

A 53-520.—The Microid Telemicroscope—*continued.*

The Microid Image Comparator is a metal box about $4 \times 3 \times 1\frac{3}{4}$ in. in which is mounted, side by side, two biconvex lenses of 7·5 and 10 cm. focal length respectively. In the other end of the box a glass scale, engraved in mm. and with a matt surface, is provided. The position of the scale is adjustable through a small distance.

	£	s.	d.
A 53-520. MICROID TELEMICROSCOPE (Tarrant: *Physics*, p. 95). Tripod foot with stainless steel rods, universal bosshead, four single and two double lens holders. Lenses, scale engraved on glass, image card holders and chart of components and distances ..	5	10	0
A 53-525. MICROID IMAGE COMPARATOR. Metal box about $4 \times 3 \times 1\frac{3}{4}$ in. containing two lenses and engraved, ground-glass scale ..	2	5	0

EXPERIMENTAL NOTES

The apparatus is designed for simplicity and rapidity in use. Any component not required may be swung out of the line of sight. Distances between the lenses may be conveniently measured by means of a metre rule. The lenses are not achromatic, partly to avoid a prohibitive price and partly to enable students to observe the effects produced by chromatic aberrations. These, however, are never of sufficient magnitude to interfere with experimental work. In order to keep the length of the optical system within convenient limits an erecting lens for use with the astronomical telescopes is not included.

The experiments which may be performed with the Telemicroscope are of three kinds:—

(*a*) The setting up and demonstration of different types of telescope and microscope.

(*b*) The measurement of the magnification of the different systems.

(*c*) The determination of the magnitude of the field of view.

In each experiment, attention should be given to the curvatures of the lens surfaces and in particular it should be observed that the plano-convex lenses are always turned with their curved surfaces on the side where the light is least converging. This arrangement distributes the total deviation between the plane and the convex surfaces and thus reduces the aberration.

(*a*) **TO SET UP TELESCOPES AND MICROSCOPES.**—The values given for the distances of separation of the lenses and their focal lengths, should be regarded as approximate and as a useful guide to assist in setting up the selected system. Some final focussing adjustment may be necessary.

(1) **Galilean Telescope.**—Use the telescope objective 6A ($f = 50$ cm.) and the biconcave eyepiece 3B ($f = 10$ cm.). Their distance of separation should be about 40 cm. The other lenses may be rotated out of the line of sight. The image is erect, is very bright, is magnified five times and the field of view is very small. If the eye is withdrawn from the eyepiece in the direction of the axis of the system, the field of view diminishes in size.

(2) **Simple Astronomical Telescope.**—Use the telescope objective 6A ($f = 50$ cm.) and the plano-convex eyepiece No. 1 ($f = 10$ cm.) separated by a distance of about 60 cm. Support a thin card in the image screen holder on the boss of lens holder 2 at a distance of 10 cm. from the eyepiece. Show that a real image is formed at this point. Notice that when the eyepiece is used the magnification produced is five times. Notice also that the image is inverted and is slightly less bright than that formed by the Galilean system. The field of view is still very small but increases considerably as the eye is withdrawn from the eyepiece, being a maximum with the eye 9 cm. from the eyepiece. This point is called the eye ring.

(3) **Astronomical Telescope. Simple Field Lens.**—With the arrangement of lenses 1 and 6A used in the simple astronomical system rotate component 2 (plano-convex lens $f = 10$ cm.) into the field at a distance of 10 cm. from the eyepiece. Since the real image formed by objective 6A falls in the centre of this field, lens 2, its introduction affects neither the position of the real image of the whole system nor the focussing of the instrument. An improvement immediately apparent is that the size of the field of view has been greatly increased but a disadvantage is that dust particles on the field lens are visible in the field of view.

(4) **Astronomical Telescope with Huyghens Eyepiece.**—Erect lenses 3A and 6A at distances respectively of 20 cm. and 55 cm. from lens 1. Comparing the results with those obtained in the previous arrangement it will be observed that the eyepiece is achromatic, with consequently reduced chromatic aberration, and that the field of view is slightly smaller. This, however, increases on moving the eye away from the eyepiece.

The focal lengths, surface curvatures and distances of separation of the eyepiece and field lens in this type may be widely varied. In some cases a biconvex eye lens having radii of curvatures in the ratio 1 : 6 is used in combination with a meniscus field lens having radii of curvature in the ratio of 11 : 4, with a focal length which is three times that of the eyepiece. For the present purpose, however, the lenses employed are quite suitable.

(5) **Astronomical Telescope with Ramsden Eyepiece.**—Erect lenses Nos. 2 and 6A at distances respectively of 6·7 cm. and 59 cm. from lens 1. Notice the very large and flat field of view and the exceedingly low chromatic and spherical aberration. There is a slight increase in magnification as compared with the Huyghens eyepiece. The field of view decreases in size on withdrawing the eye so that observations should be made with the eye in close contact with the eyepiece.

(6) **Microscope.**—Erect the objective 3 and the object (engraved scale) 6B about 6·7 cm. away. View the image with any of the eyepiece systems previously described (including the Galilean, though this gives a small field). Adjust the position of the object until a sharply defined image is obtained. The object should be well illuminated from behind. Estimate the magnification produced and notice the aberrations of the system.

(7) **Compound Microscope.**—Insert into the system used in 6 above, lens No. 4 ($f = 15$ cm.) at 7·5 cm. from the centre of No. 5. The distance piece sliding on the rod does not allow these lenses to be

[*continued overleaf*

A 53-520.—The Microid Telemicroscope—*continued.*

placed closer together than 7·5 cm. This constitutes, effectively, a Wollaston doublet, the difference being that in the original computation lens No. 4 was a plano-convex (f = 15 cm.) with its plane side towards the object, whereas in the present model the cheaper, biconvex lens is almost as satisfactory. Readjust the position of the object and notice the marked decrease in spherical aberration.

(*b*) **EXPERIMENTAL DETERMINATION OF THE MAGNIFICATIONS PRODUCED BY THE DIFFERENT OPTICAL SYSTEMS** (see also the Microid Image Comparator).—The magnification produced by each of the five different types of telescope described may be determined by the usual method of observing a suitable scale by direct vision with one eye and simultaneously with the second eye through the telescope. The position of the objective must be carefully adjusted so that the final image is formed at infinity, otherwise difficulty will be experienced in superimposing the object and its image and no accurate comparison of the two apparent sizes will then be possible.

The magnification produced by any of the ten possible types of microscope may be determined by a similar method. Here, however, one eye should observe the object (glass scale in 6B) through the instrument while the other is focussed on a suitable metre rule placed 25 cm. away from that eye. (The standard value for the least distance of distinct vision is 25 cm.)

(*c*) **EXPERIMENTAL DETERMINATION OF THE SIZE OF THE FIELD OF VIEW.**—(1) **Microscopes.**—The experimental determination of the magnitude of the field of view with the different types of microscope is directly measured by means of the engraved scale object 6B. The following figures illustrate the values obtained :—

COMPOUND MICROSCOPE

Simple Objective		Wollaston Objective	
Eyepiece	Field of view mm.	Eyepiece	Field of view mm.
Galilean	0·15	Galilean	0·2
Astronomical ..	2·3	Astronomical ..	3·1
Huyghens ..	4·4	Huyghens	5·4
Ramsden ..	5·1	Ramsden ..	7·0

(2) **Telescopes.**—For determination of the magnitude of the field of view of the telescopes any distant accessible object may be employed. A convenient object is one having a uniform spacing—such as a line of railings. Otherwise, two moveable distant objects may be viewed and their distance apart varied until they are on opposite edges of the field of view. Typical results are as follows :—

Astronomical	0·24°
,, with field lens	0·54°
,, ,, Huyghens Eyepiece	0·56°
,, ,, Ramsden Eyepiece	0·52°

The **Microid Image Comparator** is used for adjusting telescopes and microscopes either for infinity or for the least distance of distinct vision and for determining in a direct manner the magnification produced by telescopes in either type of adjustment.

It may first be held up to the light so that the images of distant lights formed by the 10 cm. f lens fall, sharply in focus, upon the ground glass screen. Since the focal length of the lens is known, the angle between the beams of parallel light from two such sources is readily obtained by measuring the distance between the two images on the screen.

To ascertain whether a telescope is producing its final image at infinity the 'relaxed' (10 cm. f) lens is placed in contact with the eyepiece of the telescope directed towards a bright source. If the telescope is correctly adjusted, the image on the screen should be sharply in focus.

In a similar manner, using the 'accommodated' (7·5 cm. f) lens the telescope may be adjusted to produce its image at the least distance of distinct vision.

The apparent magnification produced by a telescope system is found by viewing two distant luminous objects. The magnification is the ratio of the distance between the images on the screen, when the Image Comparator is placed over the telescope eyepiece, to the distance between the same images when the Image Comparator is used to view the objects directly, *i.e.* without the interposition of the telescope. The 'relaxed' or the 'accommodated' lens is used according to the arrangement of the system considered.

A very satisfactory luminous source can conveniently be contrived for these experiments with two electric (flash) lamp bulbs placed at a suitable distance from the telescope. To avoid difficulty in measuring the separation of the images on the screen when the source is viewed directly, larger distances may be employed to separate the components of the source.

When a telescope is employed with its final image formed at the least distance of distinct vision the magnification produced may be expressed by the formula

$$\text{magnification} = \frac{f \text{ of object glass}}{f \text{ of eyepiece}} + 1$$

whereas if the final image is formed at infinity, the formula becomes

$$\text{magnification} = \frac{f \text{ of object glass}}{f \text{ of eyepiece}}.$$

The student should verify these formulæ for all the different telescope systems which can be erected with the Telemicroscope.

Griffin and Tatlock Limited from their five centrally situated Houses, provide a unique organisation for the supply of Complete Laboratory Equipment.



A 53-750—755.



A 53-765.

		£	s.	d.
A 53-750.	**REFRACTOMETER**, for examining materials the refractive indices of which lie between 1·42 and 1·49, and with the lower part of scale reading percentage soluble solids of sugar solutions from 50 per cent. to 81 per cent. With thermometer in protecting case. Complete in case .. .. *tx*	44	11	0
A 53-755.	**Ditto**, with optical system arranged to read between 1·34 and 1·43 and sugar scale 0 to 50 per cent. .. .. *tx*	44	11	0
A 53-760.	**Thermometer**, 0° to 50° C. in $\frac{1}{2}$°, for above .. .. *tx*	0	10	9

A compensator is provided which gives a colourless border-line, enabling the instrument to be used with white light. An eyepiece scale is provided upon which the position of the border-line is noted, and a micrometer screw carrying a drum enables readings to be taken to a tenth of a scale division. The refractive index is thus obtained to 0·0001. Another drum corrects the sugar scale for any temperature between 15° C. and 30° C. The prism-box is arranged for the circulation of hot water for examining such fats, etc., as are opaque at ordinary temperatures, and a thermometer in protecting jacket is supplied for noting the observation temperature.

A 53-765.	**REFRACTOMETER, standard model**, for the examination of transparent liquids, plastic or solid bodies, the refractive indices of which lie between 1·3 and 1·7, reading direct to 0·001. With protected thermometer and all accessories .. .. .. *tx*	63	0	0

The instrument has been designed to give great rigidity, thus avoiding the frequent checking of adjustment, and special attention has been paid to both the mechanical and optical design to render it speedy and convenient in use.

The telescope and scale magnifier eyepieces are fixed at the average interpupillary distance, enabling the border line and divided scale to be viewed simultaneously, and securing constant illumination of the scale. Adjustment of the border line to the intersection of the cross wires is actuated by means of a carefully designed screw motion. The prism boxes are jacketed for water circulation, the lower half being completely detachable to allow for the easy and rapid examination of viscous or solid bodies. A cylindrical metal cover with leather handle is readily attached to the body of the instrument by means of one screw, rendering the instrument conveniently transportable.

Extras for Refractometer A 53-765

			£	s.	d.
A 53-765 a.	**Sugar scale** .. .. *extra*	*tx*	3	16	0
,, ,, **b.**	**Prism system**, reading to 1·74 .. .. *extra*	*tx*	6	19	3
,, ,, **c.**	**Quartz Test Pieces**, showing ordinary and extraordinary rays	*tx*	1	15	0
,, ,, **d.**	**Thermometer**, 0° to 75° C. in $\frac{1}{2}$°	*tx*	0	10	9
,, ,, **e.**	**Polarising Eyepiece** .. .. *extra*	*tx*	3	10	0
,, ,, **f.**	**Enclosed Lamp** (0·3 a., 4 v.), built into prism box .. .. *extra*	*tx*	2	13	3

A 53-770.	**WATER CIRCULATOR, Constant Temperature**, for heating by gas burner, suitable for Refractometers **A 53-750—765** .. .. *tx*	9	10	0
A 53-775.	**Ditto**, for electrical heating .. .. *tx*	10	2	6

Please state voltage when ordering.

We are Agents for the finest productions of other Specialist Makers.

PRISM AND DIFFRACTION GRATING

A simple apparatus for producing a large (4 ft.) spectrum



A 54-250.

Demonstrations on the formation of spectra and their properties form a fundamental part of any course of lectures on light. The demonstrations can most effectively be carried out with a large spectrum capable of being seen by the whole class.

SPECIFICATION

A very high dispersion is obtained by use of a 45°, 45°, 90° prism with a diffraction grating replica cemented to the hypotenuse face as suggested by Hartridge. A bright spectrum 4 ft. long and 3 ft. wide is well within the limit of projection when using a 500 c.p. projection lamp or an arc lamp of equivalent power, at a distance of about 12 feet.

	£ s. d.
A 54-250. PRISM, Right-angled, crown glass, length of edge about 50 mm., length of hypotenuse about 70 mm. with large **grating replica** 14,450 lines per inch cemented to hypotenuse face. With velvet lined case with hinged lid and clip, specially designed to prevent damage to prism and grating during transit and storage	r 4 12 6
A 54-255. Condenser A (*see experimental notes*), plano-convex, mounted, about 55 mm. diam., 6 cm. focal length	r 1 7 6
A 54-260. Lens C (*see experimental notes*), achromatic, 38 mm. diam., 15 cm. focal length ..	r 1 2 0
A 54-265. Lens E (*see experimental notes*), achromatic, 55 mm. diam., 25 cm. focal length ..	r 1 10 0

EXPERIMENTAL NOTES

A science lantern is a convenient light source and may be used in the manner described by Swindells (*Science Masters' Book, Ser. I, Pt. I*, 103).

An optical system, the arrangement of which is due to Duckworth (*ibid*, p. 106), is described below. It provides an inexpensive means of demonstrating spectral phenomena, for those not equipped with a science lantern.

The light is concentrated by a small condenser A, 55 mm. diam., 6 cm. focal length, on to a slit B measuring 50 × 1 mm. The lens C is achromatic, 38 mm. diam. and 15 cm. focal length. D is a diaphragm to stop stray light, E another achromatic lens 55 mm. diam., 25 cm. focal length and F another diaphragm. G is the prism having a diffraction grating replica cemented to the hypotenuse face. H is a screen with a rectangular hole and SP the projection screen.

To adjust the apparatus the prism is removed. The projection or arc lamp is adjusted to illuminate the slit as brightly as possible and the lenses C and E are moved to give a clear, real image of the slit on the screen. The prism is then placed in position and a bright spectrum results at SP, an image of the slit appearing by total reflection at R.

The absorption spectra of dyed gelatines can be demonstrated by placing the gelatines between the lamp and the prism. The colour by transmitted light shows at R. If it be desired to place the screen SP between the apparatus and the class, translucent tracing cloth or paper makes an excellent screen.

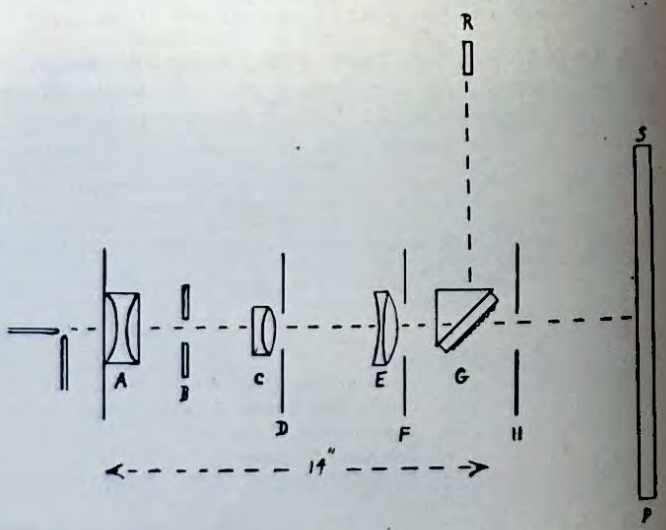
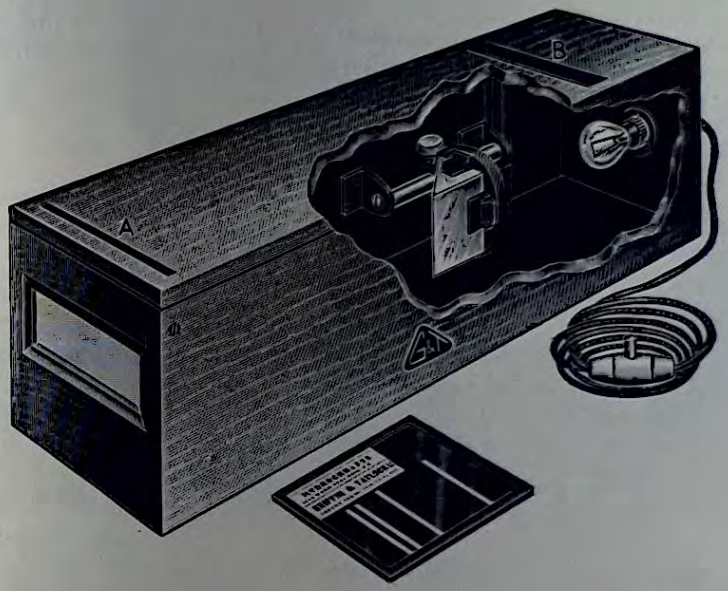


Diagram of E. H. Duckworth's Optical System.

Diffraction Gratings, see A 55-820—840.

THE MICROID SPECTRUM EFFECT APPARATUS

A convenient apparatus for demonstrating the phenomena of emission and band spectra without the use of a spectroscope



A 54-280$_3$

It is usual to demonstrate line and band spectra to students by the use of a spectroscope, vacuum tube and induction coil, or of a flame in which a salt of the element is introduced on a platinum wire. The inconvenience of such an arrangement is obvious. Each student must view the spectrum individually and the phenomenon cannot readily be exhibited to a group as explanation proceeds.

In the present apparatus a bright continuous spectrum is produced by means of a lamp, and a prism and diffraction grating, and is focussed on to a ground glass screen in the end of a darkened box. Specially prepared slides, opaque in parts and transparent in others can be inserted between the prism and screen. Light is transmitted through the transparent parts only and the effect on the screen is as that seen through a spectroscope viewing the spectrum of an element corresponding to the slide in use.

Screen demonstration is thus made possible, a group of students can view the effect simultaneously, special features can be pointed out by the lecturer, who can himself see the spectrum at the same time as the students, and the spectra of a number of elements can be rapidly, yet fully explained. Colour absorption and transmission experiments can also be carried out.

It may be objected that the spectrum obtained is artificial. It is no more artificial than a wall chart and is a good deal more realistic. Moreover, the simplification of discussion by the elimination of accessory apparatus, and the concentration of attention on the effect itself, without reference to the means whereby it is attained, have been found to introduce a breadth of treatment of spectral phenomena, which time does not allow when the usual apparatus is employed. It has been used with conspicuous success in the case of young students.

SPECIFICATION

A polished wooden box about 26 × 5 × 5 in., net weight about 7 lb., is treated internally with optical black and is fitted with a hinged lid. At one interior end of the box is mounted a centring, flanged back-plate s.b.c. lampholder connected to a length of flex containing a through-type switch. The lamp required is a Class F projector type.

On a side of the box is mounted a rod along which is adjustable a holder containing a biconvex lens and supporting, by means of special clips, a large prism on to the hypotenuse face of which is cemented a diffraction grating replica having 14,450 lines per inch. At the other end of the box a ground glass screen is fitted, on which a continuous spectrum may be formed.

[*continued overleaf*

SPECTRUM PRODUCTION

A 54-280. The Microid Spectrum Effect Apparatus—*continued.*

The lid of the box is provided with two slots, A and B. The wide slot B near the lamp end is made to accommodate filters and other materials, such as didymium glass, to demonstrate their absorption spectra. In the narrow slot A, near the screen end, prepared slides may be inserted.

The slides measure $4\frac{1}{4} \times 3\frac{1}{4}$ in. and are generally photographic plates fully exposed to light and developed. The dense emulsion is then cut away in positions corresponding to the spectral lines of the element in question so that, when the slide is inserted in the path of the continuous spectrum, light is transmitted only through the portions from which emulsion has been removed and the effect of a spark spectrum of the element is produced. Three slides of this type showing respectively the mercury, sodium and hydrogen spectra are supplied. The sun's spectrum is obtained by ruling on ground glass black lines to correspond to Fraunhofer lines. A further slide is available to demonstrate the Swan spectrum of the blue cone of the bunsen flame, as an example of a typical band spectrum.

PRICES

	£	s.	d.
A 54-280. MICROID SPECTRUM EFFECT APPARATUS. Polished wood box about 26 × 5 × 5 in. equipped with centring s.b.c. lampholder, diffraction grating replica on prism, with lens and holder and projection screen. **Without** lamp or slides .. .. *each*	10	10	0

Accessories for A 54-280

	£	s.	d.
A 54-280 a. Slides, for above to demonstrate spectra of sodium, hydrogen, and mercury, Fraunhofer lines and Swan spectrum .. .. *each* 12 6. *Set of* 5	3	0	0
" " b. **Colour Filters,** mounted between glass plates to fit slot A. Three primary and three secondary available .. .. *each* 7 -. *Set of* 6	1	17	6
Lamps, Projector, Class 1, 24 watt, with s.b.c. cap, 6 or 12 volts, .. see **A 58-495.**			

EXPERIMENTAL NOTES

To set up the apparatus, insert into the lampholder a projector lamp, which adjust so that the filament is vertical. Run 6 volt lamps from a 7 volt supply and 12 volt lamps from a 14 volt supply. See that the prism face is firmly in contact with the face of the lens-holder. Centre the lamp, by adjusting the lampholder in its flanged back-plate until the spectrum is centrally distributed on the ground glass screen. Focus the spectrum by sliding the lensholder along the supporting rod and towards or away from the screen until the spectrum is clearly defined. Focussing is assisted if a colour filter or a cobalt glass is inserted during the focussing, for then attention can be concentrated on the sharpness of the absorption bands, which the filter shows. The lid of the case may now be closed and the apparatus is ready for use.

Emission Spectra.—When excited, *elements* yield bright line spectra, which are demonstrated in this apparatus by the use of slides made to reproduce the effects of a spark discharge in sodium, hydrogen or mercury. Insert any required slide into the slot A immediately behind the ground glass screen. Parts of the continuous spectrum are then obliterated and only a series of bright lines is visible. The slide is marked with the wavelengths at which the lines occur. The sodium slide shows the lines D_1 and D_2. Hydrogen shows 6563, 4861, 4340, 4102 A.U., and in the mercury slide eight lines can be seen.

Band Spectra.—When *compounds* are excited they yield spectra in which occur bands of light brighter towards one end of the spectrum than the other. The spectra are normally transient, since the compounds rapidly decompose into their constituent elements, which yield their own characteristic line spectra. The Swan spectrum, that of the blue cone of the Bunsen flame is a typical band spectrum, shown by the use of the special slide supplied.

Absorption Spectra.—The primary and secondary colour filters inserted in the slot near the screen are instructive for showing absorption bands.

The slot B may be used for the introduction of slips of didymium or cobalt glass or potassium dichromate filters, all of which show the characteristic absorption. (If didymium glass is not available, a solution of didymium nitrate may be prepared in the manner described by Rogers, *Science Masters' Book, Ser. II, Pt. I,* 123.) Potassium dichromate is particularly useful as exhibiting its monochromatising effect and explaining its use for the purpose in polarimetric work.

Liquids may be introduced in a glass cell placed inside the box between the lamp and the prism. A solution of potassium permanganate is very suitable for this demonstration as it shows two well-marked absorption bands, one in the green and the other in the blue. It is convenient to commence with water in the glass cell and gradually to increase the concentration of potassium permanganate by the slow addition of small quantities of a strong solution of the salt. As the concentration is increased the two bands gradually broaden and finally coalesce. With a concentrated solution the whole of the visible spectrum is blotted out, showing that the solution is opaque to all visible radiations.

A further example of absorption spectra may be shown by the use of the Fraunhofer line slide inserted into the slot A. This slide is constructed of ground glass ruled with opaque lines to correspond to those lines in the spectrum of the sun caused by the absorption of some of the constituents of the white light emitted by the sun, as it passes through the cooler surrounding envelope, the chromosphere.

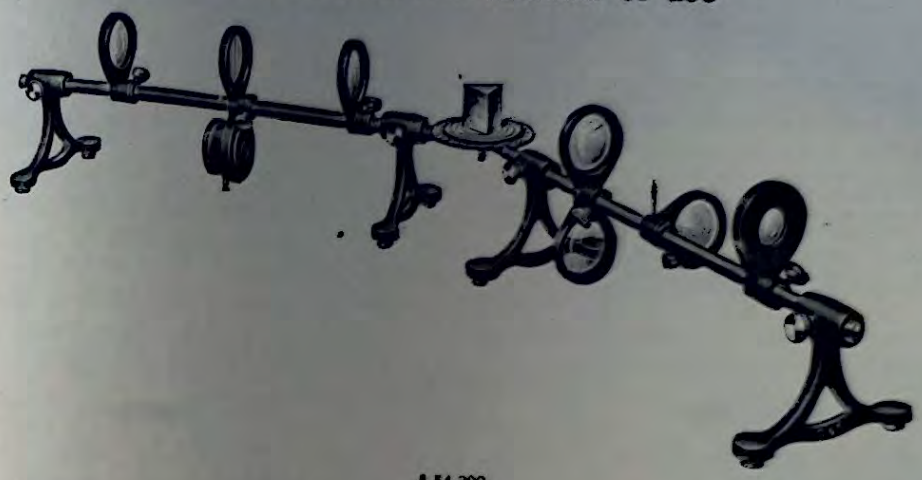
Colour Phenomena.—With the range of primary and secondary colour filters available a convenient method is provided for the demonstration of all the usual colour phenomena. The primary slides of red, green and blue, introduced in turn into the slot A, transmit only those parts of the spectrum, and therefore show only a sensibly monochromatic band. The secondary colours, yellow, peacock blue and magenta, each transmit more than one colour. Thus, yellow passes all colours except blue and violet, peacock blue transmits only the green and blue parts of the spectrum, and magenta absorbs the central part, transmitting red and blue.

If two of the secondary colours are placed together in the apparatus only the common colour is transmitted.

The colour mixing which occurs when pigments are compounded may be illustrated in this way. Thus, yellow and peacock blue produce green, yellow and magenta transmit red, while magenta and peacock blue give blue.

THE MICROID CONSTRUCTIONAL SPECTROMETER

Unique new demonstration model to exhibit principles of spectrometer construction and method of use



A 54-300.

It is the experience of many science teachers that students find difficulty in understanding how a pure spectrum is produced. The result is that the principles of the spectrometer are never firmly grasped and much of the subsequent work in optics becomes confused.

The Microid Constructional Spectrometer is designed to exhibit the principles of spectrometer construction and operation in a simple and clear manner. Each component of the system is visible for demonstrational purposes. The arrangement and spacing of the components can be varied and the effect upon the type of spectrum obtained noted. A useful feature is the incorporation of a lamp for the ready production of a continuous spectrum. Elementary spectral photography can be carried out. Examples of the possibilities are shown in Figs. 2-4.

SPECIFICATION

The collimator and telescope systems are each mounted on stainless steel rods about 50 cm. long. The two parts are separable. The telescope pivots round a prism table 4 in. diam. provided with a scale graduated in degrees. The collimator supports are fitted with rubber feet ; those of the telescope with brass feet so that it may be rotated easily on the bench.

The collimator is fitted with one double and two single lens holders. The first is a biconvex lens of short focal length to condense light from any desired source on to the fixed slit in the double lens holder, the other side of which contains the lamphouse. A 12-volt festoon lamp having a straight line filament, acting as an illuminated slit, is interchangeable with the fixed slit by rotation of the double lens holder. The lamphouse is provided with terminals. The lens nearest the prism table is the collimating lens, of focal length 15 cm. The fixed slit is ruled on the blackened back of a silvered plane mirror which is used for focussing the telescope at infinity. The lenses of the telescope system are similarly mounted in holders adjustable as required. The double holder contains a lens of 100 cm. *f*, used to form a large spectrum on a wall or screen, and one of 15 cm. *f*, used to form a spectrum on the lens holder screen. A scale ruled in mm. is provided on the latter for measurements of dispersion. This holder has clips by which photographic paper can be supported for spectrographic work. The pin attached, when adjusted to parallax with the spectrum, serves the purpose of crosswires for the 5 cm. *f* eyepiece lens in the last holder, thus providing all the essentials of a complete spectrometer.

Angles are read on the graduated scale by means of a pointer on the telescope rod. When the telescope and collimator are assembled this pointer is slipped along the telescope rod in the direction of the prism table and locked in position by a screw beneath the rod.

£ s. d.

A 54-300. MICROID CONSTRUCTIONAL SPECTROMETER. Collimator with one double and two single lens holders, fixed slit, lenses and lamphouse. Prism table divided in degrees. Telescope with one double and two single lens holders, lenses, pin, graduated image screen. Stainless steel rods throughout. **Without** prism or lamp 8 0 0

Lamps for above, 6 or 12 volt, 6 watt, festoon pattern, .. see **A 58-295—297.**

[continued overleaf

A 54-300. The Microid Constructional Spectrometer—*continued.*

EXPERIMENTAL NOTES

First focus the telescope to receive parallel light. This may be done either by focussing sharply on the graduated screen the image of a distant object, or by eliminating parallax between the pin and its inverted image obtained by placing a plane mirror immediately behind the telescope objective. (If desired, the mirror-backed slit may be used for this purpose.) The collimator is next adjusted so that the image either of the slit or of the line filament is sharply in focus on the graduated screen in the telescope. These adjustments completed, the apparatus may be used for all demonstration purposes, and much individual work, for which more expensive instruments are normally employed.

Experiments such as investigating the laws of reflection from a plane mirror, or of determining the angle or refractive index of a prism can readily be performed, the final image being obtained either on the screen or by means of the image pin. In these experiments, however, care should be taken that the prism table is not disturbed while the telescope is rotated and the position of the pin or screen must not be altered during the course of an experiment.

Reflection.—Determination of angle of a nominal 60° prism.

Telescope angular reading for one reflected ray $= +74{\cdot}5°$.
" " " other " " $= -45{\cdot}8°$.
Angle of Prism $= \frac{1}{4}(74{\cdot}5 + 45{\cdot}8) = \mathbf{60{\cdot}2°}$.

Refraction.—Determination of refractive index of a prism for mean red light.

Angle of minimum deviation on one side $= +36{\cdot}5°$.
" " " other " $= +37{\cdot}0°$.

$$\mu = \frac{\sin \frac{1}{2}(A + D)}{\sin \frac{1}{2} A} = \frac{\sin \frac{1}{2}(60{\cdot}2 + 36{\cdot}75)}{\sin 30{\cdot}1}$$

$$= \frac{\sin 48{\cdot}48}{\sin 30{\cdot}1} = \mathbf{1{\cdot}49}.$$

Spectra.—A continuous spectrum can readily be produced with the apparatus, by using the line filament source. In order to utilise the full apertures of the large lenses incorporated in the instrument and thus to obtain bright spectra, it is desirable to use large prisms with sides 2-3 in. in length. Smaller prisms produce spectra less easily visible on the screen. Owing to the finite size of the lamp filament a small amount of overlapping of the images occurs, and it is for this reason that a prism of low dispersive power will produce unsatisfactory results. If possible a carbon disulphide prism should be used. The helical construction of the filament explains the horizontal bands occasionally observed in the spectrum.

A continuous spectrum of reasonable intensity can readily be focussed on a screen or a wall at least 1 metre distant by means of the lens of 100 cm. *f* in the double lens holders of the telescope. The effect of interposing coloured filters can be demonstrated and the spectral components reflected by pigments investigated.

Line spectra may be produced by the use of any suitably excited source. Discharge tubes containing various gases are available. The capillary tube pattern, operated by a 1 in. spark induction coil, will be found very satisfactory as the narrowness of the source makes it possible to dispense with the slit, and for the discharge tube, placed about 15 cm. from the collimator lens, to act as its own slit. Otherwise the bull's eye condenser may be used to produce a concentrated image of the source on the slit.

Dispersive power measurements may be carried out. In these experiments the angle to be read may be too small for accurate reading on the divided circle. For this purpose the telescope image screen is provided with a scale engraved in mm. The required angle is then the distance on the scale between the desired lines, *e.g.*, red and blue, divided by the focal length of the telescope objective.

$$\text{Dispersive power} = \frac{\mu_B - \mu_R}{\mu_{mean} - 1}$$

$$\mu = \frac{\sin \frac{1}{2}(A + D)}{\sin \frac{1}{2} A}$$

where D = angle of deviation in radians.

$$\therefore \delta\mu = \frac{\frac{1}{2} d\mathrm{D} \cos \frac{1}{2}(A + D)}{\sin \frac{1}{2} A}$$

∴ approximately

$$(\mu_B - \mu_R) = \frac{1}{2}\left(\frac{\cos \frac{1}{2}(A + D)}{\sin \frac{1}{2} A}\right)$$

(Change in angle of deviation between blue and red.)

Spectrography.—If the apparatus is adjusted to produce a spectrum (either line or continuous) sharply focussed on a cardboard screen placed in the clips on the telescope lens holder screen, interesting experiments can be performed on the photography of spectra. The work must be carried out in a dark room and the photographic part of the apparatus carefully shielded from stray light from the source. When the desired spectrum has been focussed, the cardboard screen should be removed and replaced by either bromide paper (for photography in the visible and near U.V. parts of the spectrum), or by panchromatic or infra red plates or films (for photography of the red and infra red). The exposures in the latter cases are often longer than for normal yellow, blue or violet. The exposure necessary may be determined by covering the sensitised surface of the plate or paper with a small screen which is lifted slightly at intervals so that the paper is exposed in strips for periods of 1, 4, 16, 64, 256, etc., secs. respectively. The optimum exposure for a second paper is thus obtained quite simply. The dispersion obtained will depend upon the type of prism employed. The photographs reproduced below have been obtained by the use of a diffraction grating replica of 14512 lines per inch.

Direct Vision Spectrometer Model.—This model is easily made by combining a carbon disulphide prism with a glass prism of low dispersive power. With the crown glass type of prism commonly employed, the deviation is not totally compensated but is reduced sufficiently to demonstrate the principle. The CS_2–crown glass combination produces a dispersion equal to about two-thirds of that for the CS_2 prism.

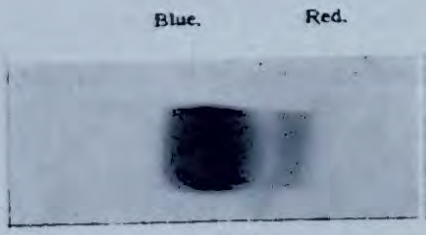


Fig. 2.

Continuous spectrum recorded on a panchromatic plate.

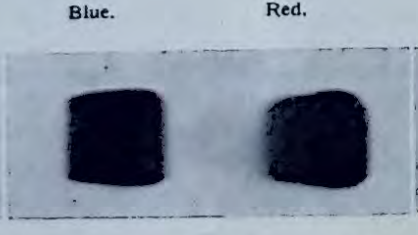


Fig. 3.

Continuous spectrum recorded on an infra red plate of sensitivity range
3500—5500 A.U.
7000—9500 A.U.

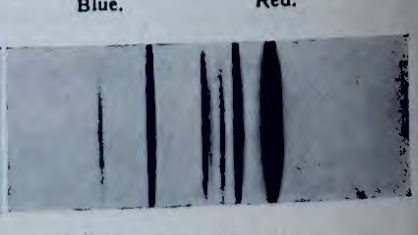


Fig. 4.

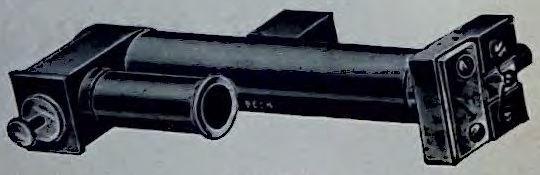
Helium discharge tube recorded on a panchromatic plate. No slit was employed, the discharge tube acting as its own source. The lenses were used at full aperture.



A 54-320.



A 54-325.


A 54-330.

	£	s.	d.
A 54-320. **SPECTROSCOPE, Direct Vision, Diffraction,** miniature pocket size, 2 in. long, $\frac{5}{16}$ in. diam. with plain slit, in case .. .. *t*	1	11	0
A 54-325. **SPECTROSCOPE, Direct Vision,** pocket size, $3\frac{1}{2}$ in. long, $\frac{3}{4}$ in. diam. This instrument will show many Fraunhofer lines and the absorption bands of gases and liquids ; with plain slit, in case .. .. *r*	6	0	0
A 54-327. **Ditto,** as **A 54-325** but with adjustable slit .. .. *r*	8	10	0
A 54-330. **SPECTROSCOPE, Direct Vision,** pocket size, prism type, having a dispersion of approx. 10°, with adjustable calibrated scale, giving direct readings in wavelengths and viewed in the same field as the spectrum. Slit width and focussing adjustments are provided. Complete in leatherette covered case .. .. *tx*	12	10	0
A 54-332. **Ditto,** with comparison prism .. .. *tx*	13	10	0


A 54-335.


A 54-345.

	£	s.	d.
A 54-335. **SPECTROSCOPE, Direct Vision,** with 5-element prism of high dispersion, giving a wide spectrum. Fixed slit with cover glass. Mounted on wood pillar and base. Tube 20 cm. long, with sliding focussing, and fitting to hold test tube .. .. .. *tx*	4	5	0
A 54-340. **SPECTROSCOPE, Direct Vision, Diffraction,** telescopic model 8 in. long, giving large scale spectrum with high definition. With adjustable slit and focussing adjustment. A rotating head with drum divided 0–100 causes the spectrum to traverse the field of view. In case .. .. *tx*	10	10	0
A 54-345. **SPECTROSCOPE, Wavelength,** including stand .. .. *tx*	20	0	0

This spectroscope is constructed so that direct readings of wavelength can be taken. The instrument has a collimator with an accurately made adjustable slit. It employs a replica diffraction grating. For examining the spectrum formed a telescope is provided, which is hinged at one end, its relative angle with the collimator being varied by a micrometer screw motion. This screw moves the telescope on a sine motion, and the positions of the lines of the spectrum, as they traverse the cross-line in the eyepiece, are therefore read direct in wavelengths. The milled head of the screw has 100 divisions, each division representing 10 Ångström Units, and an index gives the number of complete revolutions of the screw.

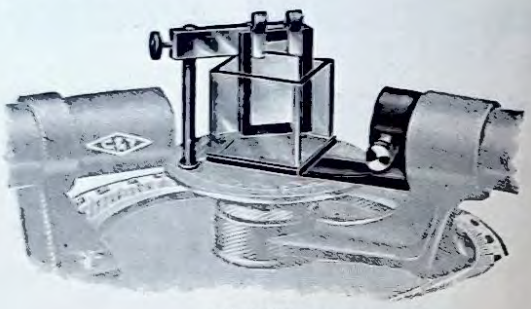
A 54-350. **High Power Eyepiece,** for above .. .. *tx*	1	0	0

THE MICROID SPECTROMETER MODEL A

A special design for school use

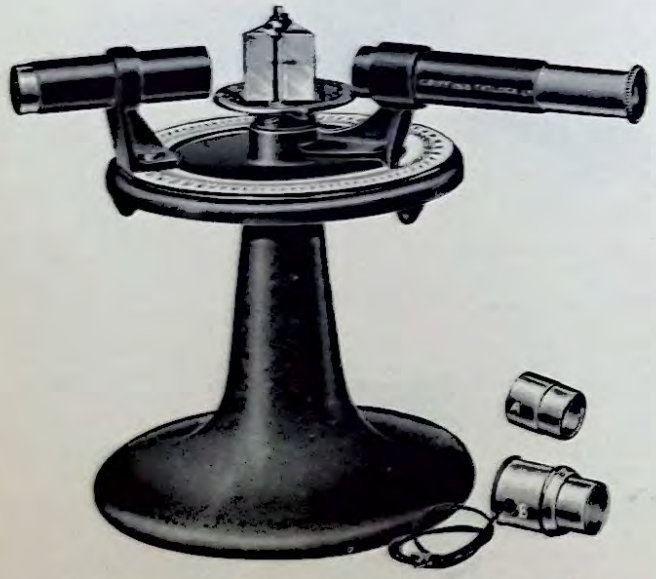


A 54-390 + 390 b, c (or d), f.



A 54-390 g.

The Microid Model A Spectrometer is designed to function simply and effectively. Instruments incorporating many refinements are too expensive for elementary work. The cost has been kept low solely by simplification of design. Fine adjustments and verniers are not fitted, but the accuracy obtainable is sufficient. The instrument is robust and may be placed in the hands of inexperienced students. The lamphouse enables it to be used outside a dark room.



A 54-390 + 390 a. Detached **A** 54-390 b and c (or d).

SPECIFICATION.

The divided circle is of heavy brass, 7 in. diam. and divided in degrees. It is provided with three short feet which support it on the bench. A special base casting, 8 in. high giving great stability, is available for fitting conveniently to the divided circle, thus raising the telescope to eye level.

The telescope is substantial enough to remain stationary under its own weight. The objective is $\frac{7}{8}$ in. clear aperture with drawtube focussing. The lenses are not achromatic—a feature which contributes to the low price of the instrument. This, however, is no great disadvantage, since in most measurements, monochromatic light is used.

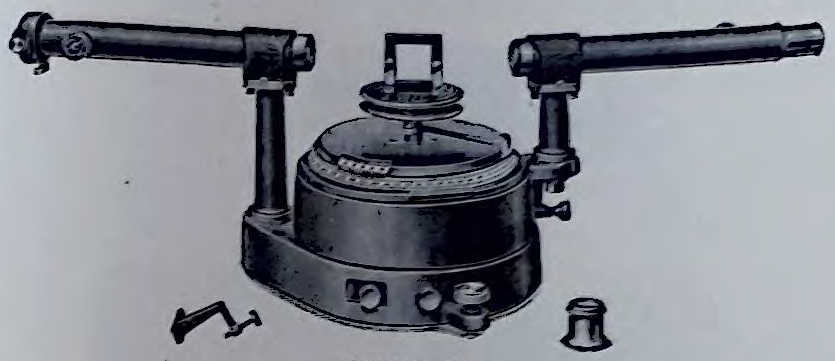
The collimator is adjustable by drawtube and is provided with a fixed slit. A lamphouse containing a 4 volt lamp may be fitted to the collimator. In conjunction with the light filters **A 54-390 c** or **d**, which fit conveniently between the lamphouse and collimator, the lamp may be used as a source of monochromatic light.

The prism table is rotatable, and is graduated every two degrees, the angles being read by a pointer attached to the base of the instrument. Clamps for the prism and prism table are provided.

A 54-390. MICROID SPECTROMETER, MODEL A, with divided circle and prism table, pointers, telescope, and collimator with fixed slit. **Without** prism .. .. .. *r* **8 10 0**

Component and Extra Parts for A 54-390

		£	s.	d.
A 54-390 a.	**Base,** heavy cast iron, for above, 8 in. high, 8 in. diam., to raise telescope to eye level	*r* 2	0	0
„ „ **b.**	**Lamphouse** for above, fitting over both collimator and filter mountings. **Without** lamp	*r* 1	8	0
„ „ **c.**	**Filter,** Wratten monochromatic, in tubular mount which may be inserted between lamphouse and collimator	*r* 0	8	0
„ „ **d.**	**Filter,** mounted as above, transmitting strong lines at 5700 and 7000 A, for use in the measurement of dispersive power	*r* 0	8	0
„ „ **e.**	**Prism,** 75°, 60°, 45°, 38 mm. largest face, 39 mm. high, good quality crown glass, not optically worked	*r* 0	5	6
„ „ **f.**	**Mirror,** plane, 2 × 1 in., good quality	0	0	4
„ „ **g.**	**Critical Angle Accessory** (Watson: *Practical Physics*, § 119). Parallel-sided glass air-film, cubical glass tank with means for attaching the former to the prism table and the latter to the telescope	*p* 3	10	0
	Lamp, 3·5 volt, for above, ...	see **A 58-240.**		

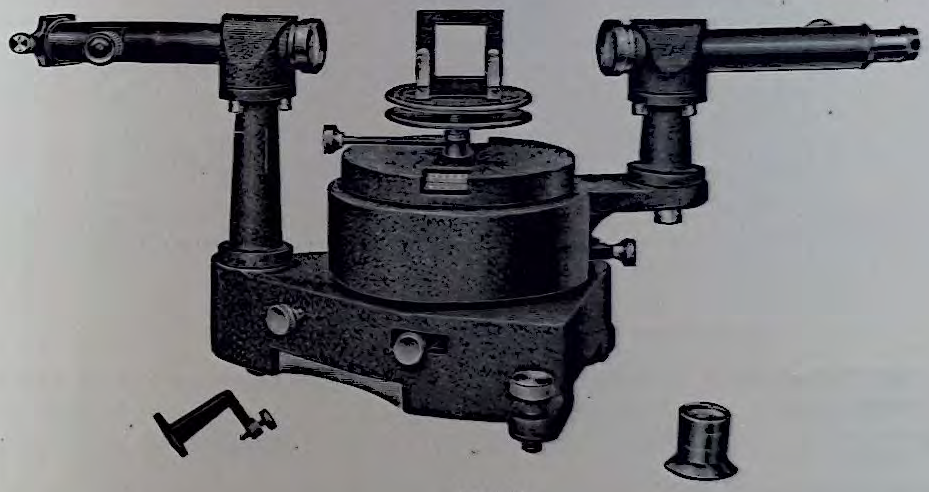


A 54-450—455.

£ s. d.

A 54-450. **SPECTROMETER,** with protected 5 in. diam. circle read by opposite verniers to 1 minute. Telescope with 7 in. focus, 1 in. clear aperture object glass, Ramsden eyepiece, glass cross-line graticule, rack and pinion focussing. Telescope and circle move together. Collimator with rack and pinion focussing, 1 in. clear aperture object glass, slit with one jaw fixed, the other adjustable by fine screw. Telescope bracket and prism table both fitted with fine adjustment screws for rotation. In wood case approx. 18 × 12 × 10 in., complete with grating holder, prism clamp, watchmaker's eyeglass for reading verniers, dense flint glass prism 1⅛ × 1⅛ in. Nett weight of instrument, 32 lb. .. .. .. *t* 22 0 0

A 54-455. **Ditto,** as **A 54-450,** but with 6 in. diam. circle, 8½ in. focus object glasses, and adjustable slit fitted with comparison prism, and wedge to reduce length of slit .. *t* 26 0 0



A 54-465.

A 54-465. **SPECTROMETER,** with fixed protected 7½ in. diam. circle. The movement of the telescope is read to 30 sec. by two opposite verniers on the lower edge of the circle, and the movement of the prism table to 30 sec. by two opposite verniers on the upper edge of the circle. Telescope with 10 in. focus, 1 in. clear aperture object glass, Ramsden eyepiece, glass cross-line graticule, rack and pinion focussing. Collimator with rack and pinion focussing, object glass 10 in. focus 1 in. clear aperture, protected adjustable slit with comparison prism, wedge for adjusting length of slit, and adjustment for setting the jaws parallel. Telescope bracket and prism table both fitted with fine adjustment screws for rotation. In wood case approx. 21 × 10½ × 9½ in., complete with grating holder, watchmaker's eyeglass for reading verniers, dense flint glass prism 1⅛ × 1⅛ in. Nett weight of instrument 40 lb. .. .. *t* 36 0 0

A 54-470. **Polariser and Analyser,** for attaching to spectrometers **A 54-450—465,** with Nicol prisms ; mounted to fit object glasses .. .. *pair t* 8 0 0

A 54-475. **Ditto,** mounted in divided circles reading to 5 min. .. .. .. *pair t* 14 0 0



A 54-480.

	£	s.	d.
A 54-480. SPECTROMETER, Wavelength, Direct Reading, designed to meet the demand for an instrument which may be used for investigation in the infra-red and ultra-violet, giving an accuracy of reading of approx. 1 A between 4000 A and 5500 A, and 3 A to 6 A up to 8000 A. Complete with glass prism, shutter eyepiece and cross-wires, suitable for illumination by electric lamp .. ..*tx*	90	9	0

The dense flint glass prism, refractive index 1·76 approx., gives high dispersion over the visible spectrum. The mirror system, which replaces the usual object glasses, eliminates all chromatic aberration, allowing all regions of the spectrum to be in focus in the same plane. The use of **aluminised** mirrors, which maintain their reflecting power without tarnish, provides illumination equivalent to the usual lens system without its disadvantages. In the extreme ultra-violet over 85 per cent. of the light is reflected.

The scale, reading in wavelengths over the visible spectrum, is approx. 90 cms. long, each division corresponding to 10 A.

The entire optical system is enclosed in a single metal casing, and, with the addition of various accessories as required, the instrument may be used for the examination of absorption and emission spectra, over the range of spectrum between wavelengths 2100 A and 100,000 A.

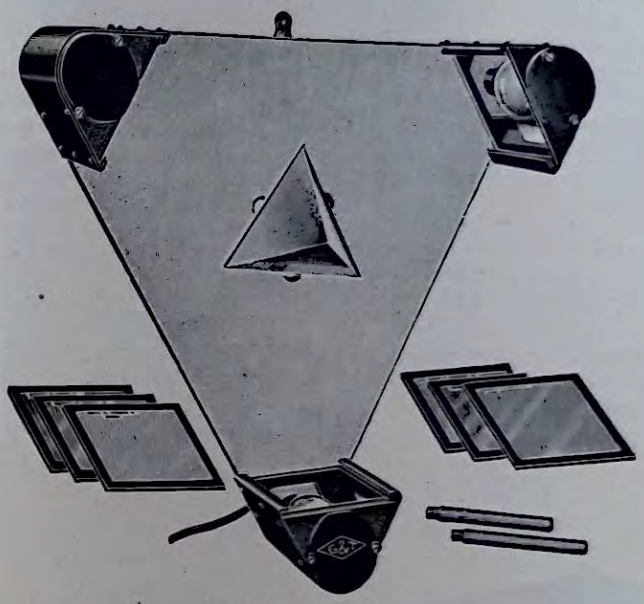
Component and Extra Parts for A 54-480

		£	s.	d.
A 54-480 a.	**Quartz Prism,** for use in the infra-red to 40,000 A, or ultra-violet to 2100 A .. *tx*	22	12	3
" " b.	**Rocksalt Prism,** for use in the infra-red to 100,000 A .. .. *tx*	6	12	3
" " c.	**Sleeves,** evenly divided, to fit on drum of spectrometer, for use with either the quartz or rocksalt prism .. .. *tx*	3	2	8
" " d.	**Conversion Tables,** for use with above sleeves, for obtaining wavelengths readings] in the infra-red .. .. *tx*	7	19	6
" " e.	**Sleeve,** divided, to fit on drum of spectrometer, reading in wavelengths direct in the ultra-violet to 2100 A, using quartz prism .. .. *tx*	7	13	2
" " f.	**Slit,** with symmetrically-opening stainless steel jaws, for use when instrument is required as a monochromatic illuminator, or for use with a thermopile.. .. .. .. *tx*	13	4	5
" " g.	**Levelling Screws,** to stand of instrument .. .. *tx*	4	16	3
" " h.	**Fluorescent Eyepiece,** for ultra-violet spectrum investigations between 2200 A and 6000 A *tx*	7	13	2
" " k.	**Fluorite Plates,** to cover slits, when desired to make instrument air-tight .. .. *tx*	5	11	5
" " m.	**Camera,** metal, interchangeable with eyepiece, for photographing spectrum, complete with viewing telescope for observing spectrum before photographing and shutter for exposing *tx*	25	1	1
" " n.	**Aluminised Slit Mirror,** for use with rocksalt prism for extreme infra-red .. .. *tx*	2	8	10
" " n.	**Slit}Rods,** mounted on spectrometer, to carry auxiliary apparatus .. .. .. *tx*	6	5	3

Your attention is drawn specially to the numerous new and distinctive designs in this Catalogue. They are of exceptional interest to you.

THE MICROID COLOUR MIXING TRIANGLE

An effective apparatus for use in demonstrating additive, subtractive and complementary colour phenomena



A 54-730.—Side 21 in. long.

The theory of colour vision is under continuous discussion. It has exercised the minds of the most acute classical physicists so that the names of Young, Helmholtz and Maxwell are inseparably linked with it. Special interest therefore attaches to this apparatus by which colour phenomena, additive, subtractive and complementary, can be exhibited with a minimum of trouble and on a scale by which demonstrations can be given to, and seen clearly by, every member of a large class.

SPECIFICATION

An equilateral triangular wood base of side about 21 in. is provided at each apex with a ventilated lamphouse consisting of a cast, light-metal frame on which a parabolic metal mirror is mounted. Grooves are provided on the front of each lamphouse to accommodate filters of which three primary—red, green and blue, and three secondary—magenta, yellow and peacock blue, are supplied. The filters are about 6 × 5 in. and are mounted between glass plates edged with binding strip. 40 watt pearl lamps are used in the lamphouses. A length of flex and a lamp adapter are included.

A regular tetrahedron is supplied, provided at the centre of its base with a wooden peg, which can be placed in a hole in the centre of the baseboard. Three symmetrically disposed holes in the baseboard on the centre lines of the lamps are used for the insertion of rods for investigation of shadow characteristics.

The apparatus is finished in a matt white which shows up the colours well and does not give rise to undesirable reflections. It is intended for horizontal use on the bench, or, suspended by the plate provided, vertically on the wall.

	£	s.	d.
A 54-730. MICROID COLOUR MIXING TRIANGLE (Savage: *School Sci. Rev.*, 1932, **13**, 87), wooden triangular base about 21 in. side, with lamphouses, three each primary and secondary colour filters, tetrahedron and three wooden rods. Finished matt white. **Without** lamps	*r* 8	15	0
Lamps, for above, 40 watt Pearl, B.C., ...	see A 58-350.		

[*continued overleaf*

A 54-730.—The Microid Colour Mixing Triangle—*continued.*

EXPERIMENTAL NOTES

Some of the experiments which may easily be performed with the apparatus are described below. It will be noted that they may be varied by the use of two lamps only, by interposing a cardboard screen in front of any lamp which is not required.

(1) Insert the primary filters in their grooves and illuminate the lamps. If the tetrahedron is not in position it will be possible to find at points on the screen colours which result from the addition of the three primary colours in amounts depending upon their relative distances from the sources. Thus all possible combinations of colour will be found somewhere on the screen. The centre will be a good white. This experiment demonstrates colour mixing in a most convincing manner.

(2) Place the tetrahedron in the centre hole of the screen. When in the position shown in the illustration each of the faces reflects one colour only. Rotate the tetrahedron and all combinations of any two primary colours will be shown in all possible percentage mixtures. The shadows show unmistakably the secondary colours, magenta, yellow and peacock blue.

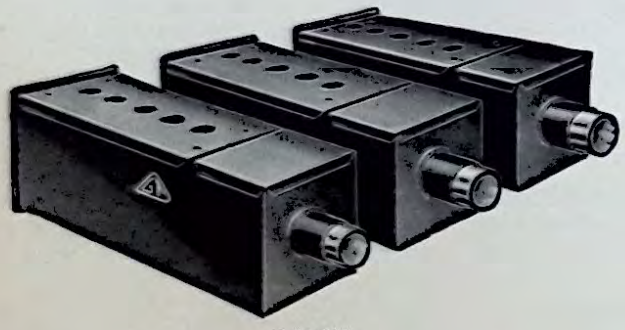
(3) Place one of the rods in the centre hole. The three shadows cast by the lamps are complementary to the respective primary colours. The demonstration is most effective.

(4) Place two of the rods in holes so that their shadows intersect at the centre of the screen. The third primary colour is shown at the point of intersection.

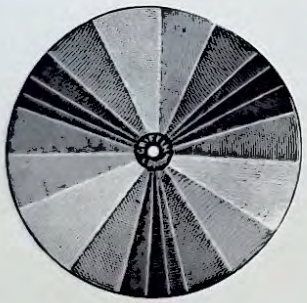
(5) With a rod placed in the centre hole and two lamps illuminated it will be found that the shadows have the same colour as the filter illuminating the shadow.

(6) An interesting psychological experiment in colour perception may be performed by substituting either a ground glass screen or a sheet of tissue paper for one of the filters. Combine this with the light from each of the filters in turn. The shadow of the rod cast by the red light then appears green; that opposite the blue appears yellow and so on. These are subjective colours, corresponding to the complementary colours of the filters employed. That they are subjective may be shown by screening the white diffuser and observing that the shadow cast by the rod is then black.

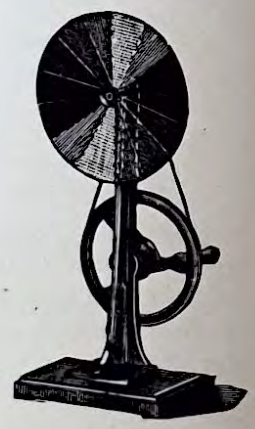
(7) The effect of intensity of light can readily be shown by making use of a dimmer which consists of three glass tubes filled with sodium sulphate solution and containing iron rods, the submerged depth of which can be varied *vide* Savage: *School Sci. Rev.*, 1932. **13**, 87.



A 54-750.



A 54-760.

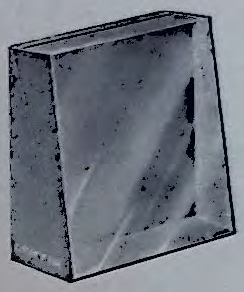


A 54-770.

	£ s. d.
A 54-750. LANTERNS, colour mixing, Set of three (Savage: *School Sci. Rev.*, 1931, **13**, 12). Each lantern constructed in sheet metal $4\frac{1}{4} \times 4\frac{1}{4} \times 10\frac{1}{2}$ in. long, ventilated and with light baffles; fitted with lamp-holder to take lamp up to 150 watts, circular aperture in front of lamp, slot to take filter mounted similarly to lantern slide, projection lens 1 in. diam., 3 in. focal length with sliding focussing. Each lantern can carry a different coloured filter, and the three coloured images on the screen may be made to overlap as desired. **Without** lamps or filters .. .. *set of three*	**6 0 0**
Filters, see **A 54-935.** **Lamps,** see **A 58-350.**	
A 54-760. COLOUR DISC, 12 in. diam., with three sets of 7 colours .. .. *p*	**0 5 0**
A 54-765. Ditto, 8 in. diam., with one set of seven colours .. .. *p*	**0 3 6**
A 54-770. Whirling Stand, for rotating **A 54-760—765**	**1 15 0**
A 54-775. COLOUR DISCS, Maxwell, for experiments on the mixing of colours. Two sets of 9 card discs respectively 8 in. and 4 in. diam. In each set are 7 coloured discs, one black and one white disc. Each disc has a hole in the centre to fit on the whirling table, and is slit radially to permit of overlapping to any desired extent	**0 15 0**



A 54-850.



A 54-860.



A 54-880.

	£	s.	d.
A 54-850. RECOMPOSITION OF LIGHT, Wright's Apparatus, for recomposing the spectrum by superposition, mounted on tripod stand	1	2	6

7 mirrors 2 in. high and ¾ in. wide, mounted in a row on discs which rotate on vertical axes. The coloured images of the slit are focussed on the mirrors, which should then be turned to reflect the light on to the same spot on the screen.

A 54-860. ACHROMATIC COMBINATION. Prisms of flint and crown glass, forming an achromatic combination, $1\frac{3}{4} \times 1\frac{3}{4}$ in.	1	4	0
A 54-880. ACHROMATIC COMBINATION. Lenses of flint and crown glass, uncemented, 2 in. diam., for demonstration purposes	1	5	0

Achromatic Lenses, ... see also **A 52-580**



A 54-935.



A 54-940.

	£	s.	d.
A 54-910. GELATINE FILMS, Coloured, 4 × 3 in., Set of 14 different colours—yellow, medium amber, light orange, red, ruby, pink, magenta, peacock blue, deep blue, emerald green, dark green, purple, neutral, matt .. .. *set*	0	3	6
A 54-920. GELATINE FILMS, in sheets 22 × 17½ in. .. .. *each*	0	3	6

Red No. 14. Yellow No. 1. Peacock Blue No. 15.
Green No. 24. Magenta No. 13. Purple No. 25.
Blue No. 20.

A 54-930. LIGHT FILTERS, Wratten (*Science Masters' Book, Ser. I, Pt. I,* 71), coloured gelatine films, 2 in. square, unmounted, as recommended by E. G. Savage. No. 29 Red, 58 Green, 46 Blue, 12 Compound Yellow, 32 Magenta, 44 Peacock Blue, and the Monochromats 70 Deep Red, 71a Orange Red, 72 Orange Yellow, 73 Yellow Green, 74 Pure Green, 75 Blue Green .. .. *each*	† 0	2	0
A 54-935. Ditto, mounted as lantern slides 3¼ × 3¼ in., with 1¾ in. opening. Suitable for use in Colour Mixing Lanterns **A 54-750** .. .. *each*	† 0	5	0

A 54-940. GLASS PLATES, Coloured. Red, Orange, Yellow, Green, Blue, Indigo, Violet.

Dimensions	4 × 3	6 × 6 *in.*
	9d.	2 3 *each*

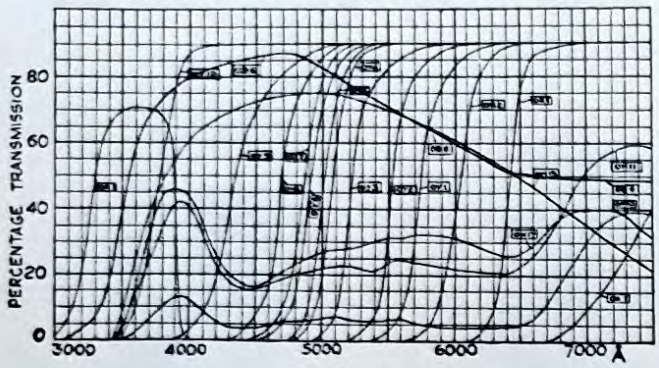


Fig. I.

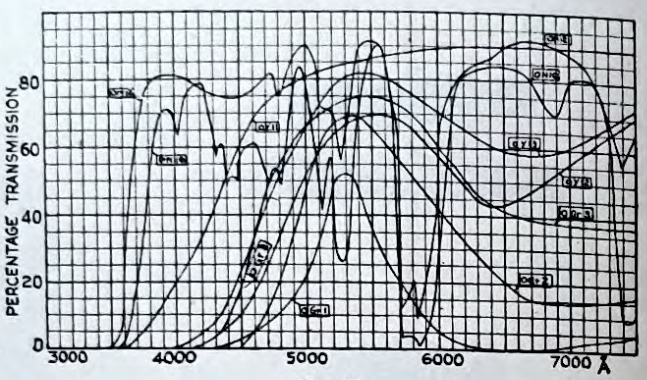


Fig. II.

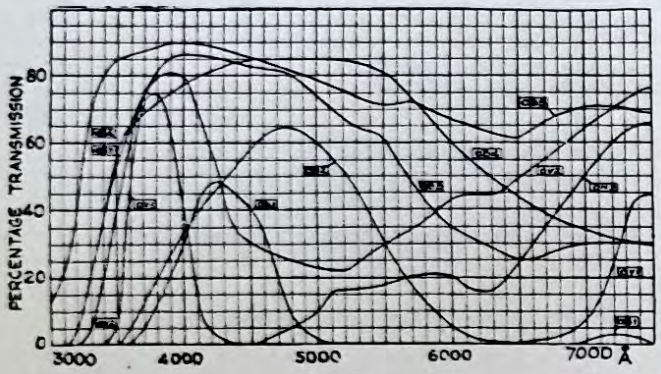


Fig. III.

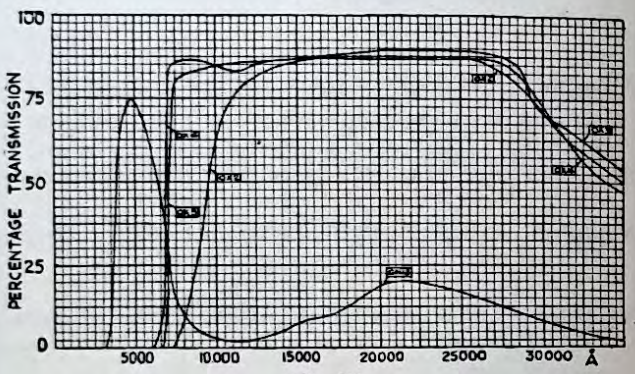


Fig. IV.

A 54-960—995.—Transmission curves for 2 mm. thickness.

OPTICAL GLASSES (Filters), Coloured, 2 mm. thickness, ground, polished and edged; guaranteed ± 4′ prismatic error. Any colour from table below, except Infra-Red and Ultra-Violet. Other sizes specially cut up to 12 in. square—*Prices and large catalogue on application.*

Size	1 × 1	3¼ × 3¼ *in.*
A 54-960. Optically worked	r 8/6	r 25/- *each*
A 54-965. Unworked and unedged	r 1/3	r 12/6 *each*

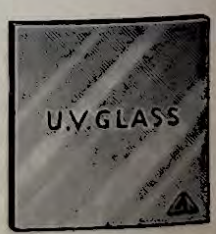
Ref. No.	Colour	Features
OR.1, OR.2 (Fig. I)	Red	Noteworthy for sharpness of spectral cut.
OY.1, OY.2 (Fig. I)	Orange	
OY.3 to OY.9 (Fig. I)	Yellow	
OY.10 (Fig. I)	Yellow	Haze filter; ultra-violet absorbing.
OY.11 (Fig. II)	Yellow	Uranium glass, fluorescent.
OY.12, OY.13 (Fig. II)	Orthochromatic	For panchromatic plates.
OGr.1 (Fig. II)	Green	Primary green.
OGr.2, OGr.3 (Fig. II)	Green	For panchromatic plates.
OB.1 to OB.5 (Fig. III); OB.6 (Fig. I)	Blue	Includes three Daylight Correction Filters.
OV.1, OV.2 (Fig. III)	Purple	Red and Blue transmission bands.
ON.10, ON.11, ON.17 (Fig. I) ..	Neutral	Includes Heat Absorbing Neutral ON.17.
ON.1 to ON.8	Sextant Shades	Densities 0·5-2·6 per mm.
ON.12, ON.16 (Fig. II)	Didymium	Marked absorption of sodium light.
ON.13 (Fig. I visible transmission, Fig. IV heat transmission) ..	Heat Absorbing	Max. visible with min. heat transmission.
OX.1 (Fig. I)	Ultra-Violet	Max. U.V. with min. visible transmission.
OX.2 to OX.4 (Fig. IV)	Infra-Red	Max. I.R. with min. visible transmission.

OPTICAL GLASSES (Filters), Infra-Red, ref. No. OX.2, OX.3, OX.4 (Fig. IV).

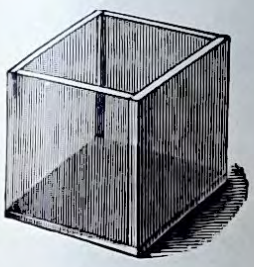
Size	1 × 1	3¼ × 3¼ *in.*
A 54-970. Optically worked	r 10/-	30/- *each*
A 54-975. Unworked and unedged	r 1/6	14/- *each*

Ditto, Ultra-Violet, ref. No. OX.1 (Fig. I).

Size	1 × 1	3¼ × 3¼ *in.*
A 54-990. Optically worked	r 10/-	30/- *each*
A 54-995. Unworked and unedged	r 1/6	14/- *each*



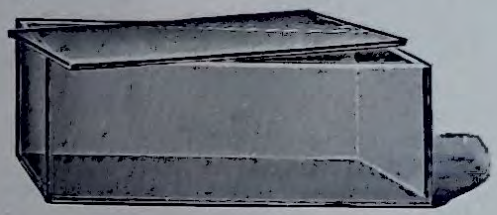
A 54-990—995.



A 55-230.



A 55-235.



A 55-240.



A 55-245.

GLASS CELLS AND TROUGHS, A 55-230—245, are made of extra white parallel plate glass with cemented joints fused at 600° C., resistant to the action of acids and alkalies. The plane surfaces are free from defects and yield images free from distortion, making them specially suitable for light filters, absorption cells, etc. All dimensions are inside measurements.

A 55-230. Cells, Glass, Cubical, with cover.

Size	30	40	50	60	70	80	90	100	*mm.*
	12/-	**16/-**	**20/-**	**23/-**	**25/-**	**27/-**	**32/6**	**35/-**	*each*

A 55-235. Cells, Glass, Rectangular, tall form, with cover. (Thickness = measurement from front to back.)

Height ..	50	50	60	80	100	100	100	100	100	130	*mm.*
Length ..	40	50	30	60	50	60	100	100	100	130	*mm.*
Thickness ..	10	10	30	10	20	10	10	20	50	30	*mm.*
	14/6	**14/6**	**15/6**	**16/6**	**17/6**	**21/-**	**25/-**	**26/-**	**28/-**	**32/6**	*each*

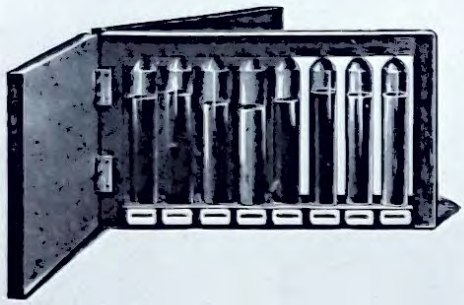
A 55-240. Cells, Glass, Rectangular, low form, with cover. (Thickness = measurement from front to back.)

Length ..	60	60	80	100	120	*mm.*
Height ..	25	30	20	40	50	*mm.*
Thickness ..	25	60	40	40	50	*mm.*
	16/6	**17/6**	**19/-**	**25/-**	**30/-**	*each*

A 55-245. CELLS, Glass, U-Shape.

Height ..	30	30	50	50	80	80 *mm.*
Width ..	20	20	20	20	20	40 *mm.*
Thickness ..	5	10	5	10	5	10 *mm.*
	15/-	**17/6**	**22/-**	**25/-**	**30/-**	**32/6** *each*

A 55-250. CELLS, Glass, Cementless. Vessels are also available, made by two distinct processes —(*a*) by direct fusion, (*b*) by the adhesion of the glass parts in optical contact, both resistant to reagents. With process (*b*), cells of the very highest accuracy can be achieved, since they are formed at temperatures well below the softening point of the glass. A liquid path length accuracy of 0·15 per cent. is obtained. The range of shapes and sizes is limited. .. .. *Prices quoted on receipt of dimensions.*



A 55-520.





A 55-540.

	£	s.	d.
A 55-520. FLUORESCENT LIQUIDS, Set of 8, in sealed glass tubes, in case 10 × 6 in. Tubes are named with the component of the solution which they contain, and fluoresce in different colours under the mercury vapour lamp .. .. *p*	2	5	0
A 55-530. PHOSPHORESCENT PAINT (Luminous Paint) .. .. *bottle*	0	2	0
A 55-540. PHOSPHORESCENT POWDERS, Set of 6 glass tubes in box about 4 in. square with blue fluorescent screen in lid. Powders are arranged to fluoresce in order of the spectral colours:—Red, orange, yellow, green, blue, violet	2	0	0
A 55-560. FLUORESCENT POWDERS, Deep Red, Orange-Yellow, Lemon-Yellow, Green, Mauve, Deep Blue .. .. 10 *gram tube*	0	6	6
A 55-565. Ditto, Blue-Green, very long afterglow .. .. 10 *gram tube*	0	4	6

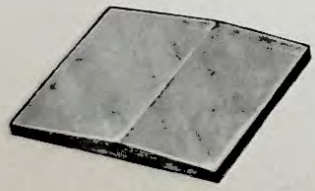
A 55-570. Media, for preparing luminous paints from above fluorescent powders.

For	A 55-560	A 55-565	
	4/6	3/9	100 *ml.*

A 55-580. Thinner, for luminous paints **A 55-570** .. .. 250 *ml.*	0	3	6
A 55-590. FLUORESCENT MINERALS, 2 × 1½ in. approx.—Autunite (*Yellow-Green*), Arragonite (*Pink*), Calcite (*Red*), Fluorite (*Purple*), Wernerite (*Green*), Willemite (*Green*), Zinc Blende (*Golden*) .. .. *each* 9/-; *set*	3	0	0



A 55-705.



A 55-710.



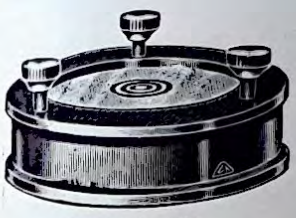
A 55-715.

A 55-705. INTERFERENCE APPARATUS, Young. A cell in which are mounted a fine slit at one end and two parallel slits at the opposite end. The slits are made after Rayleigh's method by engraving fine lines on silvered glass. The fringes are seen on holding the double slit close to the eye, or they can be projected on to a screen on the optical bench. Mounted on ⅜ in. diam. brass stem .. .. *r*	3	15	0

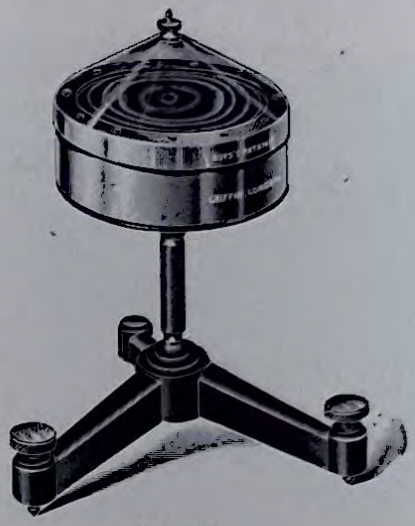
A 55-710. INTERFERENCE PRISMS, Fresnel, unmounted.

Dimensions	40 × 30	50 × 44	*mm.*
	15/-	17/6	*each*

A 55-715. INTERFERENCE PRISM, Fresnel, 50 × 44 mm., mounted on ⅜ in. diam. brass stem *r*	2	0	0



A 55-740—745.



A 55-780.



A 55-820.

	£	s.	d.
A 55-740. NEWTON'S RINGS. A pair of glasses 6·5 cm. diam. with worked surfaces. One of the contact surfaces is plane and the other has a slight spherical curvature giving wide rings of colour. Mounted in a brass cell with 3 pressure screws	3	0	0
A 55-745. Glasses only, 6·5 cm. diam., for above .. .. *pair*	0	15	0
A 55-780. RAINBOW CUP (Boys: *Soap Bubbles*) for the treatment and examination of liquid films. Including two bottles of special soap solution .. .. *r*	3	5	0

This instrument was devised by the late Prof. C. V. Boys, F.R.S., and makes it possible to produce and observe effects more brilliant and varied than any that have hitherto been possible, even with the soap bubble. It has the advantage, also, that no special skill is required, so that its use is not confined to accomplished experimentalists.

A soap film is stretched by the use of a celluloid wiper over the inturned rim of the circular brass box 5 in. diam., which is so mounted that it can be set into rotation by the hand and will then continue to spin for a long time. A transparent conical cover of thin celluloid fits over the box, the rim of which is drilled with a number of holes so that the pressure on the two sides of the film may rapidly come into a state of equilibrium. The plane form of the film is thus preserved.

Soap Solution, made to Boys's recipe, for use with above .. .. see **A 26-560**

A 55-820. DIFFRACTION GRATINGS, Transmission (Thorpe's moulded replicas of Rowland's metallic gratings, about 14,450 lines to the inch). Mounted on worked parallel plate-glass with ruled part about 1 × 1 in., suitable for visual and photographic work. Each grating has the number of lines per inch marked upon it. In velvet lined case .. *each* *r*	2	5	0
A 55-830. DIFFRACTION GRATING REPLICA, Students'. Celluloid cast grating replica, about ½ in. square, from an original Rowland grating. Mounted between two glass protecting plates, the number of lines per inch is marked on each grating. Insufficiently accurate for use in a spectroscope but suitable for hand use .. .. *tx*	0	5	1

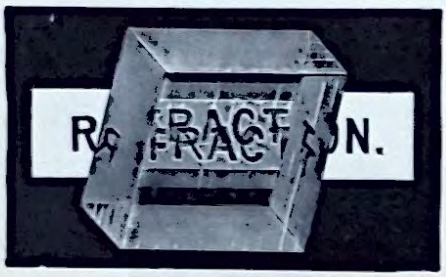
A 55-840. DIFFRACTION GRATINGS, Transmission, circularly ruled, 6,000 to 7,000 lines per in. Mounted on square glass plates.

Diameter ..	½	¾	1 *in.*
t	30/-	35/-	42 6 *each*

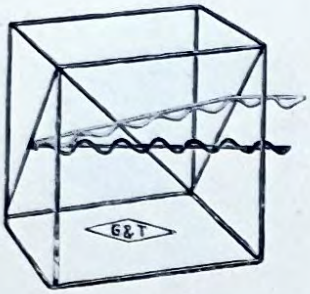
To show haloes round the moon, a lamp is placed in a light-tight box in which there is a small circular hole. This is focussed on a screen by a convex lens. When the grating is interposed a beautiful halo will be seen around the hole (Savage: *Science Masters' Book, Ser. I, Pt. I,* 89).



A 55-840.



A 56-140.



A 56-150.



A 56-170.



A 56-180.

	£	s.	d.
A 56-120. TOURMALINE PLATES, unmounted, for use as polarisers .. .. .. *from*	0	10	0
A 56-125. BLACK GLASS PLATES, about 3 × 1¾ in., optically worked on one face ..	0	10	0

A 56-140. ICELAND SPAR, polished plates to show double refraction .. *Prices on application.*

A 56-150. ICELAND SPAR MODEL, strong and accurately proportioned. Constructed of stout wire, side about 8 in. long, showing principal plane and ordinary and extraordinary wave traces, delineated in different colours .. .. *r* 1 15 0

The phenomenon of double refraction which takes place in Iceland spar, is difficult to exhibit to students by means of two-dimensional diagrams. This model, in three dimensions, has been found very helpful. The optic axis is represented and the paths and planes of polarisation of the ordinary and extraordinary rays are exhibited by typical, coloured wave traces. The mechanism of double refraction can thus be simply explained and the reason for the rotation of one image about the other when the crystal is rotated, made clear.

A 56-170. NICOL PRISMS, of rhomboidal section, with oblique ends, 22° angle of polarisation, unmounted.

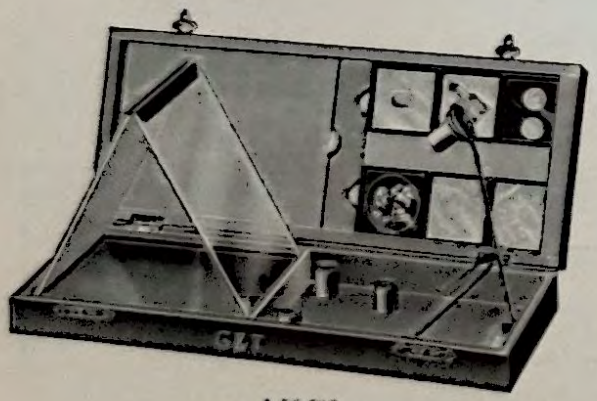
Aperture ..	7	8	10	12·5	15	20 *mm.*

Prices on application.

A 56-180. THOMPSON PRISMS, used in the same manner as Nicol Prisms, but with square end faces, 30° angle of polarisation, unmounted.

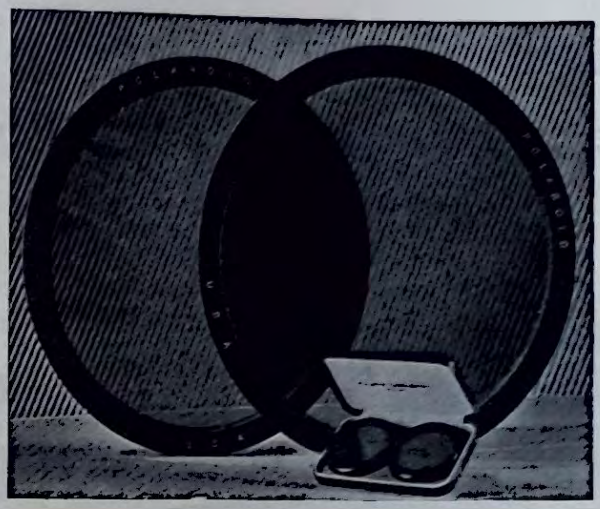
Aperture	6	8	10	13 *mm.*

Prices on application.



A 56-210.

A 56-210. POLARISCOPE. Simple form with black mirror polariser, Nicol analyser, 6 specimens showing colour (including one design), and 3 crystal specimens showing the rings and brushes. In box approx. 14 × 5 in. *p* 4 10 0



A 56-250.

	£	s.	d.
A 56-250. POLAROID, Type I, two discs, 4 cm. diam., mounted between plane glass plates in moulded rings, complete in velvet-lined snap case	4	10	0

Polaroid, Type I.—The film is a matrix for sub-microscopic dichroic crystals accurately oriented so that polarisation of visible light is uniform over the entire area. Transmits approx. 37 per cent. normally incident visible light. Polarisation of transmitted light exceeds 99·8 per cent., except at extreme ends of the visible spectrum.

A 56-252. POLAROID, Type H, unmounted, two 3 in. plastic squares. Inexpensive type for school use. In card box	0	15	0
A 56-255. POLAROID, Type II Film, unmounted, two 4 in. squares, easily cut with scissors, can be bent round to form a cylinder for Raman effect. Each piece wrapped in Cellophane, selected for its ability to produce interference colours between the Polaroid films. In box	2	8	0
A 56-260. Ditto, 12 in. square film	7	16	0

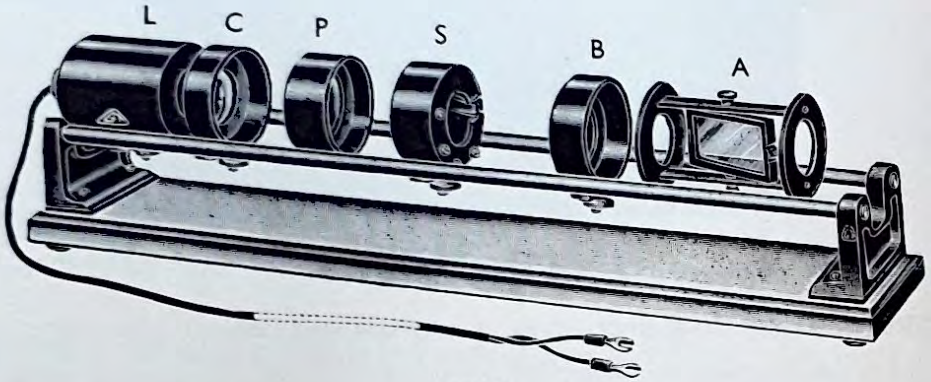
Polaroid, Type II.—Degree of polarisation, approx. 99·4 per cent., transparency, approx. 36 per cent., free from aberration, polarisation uniform over the entire area. For all applications of polarised light where highest optical quality is not essential.

Applications.—Demonstrations of polarised light; polarisation by double refraction, reflection and scattering; interference of polarised light; behaviour of birefringent materials; interference colours in crystals. Projection experiments, conversion of microscopes, refractometers, etc., as polarising instruments. Strain detection in glassware and photo-elastic stress analysis of machine models and structural parts. Intensifying or eliminating specular reflections of polarised light. Photometry, circular and elliptical polarisation, Zeeman and Raman effects; analysis and orientation of crystals. Stereoscopy and independent ocular images, smooth control of light intensity, non-glare illumination, examination of natural polarisation of sky-light, reflected glare, spiral nebulæ, etc.

A great variety of Apparatus for all branches of Physics, Chemistry and Biology is made in our own factories and approved by rigid inspection in our own Test Rooms.

THE MICROID PROJECTION POLARISCOPE

A compact apparatus combining simplicity in operation with brilliant illumination



A 56-280.

The phenomena of polarised light are, like many three-dimensional phenomena, difficult to comprehend unless the theory is supported by conclusive experimental evidence. The high cost of apparatus incorporating Nicol prisms for the demonstration of these phenomena prevents treatment of the subject with the desirable degree of experimental freedom.

The Microid Projection Polariscope, utilising a Polaroid disc as polariser and a specially selected pile of thin glass plates for the analyser, is inexpensive and gives exceptionally satisfactory results. The use of Polaroid for the polariser, and a pile of plates for the analyser, has educational advantages, and the glass plates enable the reflected image in colours complementary to the transmitted image, to be obtained. Brightly illuminated images, both transmitted and reflected, of 1 metre diam. over a projection distance of 3 metres, are readily obtained. The unconventional design of the optical bench ensures immediate alignment of the optical system, the components of which are easily and simply adjustable.

SPECIFICATION

A teak base about 22 × 4 in., fitted with rubber feet, carries a cradle type optical bench bed composed of two stainless steel rods mounted in metal blocks. The bed supports a lamphouse L accommodating a 24 watt lamp, a condensing (thick) lens C, a polariser P, a specimen slide holder S, a projection (thin) lens B and an analyser A.

The envelope of each of the components is cylindrical, so that, when placed in position, the component is immediately and precisely aligned. Those components, in which for polarisation experiments, rotation is not necessary, are fitted with a clamping bar and screw in order to give to the optical system, when set up and focussed, a stability which is not easily disturbed during manipulation.

The Polaroid disc in the polariser can be rotated ; the analyser is provided with a pile of thin glass plates about 3 × 1¼ in. fitted in a frame, which can be turned to the polarising angle by means of the milled heads provided. The frame is mounted in a holder having annular ends, on which, for rotation of the plane of polarisation, it may be rotated in the optical bench cradle.

A 56-280.—**The Microid Projection Polariscope**—*continued.*

Cellophane Slides.—By careful selection and calibration, a range of slides made in Cellophane and mounted between glass plates 1⅝ in. square is now available. The slides are held by a spring clip in either a stationary or a rotating holder designed specially for rapid and easy interchange. They are inscribed with data of path retardation and direction of fast and slow axes, which are usually placed at 45° to the edge of the slide. Colours are therefore shown when an edge of the slide is horizontal and when the vibrations in the polarised light are horizontal or vertical.

Slide A.—Quarter-wave plate 1⅝ in. square. This slide shows quarter-wave retardation for the yellow-green, 5500 Å, which, when the slides are to be used with white light, is preferable to sodium light as a standard of reference.

Slide B.—Uniform sheet 0.30 λ path retardation.

Slide C.—Uniform sheet 0.40 λ path retardation.

Slide D.—Uniform sheet 0.55 λ path retardation.

By superimposing these slides, crossed or parallel, many other thicknesses may be obtained, *e.g.*

$$B + C = 0.70\ \lambda, \quad C - B = 0.10\ \lambda, \quad B + C - D = 0.15\ \lambda.$$

Slide E.—Strip of width 15 mm., 1·1 λ path retardation. With crossed polariser and analyser, this slide shows *blue* of the second order ; with parallel, its complementary *yellow*. Two identical slides are required to show the principle of compensation. A black square is shown when the slides are crossed. A bright *green* square is shown when one slide is turned over, or when the two slides are superimposed parallel.

Slide F.—Strip of width 15 mm., 2·20 λ path retardation. This slide shows the brilliant *green* of the third order, with the complementary *red* (two required).

Slide G.—Pile of ten echelon steps, each 0·30 λ path retardation. This instructive slide shows clearly the colours of the first three orders. It has many uses. For instance, the increase of path retardation with thickness ; the rapid determination (by compensation) of path difference for any other sheet and the accurate measurement (by means of the spectrometer) of path retardation and its variation along the spectrum.

Slide H.—Similar to slide G but with fast and slow axes parallel to the edges of the slide.

Slides J and K.—Geometrical designs, showing a variety of bright colours, all of which may be varied by the superposition of uniform sheets, B, C, D or F.

PRICES

		£	s.	d.
A 56-280. MICROID PROJECTION POLARISCOPE, on wood base about 22 × 4 in. fitted with rubber feet, with cradle type optical bench, lamphouse, condenser, Polaroid polariser, fixed slideholder, projection lens and pile-of-plates analyser. **Without** lamp ..		9	0	0

Component and Extra Parts for A 56-280

A 56-280 a.	**Rotating Slide Holder,** similar to slide holder in **A 56-280** above, but without clamping bar and screw. Intended to be used for supporting a second Cellophane slide for rotation between the fixed slide and the projection lens											1	1	0
,, ,, **b.**	**Cellophane Slides,** as described in detail above. Mounted between glass plates 1⅝ in. square with bound edges, fast and slow axes marked and path retardation for λ = 5500 Å given.													
	Slide	A	B	C	D	E	F	G	H	J	K			
		6/-	4.6	4.6	5.-	4.6	6.6	12.6	7.6	12.6	12.6 *each*			
,, ,, **c.**	**Ditto, Set of 12 slides, A 56-280 b,** comprising one each A, B, C, D, G, H, J, K and two each E and F											4	5	0
,, ,, **d.**	**Cellophane Slide** similar to F above. Strip of width 1 in. mounted between glass plates 3¼ × 2¼ in. for use as shown in Fig. 2, p. 192											0	6	6
	Lamps, for above, Class F, 24 watts b.c. cap., ...											see **A 58-495**		

[*continued overleaf*

A 56-280.—The Microid Projection Polariscope—*continued.*

EXPERIMENTAL NOTES

The design adopted for the cradle type optical bench bed enables the optical system to be set up and adjusted with exceptional ease. The illustration on p. 190 shows the approximate spacing of the parts for projection over a distance of about 10 feet. At this distance a brightly illuminated circle about 3 ft. in diameter is projected. Best results are obtained with a perfectly dark room. By over-running the 6-volt lamp at 7 volts and the 12-volt lamp at 14 volts, the intensity of illumination is greatly increased without marked reduction in the useful life of the lamp.

To set up the optical system, arrange the parts in the order shown in the illustration. Place the lamphouse and the condenser C close together at one end of the bed. Depending on the distance of projection, it may be advantageous to place the condenser with its convex side nearer to the lamphouse. To insert a lamp, remove the lampholder from the lamphouse by pushing the socket outwards from the interior, place the lamp in its holder and re-insert the socket in the lamphouse.

Place the slide holder S close to the polariser and, by moving the projection lens B, focus an image of slide G on to the screen. Adjust the analyser A so that the axis of rotation of the pile of plates is horizontal or vertical as required. Adjust the plates to make (as judged by eye) an angle of about 30° with the horizontal, with the elevated end remote from L. It will be found that a brightly coloured image is then produced on the screen and a second image on the ceiling. If the distance of the ceiling from the instrument be not greatly different from that of the screen, then both images will be in focus. Should the ceiling be too distant, then by rotating the analyser through 90° the reflected image can be directed on to a wall perpendicular to the screen. It may then be possible, though this adjustment is not critical, to obtain simultaneous focussing of both the direct (transmitted) and the reflected images.

When set up and adjusted, the clamping bars attached to the lamphouse, condenser, slideholder and projection lens should be turned to engage the rods of the optical bench and the clamping screws tightened. These fittings are then firmly held in position and manipulation of the polariser and analyser will not disturb the setting.

Many instructive experiments may be performed with the projection polariscope. The variation in intensity of the image should be shown by rotation of first the analyser and then the polariser. With the polariser and analyser crossed, *i.e.* with the field dark, the piles of plates should be rotated to demonstrate the relation between the angle of the pile and the resulting polarisation.

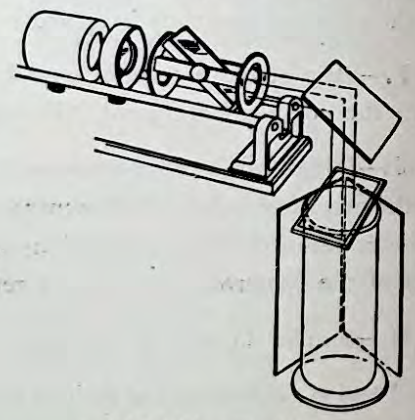
Next introduce a plain slide E (1·1 λ) into the slideholder. Colours will appear on the screen and on the ceiling. Rotate the analyser slowly and show the gradual fading of both images through the positions of no colour and the change thereafter to the complementary colour. P and A may be interchanged to show the pile of plates as polariser. The reflected image in colour is not then obtained.

Now insert a similar slide in the rotating slide holder, placed so that the two slides are in contact. The depth of focus of the projection lens is sufficient to give a clear image of the superimposed slide. Rotate the holder so that the fast axis of one slide is parallel to the slow axis of the other slide. A cross is seen on the screen having the central square black, due to compensation of path retardation. The four surrounding rectangles each show the colour due to a single thickness. Rotate the slide through 90°, so that the axes are parallel and note the new colour for the double thickness. Remove the two slides and substitute one slide of double the retardation, *i.e.* substitute one slide F. The same colour is obtained as for the two slides E superimposed parallel.

The use of the echelon slide G or H may now be shown as a means of measuring retardation. Place slide G in the fixed holder and slide B in the rotating holder. Cross the two slides and note that the first band on the image is black, corresponding to a thickness equivalent to a path retardation of 0·3 λ. If the fifth band had been black, the thickness would have introduced a retardation of 5 × 0·3 = 1·5 λ. Repeat this with slide F (2·2 λ) and note that the black is now distributed between the 7th and 8th steps on the echelon. Crossing this combination with slide C moves the black band wholly into the 6th step of the echelon.

Circularly polarised light can be demonstrated by placing the slide A in the holder. As the analyser is then rotated, the illumination on the screen remains almost constant. The slight variation from bluish grey to fawn is due to the fact that the slide is calibrated to be λ/4 for mean white light (= 5500 Å) and is not λ/4 for all wavelengths simultaneously.

The geometrical designs, slides J and K, are suggestive of the interesting coloured patterns that can be produced by construction of films of various thicknesses. The range of colours exhibited by the patterns may be increased by the use of any of the slides A-F.



A 56-280.—Fig. 2.

The apparatus lends itself particularly well to use in an experiment to show polarisation by particles in suspension. Remove the analyser, projection lens and slideholder from the bench and move the polariser, condenser and lamphouse to this end of the bench as shown in the diagram, Fig. 2. Arrange a silvered mirror at 45° to reflect the polarised beam down into a tall jar (*e.g.* a gas jar or measuring cylinder), containing water to which a few drops of milk or of gum gamboge in alcohol have been added. Observing the jar normally, rotate the polariser and note at each 90° the changes from dark to light. Now place the 2·2 λ slide F (**A 56-280b**) on top of the jar and two ordinary mirrors at 90° behind the jar. Observing the mirrors, red and green images of the jar are then seen illuminated in complementary colours, the one in the left-hand mirror and the other in the right-hand. Rotation of the polariser results in interchange of the positions of the two images.

Leaflets on new apparatus supplementary to this catalogue are frequently published.
Names added to our Mailing List on request.

THE MICROID POLARISED LIGHT AND PHOTOELASTICITY APPARATUS

A new and important series for the experimental study and projection demonstration of polarised light and photoelastic phenomena

The subject of polarised light is of growing importance. A clear comprehension of the phenomena involved can be gained only by individual laboratory work supplemented by convincing demonstration. The scope of courses has hitherto been restricted by the expensive nature of the apparatus available.

The series of apparatus here described embodies several original features and, being inexpensive and easy to use, brings a systematic study of the subject for the first time within the reach of every school. It provides for :—

(*a*) Individual work in the laboratory.

(*b*) Class demonstration and projection of all the more important phenomena.

The simplicity of the polarising system contributes to the low cost of the apparatus. This simplification has been effected without substantial loss of efficiency so that the colour phenomena which can be observed and demonstrated are exceptionally attractive. High efficiency is combined with very easy manipulation.

The range of experiment covers polarisation by reflection, refraction, double refraction, and the demonstration of the interference colours when doubly-refracting substances are examined in plane and in circularly polarised light. Provision is also made for the performance of instructive experiments in photoelasticity. This subject, developed by Professor Coker, is now employed as an aid to the solution of many mechanical problems in which mathematical calculation is difficult or even impossible.

Since this apparatus was developed (*School Sci. Rev.*, 1934, 60, 478; 61, 57; 62, 205) Polaroid has become readily available. Though provision is now made in the apparatus for the use of Polaroid, both as polariser and analyser, it is felt that the importance of teaching the laws of polarisation by reflection justify the retention of the apparatus in its original form. The Experimental Notes describe how Polaroid may be substituted for piles of plates in demonstration work. A convenient assembly for projection-photoelastic work, embodying some of these components is shown on p. 203.

SPECIFICATION

I.—Microid Simple Reflection Polariser and Analyser *for Students' use.*

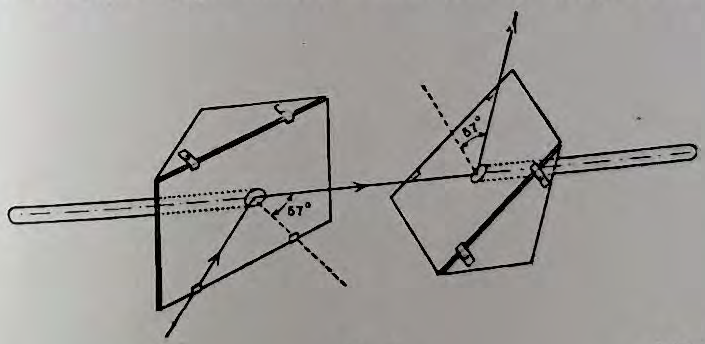


Fig. 1.



A 56-305.

Fig. 2.

Polariser.—A pile of thin glass plates 7½ × 4½ in. is blackened at the back surface and mounted on a wood block of triangular section by means of small clips recessed into its sides. The block is accurately cut to the polarising angle and the size of the plates is such that an approximately square aperture of 4 in. side is obtained for the reflected beam. Light incident on the polariser parallel to one slant face is reflected at the polarising angle parallel to the other slant face. A wood rod ⅜ in. diam. is fixed centrally in one face with its axis parallel to the direction of the polarised beam, thereby facilitating adjustment.

Analyser.—A single blackened glass plate, mounted similarly to the polariser, acts as an analyser. Together, crossed and parallel mirrors can quickly be set up, the blocks resting on a bench in front of a window or under a lamp, which is used as a source of light. If desired, the blocks may be mounted on the stand **A 56-310** with advantage to ease of adjustment and rotation.

For prices see pp. 198, 199.

[*continued overleaf*

A 56-305—385. The Microid Polarised Light and Photoelasticity Apparatus—*continued.*

II.—Microid Bench Polariscope *for Students' use or for demonstration to small groups.*

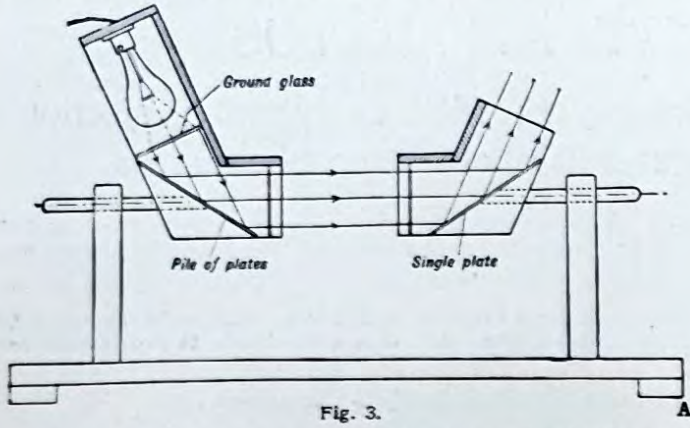


Fig. 3. A 56-315.

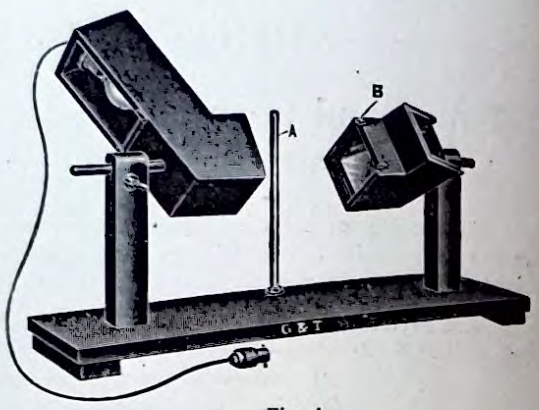


Fig. 4.

This instrument is suited to bench use by students and is not dependent upon any source of natural light. The polariser and analyser can conveniently be rotated. For experiments in photoelasticity, the rod, A, shown centrally in Fig. 4, is well adapted for holding the frame (**A 56-355**), containing a stressed celluloid specimen, or, by means of the bosshead **B 19-750**, for holding either the compression frame **A 56-365** or the slide rotator **A 56-340**.

In this polariscope, a lamphouse and an observation tube are respectively fitted to the simple polariser and analyser described on p. 193 and the whole is mounted on a stand. The base board of the apparatus is about 36 × 10 in. and is provided with two square pillars, having holes $\frac{5}{8}$ in. diam. to accommodate the rods attached to the polariser and analyser. These can be rotated by releasing the thumb screw with which each pillar is provided.

The polariser has a lamphouse to contain a 100 watt opal lamp. A ground glass diffusing screen is interposed between the lamp and the pile of plates.

The analyser has an observation hood of 4 in. clear aperture, giving a defined field of view and maintaining the line of sight. Both polariser and analyser are provided with a slot, B, to take a 5 × $4\frac{1}{4}$ in., quarter-wave plate **A 56-350** to convert the plane polarised beam into a circularly polarised beam, when required for work on photoelasticity. It is advantageous to keep the analyser fixed and to rotate the polariser. This allows attention to be concentrated on a fixed image instead of having to follow a moving image.

The double image analyser, described under IV on p. 195, and listed under **A 56-320**, p. 198, is mounted on a tripod foot of suitable height for use with the Bench Polariscope. This accessory greatly extends the usefulness of the Bench Polariscope and is therefore strongly recommended. It is intended to stand on the base of the polariscope after withdrawal of the analyser, or on the bench after reversal of the rod of the analyser in its supporting pillar.

The Bench Polariscope is not suitable for *projection.*

III.—The Microid Projection Polariser *for demonstration.*

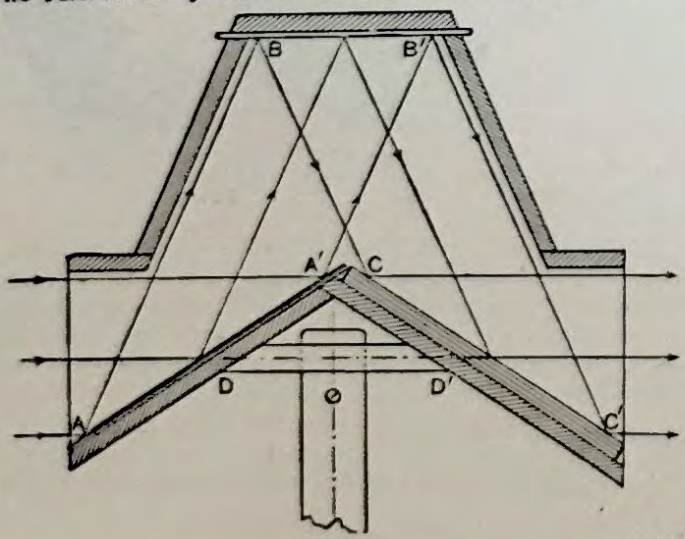


Fig. 5. A 56-325.



Fig. 6.

For prices see pp. 198, 199

A 56-305—385. The Microid Polarised Light and Photoelasticity Apparatus—*continued.*

The polariser illustrated in Fig. 6 has been devised for projection work in class demonstration. It requires a powerful parallel beam of light. The normal type of projection lantern is usually suitable and can be adapted for the purpose by removing the projection lens and employing the parallel beam emergent from the condenser. The analyser which is its complement, is described below.

Hitherto the various forms of demonstration reflection polariser in use have been of the elbow type. This type is awkward to adjust, since the lantern needs to be directed obliquely to the screen, and cannot be rotated. The present polariser has been designed to be free from these limitations.

A parallel beam from the lantern is first reflected from the silvered mirror AA^1 (Fig. 5), thence from a second silvered mirror BB^1 and finally it is reflected back to the original direction, and polarised by the pile of plates CC^1. The case is of wood about 14 in. overall length with dimensions such that the pile of plates gives a square aperture of 4 in. side. The mirrors may be removed for cleaning.

The Polariser is mounted and rotatable through more than 180° on a horizontal rod DD^1 fixed to the case, so that the axis of rotation is that of the lantern beam. The instrument is supported on a heavy conical base by means of a stainless steel rod ½ in. diam. The height of its optical centre is adjustable between 13 and 21 in. The aperture from which the polarised beam emerges is grooved to accommodate a 5 × 4¼ in. quarter-wave plate for the production of circularly polarised light.

IV —The Microid Double Image Analyser *for use in either projection work or individual observation.*

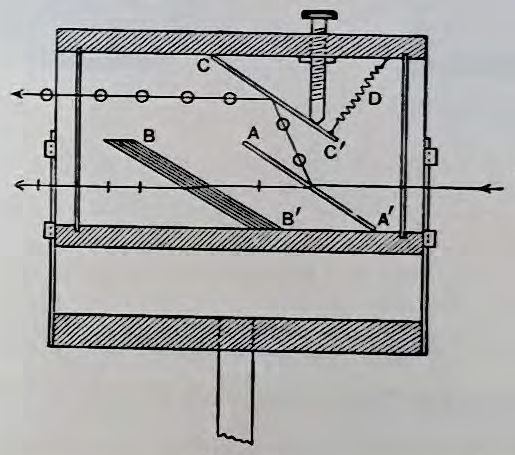


Fig. 7.

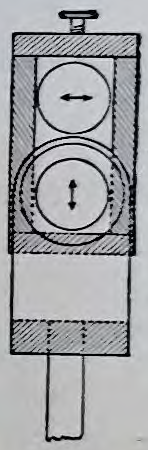


Fig. 8.



Fig. 9.

A 56-320, 330.

The Double Image Analyser serves all the purposes of a Nicol prism. It has been designed specially for use with the projection polariser, Fig. 6, above, but can be used also for individual laboratory work. It is designed so that both the transmitted and the reflected vibrations (equivalent to the ordinary and the extraordinary rays of the Nicol prism) can be separated and, if required, superimposed on the screen. This constitutes a distinct advantage for teaching purposes.

A part of the incident light is reflected from a clear glass plate, AA^1 (Fig. 7), is again reflected from a blackened glass mirror CC^1, set at the polarising angle, and emerges nearly parallel to the beam transmitted through the pile of glass plates BB^1, but polarised in the plane at right angles as shown in Fig. 8. The first plate, AA^1, at which most of the reflection takes place, is separated from the pile BB^1 because the reflected image is thereby free from multiply-reflected images.

The mirror CC^1, hinged at C, is adjustable by a screw through the case, engaging the metal sheath which holds the mirror, a weak spring D preserving contact. By slight adjustment of the screw, the two images, polarised in planes at right angles, may be brought together on the screen.

The case of the Analyser is about 4 × 2½ in. with a clear transmission aperture about 1 in. diam. It is mounted in rings screwed to the ends to rotate about the axis of the transmitted beam. These rings fit in the arms of a U-shaped bracket supported on a vertical stem ⅝ in. diam. which is mounted on a tripod foot (Fig. 9). The height of the optical centre is adjustable between 14 and 17 in.

V.—Convex Lens *for use with the Projection Polariser.*

Lens 10 cm. diam., focal length about 20 cm. This lens will be found to give a screen image about 4 ft. 6 in. diam. at 20 ft. If the lantern does not give sufficient illumination to warrant so large an image, a lens of longer focus may be substituted, *e.g.* 30 cm.

For prices see pp. 198, 199.

[*continued overleaf*

A 56-305—385. The Microid Polarised Light and Photoelasticity Apparatus—*continued.*

VI.—Microid Slide Holder and Rotator *for use in demonstrations and in photoelasticity.*

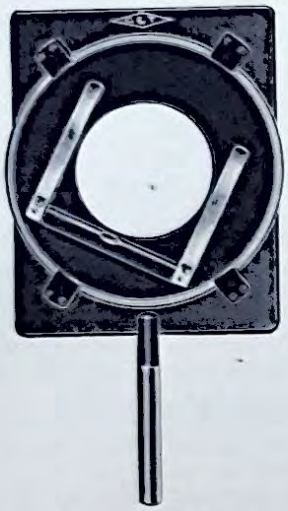


Fig. 10.—**A 56-340.**



A 56-345.—Fig. 11.—Slide G.



A 56-345.—Fig. 12.—Slide J.



Fig. 13.

This accessory (Fig. 10) is intended for use with either the Bench Polariscope or the Projection Polariser. It enables two Cellophane slides (see p. 197) to be supported simultaneously between the polariser and analyser, and provides for convenient rotation of one of them.

The rotator is a circular disc with milled edge, about 5 in. diam., mounted on a rectangular plate about $6 \times 4\frac{3}{4}$ in. by means of four brackets. The milled edge of the disc thus overlaps the smaller dimension of the rectangular plate, leaving two milled segments by which the disc may be rotated. The disc is provided with a pair of spring clips and an aperture about $2\frac{1}{2}$ in. diam. The plate also is provided with a pair of spring clips and is mounted on a stem of standard ($\frac{3}{8}$ in.) diam.

One slide, supported in the clips on the plate, remains stationary. The other, fitted in the clips on the disc, rotates with the disc. The rotator may be supported either in the universal bosshead, Fig. 13, recommended for use with the Bench Polariscope, or on a tripod foot for use with the Projection Polariser.

VII.—Microid Cellophane Slides. The use of calibrated Cellophane, in place of selenite or mica, makes for simplicity in preparation, and the extraordinarily low cost, compared with that of slides of similar size made in the traditional materials, allows of multiplication, so that individual work may be carried out by every member of a class. In these slides the thickness is uniform, the transparency is good and the colours are therefore bright and clear. Very beautiful and striking effects may be obtained.

These Cellophane slides, described in detail below, are used in many of the experiments described on pp. 200–202 and typical examples are illustrated in Figs. 11 and 12. They are made from carefully selected Cellophane and are mounted between glass plates $3\frac{1}{2} \times 2\frac{1}{2}$ in. The fast and slow axes are clearly marked, and are usually placed at 45° to the length, so that colours are shown when the slide is horizontal, and the vibrations in the incident polarised light are horizontal or vertical. The path retardation for mean white light (yellow-green = 5500 Å) is given on each slide. For the variation of path retardation with wavelength in Cellophane see Expt. 6, p. 200.

Description of Cellophane Slides

Slide A.—Quarter-wave plate $3 \times 2\frac{1}{2}$ in. This slide shows quarter-wave retardation for the yellow-green, 5500 Å, which, when the slides are to be used with white light, is preferable to sodium light as a standard of reference. A large ($5 \times 4\frac{1}{4}$ in.) quarter-wave plate for use with the Bench Polariscope and the Projection Polariser is listed under **A 56-350.**

Slide B.—Uniform sheet 0·30 λ path retardation.

Slide C.—Uniform sheet 0·40 λ path retardation.

Slide D.—Uniform sheet 0·55 λ path retardation.

By superimposing these four slides, crossed or parallel, many other thicknesses may be obtained, *e.g.*

$$B + C = 0{\cdot}70\,\lambda. \quad B - C = 0{\cdot}10\,\lambda. \quad B + C - D = 0{\cdot}15\,\lambda.$$

For prices see pp. 198, 199.

A 56-305—385. The Microid Polarised Light and Photoelasticity Apparatus—*continued.*

Slide E.—Strip of width one inch 1·1 λ path retardation. With crossed polariser and analyser, this slide shows *blue* of the second order; with parallel, its complementary *yellow*. Two identical slides are required to show the principle of compensation. A black square is shown when the slides are crossed. A bright *green* square is shown when one slide is turned over, or when the two slides are superimposed parallel. The two slides are held simultaneously in the slide rotator.

Slide F.—Strip of width one inch 2·20 λ path retardation. This slide shows the brilliant *green* of the third order, with the complementary *red* (two required).

Slide G.—Pile of ten echelon steps, each 0·30 λ path retardation. (Illustrated in Fig. 11.) This instructive slide shows the colours of the first three orders well. It has many uses. For instance, the increase of path retardation with thickness ; the rapid determination (by compensation), of the path difference for any other sheet ; the accurate measurement (by means of the spectrometer), of path retardation and its variation along the spectrum ; and as the basis of a calibration experiment in photoelasticity (see Expt. 9, p. 201).

Slide H.—Similar to slide G but with fast and slow axes parallel to the edges of the slide.

Slides J and K.—Geometrical designs, showing a variety of bright colours, all of which may be varied by the superposition of uniform sheets. B, C, D or F. (Illustrated in Fig. 12).

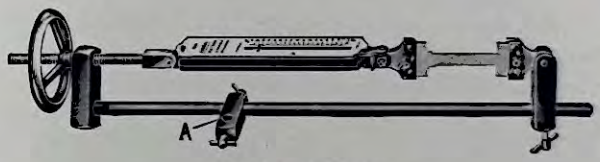


Fig. 14.—A 56-355.



Fig. 15.—A 56-365.

VIII.—Microid Tension Frame *for use in photoelasticity.*

This frame, Fig. 14, is designed to accommodate celluloid specimens of various shapes (see p. 198), to which stress can be applied and the resulting strain visually demonstrated.

The base of the frame is a rod 24 × ½ in. with a movable bracket at the right hand end and a fixed bracket at the left hand end. A threaded rod passes through the left hand bracket and is fitted with a spring balance (reading to 50 lbs. in 1 lb. steps), and with a wheel, by which tension may easily be applied to a celluloid specimen inserted in the clamps. The wheel has a travel of about 3 in. and wing nuts have been used throughout in order that specimens may rapidly be changed.

The frame may be mounted by means of the rigid bosshead A on the rod fitted to the bench polariscope (Fig. 4). Other convenient means, *e.g.* a retort stand, may be employed to support it in the field of the projection polariser (Fig. 6). Larger stresses than 50 lbs. (the maximum reading of the spring balance) may be applied by substituting a metal strip for the balance.

IX.—Microid Compression Frame

This frame, Fig. 15, is intended for use in a manner similar to that of the Tension Frame described above. Celluloid specimens of various shapes can be placed in it and the effect of pressure on them demonstrated.

The frame, having an effective aperture 1½ in. square, is mounted on a standard (⅜ in.) diam. rod. The specimen is placed in the aperture and lightly held by turning the pressure screw. The required degree of pressure is then applied. The frame is intended to be supported by means of a universal bosshead (Fig. 13) on the rod A of the bench polariscope. Other convenient means, *e.g.* a retort stand, may be employed to support it in the field of the projection polariser.

For prices see pp. 198, 199.

[*continued overleaf*

A 56-305—385. The Microid Polarised Light and Photoelasticity Apparatus—*continued.*

X.—Microid Celluloid Specimens for Tension or Compression

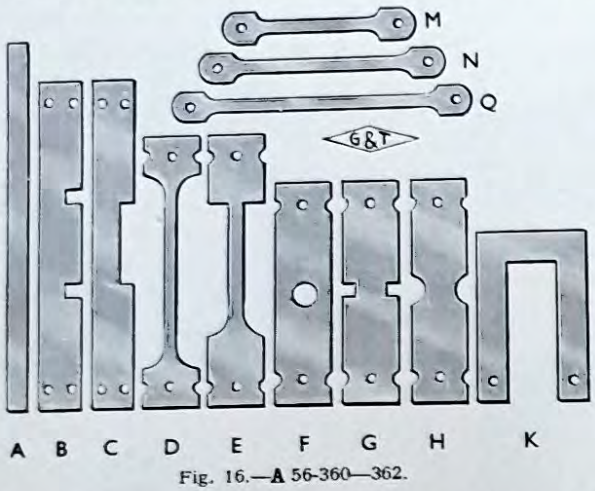


Fig. 16.—**A** 56-360—362.

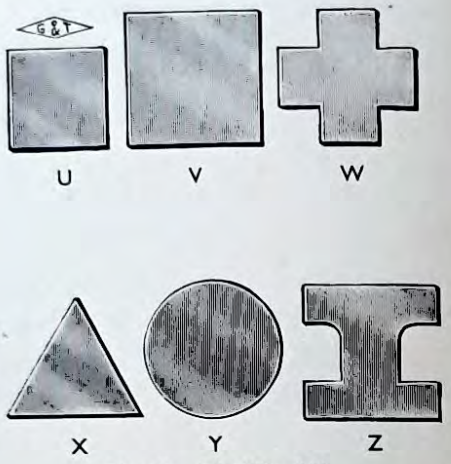


Fig. 17.—**A** 56-370—372.

These specimens, A to Q, Fig. 16, are cut from good quality celluloid sheet and will be found invaluable in introducing the student to the applications of polarised light as well as to the subject of photoelasticity. The straight strip A is for bending in its own plane, between crossed mirrors, to show the neutral axis as a black line bordered by parallel bands of colour, each indicative of the stress.

The notched beams B, C, G and H are intended to be bent in their own plane by gripping the ends between metal strips (Meccano parts are suitable). They may, however, also be stressed in the Tension Frame **A 56-355**, which, for specimens B and C, introduces also some degree of bending. It is thus possible to show the distribution of stress around the notches, and particularly the points of great stress-concentration at the sharp re-entrant angles. The colours first appear at these points and then rapidly pass through several orders.

The narrow tension strip D is designed to give a range of stress suitable for a calibration experiment with the tension frame **A 56-355** and for the determination of the stress-optical coefficient.

Specimens E, F, G and H are also for use in the tension frame, and show the general distribution of stress in several examples of interest in the study of elasticity and strength of materials. Thus E reveals the great difference between the square shoulders and filleted end to a test piece ; F, the effect of a circular hole in a plate under tension, and B and G the effect of notches in a plate under tension.

The strips M, N and Q enable a simple jointed framework to be built up, and the tension in each member to be measured by crossing with the calibrated strip D in the tension frame. Thus three strips, bolted together at one end, afford a novel verification of the triangle of forces. Specimen K is specially suited to show the dark bands in plane polarised light, shifting their position as the specimen is rotated. In circularly polarised light, these disappear (see p. 201).

Specimens U to Z, Fig. 17, are for the compression frame **A 56-365** and illustrate the effect of local or distributed load. They are of good quality stout celluloid and exhibit various important phenomena when observed between crossed mirrors.

PRICES

	£	s.	d.
A 56-305. MICROID SIMPLE POLARISER AND ANALYSER for Students' use, as illustrated and described on p. 193. Two triangular wood blocks with wood rods provided with a pile of plates and with a black glass respectively	*r* 2	17	6
A 56-310. Stand for above about 36 × 10 in. part of **A 56-315** (illustrated on p. 194), with wood pillars, in which the rods of the polariser and analyser can be inserted and locked by means of a thumb screw, and stainless steel rod A for supporting **A 56-340, A 56-355** and **A 56-365**	*r* 3	12	6
A 56-315. MICROID BENCH POLARISCOPE, for Students' use, as illustrated and described on p. 194. Polariser with lamphouse and diffusing screen, analyser with observation hood, mounted on stand and with central stainless steel rod A. Polariser and analyser grooved to accommodate the quarter-wave plate **A 56-350. Without** lamp	*r* 8	0	0
Lamp, Pearl, for above, 100 watt.	See **A 58-350**		
A 56-320. Double Image Analyser for use with above. Exactly as **A 56-330**, but mounted on tripod stand 5½ in. high	*r* 7	5	0

A 56-305—385. **The Microid Polarised Light and Photoelasticity Apparatus**—*continued.*

PRICES (*continued*)

£ s. d.

A 56-325. MICROID PROJECTION POLARISER, as illustrated and described on p. 194. Wood housing containing silvered mirrors and pile of plates for polarising. Mounted on rotatable clamp, supported on heavy conical base, and adjustable for height on stainless steel rod *r* 8 15 0

A 56-330. MICROID DOUBLE IMAGE ANALYSER, as illustrated and described on p. 195. Wood case, rotatable, containing pile of plates and adjustable mirror. Mounted on metal stem $\frac{3}{8}$ in. diam., with tripod stand 12 in. high .. .. *r* 7 5 0

A 56-332. Biconvex Lenses, diam. 10 cm. (see V, p. 195).

Focal length	15	20	30 *cm.*
	20/-	22/-	15/- *each*

A 56-334. Lens Holder, for above, mounted on tripod 12 in. high .. .. *r* 1 4 0

A 56-340. MICROID SLIDE HOLDER AND ROTATOR, as illustrated and described on p. 196. Metal plate 6 × $4\frac{3}{4}$ in. on $\frac{3}{8}$ in. diam. stem with milled rotatable disc and two pairs of slide-carrying clips .. .. *r* 3 12 6

Bosshead, Universal, *Regd. Design No.* 776037 (see Fig. 13), brass, with stainless steel screw for use with **A 56-340** and **A 56-365.** To grip two rods at any angle. Capacity $\frac{3}{16}$ to $\frac{1}{2}$ in. .. .. See **B 19-750.**

A 56-345. MICROID CELLOPHANE SLIDES, as described in detail on pp. 196, 197. Mounted between glass plates $3\frac{1}{2}$ × $2\frac{1}{2}$ in. with bound edges, fast and slow axes marked and path retardation for $\lambda = 5500$ A given.

Slide	A	B	C	D	E	F	G	H	J	K	
r	6/-	4/6	4/6	5/-	4/6	6/6	12/6	7/6	12/6	12/6	*each*

A 56-347. Ditto, Set of 12 slides A 56-345 comprising one each A, B, C, D, G, H, J, K and two each E and F .. .. *r* 4 5 0

A 56-350. MICROID QUARTER-WAVE PLATE, Cellophane, for use with Bench Polariscope and Projection Polariser to produce circularly polarised light for photoelastic and other demonstrations. Mounted between glass plates 5 × $4\frac{1}{4}$ in. with fast and slow axes marked *r* 0 10 0

A 56-352. Holder for above .. .. *r* 0 18 0

A 56-355. MICROID TENSION FRAME, for use in photoelasticity demonstrations, as illustrated and described on p. 197. With metal rod 24 × $\frac{1}{2}$ in. Spring balance reading to 50 lbs. × 1 lb. steps, wheel for applying tension and quick change clamps holding celluloid specimens. Fitted with rigid bosshead for direct attachment of frame to the rod A fitted to the Bench Polariscope .. .. *r* 4 0 0

A 56-360. MICROID CELLULOID SPECIMENS for use in Tension Frame A 56-355, as illustrated and described on p. 198. Sizes ranging from 8 × $\frac{3}{8}$ in. the largest (A) to 3 × $\frac{3}{8}$ in., the smallest (M).

	A	B	C	D	E	F	G	H	K	M	N	Q	
r	1/9	2/6	2/6	3/9	3/9	2/6	2/6	2/6	3/9	3/9	3/9	3/9	*each*

A 56-362. Ditto, Set of 12 Specimens A 56-360 .. .. *r* 1 15 0

A 56-365. MICROID COMPRESSION FRAME for use in photoelasticity demonstrations, as illustrated and described on p. 197. Stout metal frame mounted on $\frac{3}{8}$ in. diam. rod and with screw for adjustment of pressure on specimen .. .. *r* 1 12 0

A 56-370. MICROID CELLULOID SPECIMENS for use in Compression Frame A 56-365, as illustrated and described on p. 198.

	U	V	W	X	Y	Z	
r	1/9	1/9	2/9	2/-	4/-	4/-	*each*

A 56-372. Ditto, Set of 6 specimens A 56-370 .. .. *r* 0 15 0

A 56-375. Celluloid, 2 sq. ft., 2 mm. thick for making tension specimens .. .. .. *r* 0 12 6

A 56-380. Celluloid, 2 sq. ft., 5 mm. thick for making compression specimens .. .. .. *r* 1 7 6

A 56-385. QUARTZ WEDGE about 12 × 40 mm., showing 3 or 4 orders of colour. Cut with thin (10 mm.) edge perpendicular, and tapered side parallel, to optic axis. Mounted at 45° on glass plate $3\frac{1}{4}$ × $2\frac{1}{4}$ in. and protected with cover slip .. *Price on application.*

[*continued overleaf*

A 56-305—385. The Microid Polarised Light and Photoelasticity Apparatus—*continued.*

EXPERIMENTAL NOTES

The apparatus provides for a complete range of experiments on the interference colours shown by doubly refracting substances between crossed or parallel Nicols. The following are suggestive of the many uses of this simple and efficient apparatus. All the experiments should be first projected upon the screen, while explanation is being given, and later repeated by every member of the class using the simple Polariser and Analyser or the Bench Polariscope.

To Set up the Projection System.—First adjust the position of the arc of a good lantern to give a wide parallel beam to the centre of the screen, using, if necessary, one lens only of the lantern condenser. Mount the projection polariser, so that its axis is that of the parallel beam, and adjust to bring the polarised beam again to the centre of the screen. Set up the slide holder, Fig. 10, about 6 in. from the polariser, and the convex lens to focus the holder upon the screen. The lens should be of large aperture to collect as much light as possible (*e.g.* **A 56-332**).

The focal length of the lens (see V, p. 195) and its distance from the screen will determine the size of the image, and the power of the lantern and the darkness of the theatre will determine its brightness. It is essential to have the theatre darkened and all extraneous light excluded from the screen, since, apart from losses due to reflection and absorption, the intensity of the light, being distributed between two images, is always considerably reduced. To cut off stray light from the lantern a large cardboard screen placed at the lens and provided with a suitable aperture will be found useful.

The Double Image Analyser is supported in another stand at the point where the rays pass through a focus, and is adjusted so that all the light reaches the screen when the planes of polariser and analyser are parallel. The reflected image from the analyser will be located above the transmitted image, and may, when required, be brought upon the screen by a slight adjustment of the screw tilting the mirror (see Fig. 7).

This simple projection system gives good results, and is preferred for its teaching value to a system permanently mounted and enclosed. The function of every part will be appreciated by the class and not merely by the operator. Care is necessary in the alignment of the apparatus, and during a demonstration some adjustment may be necessary to keep the field of view uniformly bright.

The Microid Optical Lantern (**A 56-420a**, p. 203), when used with an arc lamp, gives excellent results in projection. The double image analyser, the projection lens, and the slide rotator can be supported in standard feet sliding on the optical bench with which the lantern is fitted. The projection polariser can be supplied mounted on a special foot (*price on application*) for supporting on the same bed. A very convenient arrangement is thus available.

Polaroid.—For the Projection Polariser there may be substituted a sheet of Polaroid supported in the Rotating Slide Holder **A 56-340**, or other suitable support, interposing between the polariser and the condenser one or more sheets of heat-absorbing glass. The beam from the condenser should not be allowed to converge on the Polaroid. A similar arrangement may be substituted for the Double Image Analyser. It should be noted, however, that the second (reflected) image is not then obtained. The interposition of a suitably inclined, plane, unsilvered, glass sheet between the analyser and the projection lens will enable the second image to be obtained.

Expt. 1.—Polariser and Analyser (*a*) parallel and (*b*) crossed.

Show the variation of the intensity of the transmitted light with the angle between the planes of polariser and analyser, rotating first the polariser, then the analyser. Incidentally, the dark field when this angle is 90° proves that a high percentage of polarised light is obtained from the pile of plates. The advantage of a pile over a single black plate may be emphasised, as increasing the amount of plane polarised light, which is a matter of first importance in projection work.

Expt. 2.—Complementary colours shown by Cellophane, or any doubly refracting substance.

Using crossed polariser and analyser, rotate slide E in the slide rotator and note the colour on the screen. This colour disappears when the marked axes of the Cellophane are parallel or perpendicular to the incident vibrations. Rotating the analyser 90° this same effect is observed, except that the colour changes to the complementary. This should be proved by bringing the two images side by side upon the screen, so that they in part overlap. The overlapping portion will be only approximately white on account of the different intensities of the two beams. By covering the stronger (transmitted) beam by a few microscope slides, the intensity may be reduced until a good white is obtained, proving the tints to be complementary.

Expt. 3.—Compensation of path retardation.

With crossed Polariser and Analyser, show two identical slides E, superimposed (*a*) with axes parallel, giving a new colour for double thickness and therefore double phase difference, (*b*) with axes perpendicular, or crossed, giving black. This demonstrates the important principle of subtraction of phase difference, or compensation, when the fast axis in one sheet is superimposed on the slow axis of another.

Expt. 4.—Variation of path retardation and therefore of phase difference and colour, with thickness.

The sequence of colours with increasing phase difference is clearly demonstrated by means of the series of echelon steps (slide G). The range may be extended by superimposing additional sheets. The colours should be named for the first, second and third orders. Crossing the steps with a single sheet of the same thickness (slide B) the colours are all lowered in the scale, and the first step will be black, showing that compensation is complete. In this way the calibrated steps enable the path retardation of any other sheet to be determined. Thus, if crossing with an unknown sheet gave the fifth strip black, the thickness is approximately $5 \times 0{\cdot}3\,\lambda$, or $1{\cdot}5\,\lambda$ path retardation.

Expt. 5.—Geometrical designs.

The geometrical designs in Cellophane will not fail to appeal to the class and to stimulate interest in the subject. By superimposing additional sheets with axes in various directions and rotating the analyser, a fine display of colours may be given. Such a display will prove a great attraction at the school exhibition on open day.

The above experiments may be extended by the addition of a few mica or selenite preparations. The wedge **A 56-385** to show the colours graduated is useful. The theory should be developed along with the experimental work, it being explained that colour is an indication of the phase difference of two plane-polarised waves. Since the velocity of the waves, and therefore phase difference, varies with wave-length, measurement must be made ultimately by spectroscopic analysis. The following method of calibrating the Cellophane steps requires a pair of small Nicol prisms.

Expt. 6.—Measurement of Path Retardation for any wavelength.

Set up and calibrate the scale of a good spectrometer in the usual way. Using a white light source, mount one small Nicol prism in front of the slit and a second, preferably larger, in front of the collimator lens. With the Nicols parallel, adjust for a bright continuous spectrum, then when they are crossed, the field should be nearly black. With the planes of the polariser and analyser horizontal and vertical respectively, insert the echelon slide G close in front of the slit, so that the axis of the Cellophane makes 45° with the horizontal, *i.e.* the steps horizontal. The spectrum will appear, crossed by black bands, for those wavelengths for which the phase difference is $2n\pi$ where n is an integer. The measurement of the wavelength of the bands is rendered more accurate as two or three spectra (for different steps) are seen at once in the telescope, one

A 56-305—385. The Microid Polarised Light and Photoelasticity Apparatus—*continued.*

above the other, the bright spectra above and below, throwing up the dark bands by contrast. Plotting the wavelengths λ of the dark bands against the number of thicknesses of Cellophane, we obtain curves of constant phase difference (δ) from which the thickness per $\delta = 2\pi$, and hence the path retardation per sheet of any wavelength may be read off.

By increasing the number of steps to 20 or 30 thicknesses of superimposed Cellophane, the bands become narrower and more numerous, the readings more exact, and thus an accurate value of the path retardation per sheet may be calculated. The values marked upon the slides have been obtained by a careful series of experiments on these lines. A typical set of readings with slide G is as follows:—

No. of steps	Wavelengths of black bands Å.
1	..
2	..
3	4830
4	6800
5	4400
6	4910
7	5800
8	4480, 6710
9	4930
10	5480
11	4530, 5960
12	4890, 6610

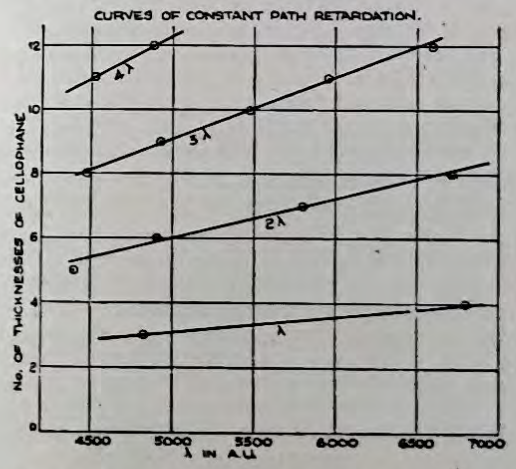


Fig. 18.—Curve showing position of dark bands in spectrum when Cellophane steps are examined between crossed Nicols.

From the graph of these values, for λ = 5500 Å,
thickness for λ path retardation .. .. = 3·32 sheets.
" 2λ " " .. .. .. = 6·68 "
" 3λ " " .. .. .. = 10·06 "
$\therefore$ Mean $= \frac{20{\cdot}06}{6}$ .. .. = 3·34 sheets per λ,
i.e. $\frac{1}{3{\cdot}34}$ = **0·300 λ per sheet.**

For other wavelengths the path retardation is as follows:—

Wavelength	4500	5000	5500	6000	6500 Å
Path retardation per sheet	0·365	0·328	0·300	0·273	0·250 λ

CIRCULARLY POLARISED LIGHT.—The accurate measurement of the path retardation per sheet for many different grades of Cellophane and similar products has indicated a means of providing good quarter-wave plates of large size at reasonable cost. Two sheets of different thickness are crossed, so that the selected combination has a path retardation given in the following table:—

Wavelength	4500	5000	5500	6000	6500 Å
Path retardation	0·308	0·277	0·253	0·232	0·215 λ

It is thus possible to set up a photoelastic bench having a beam of circularly polarised light equal in cross-section to the aperture of the polariser and to carry out interesting demonstrations in photoelasticity.

The extensive use of circularly polarised light in photoelasticity depends upon the following consideration. When circularly polarised light is incident upon Cellophane or any doubly refracting substance, two waves of equal amplitude are transmitted, *whatever the orientation of the substance*, and acquire the phase difference characteristic of the thickness. A second $\lambda/4$ plate compensates for the $\pi/2$ phase difference of the first.

Expt. 7.—Production of circularly polarised light.

Insert the large $\lambda/4$ plate into the slots in the exit aperture of the polariser. Rotate the analyser and show that the light now passes through for all positions of the analyser, though with slight variations and a certain amount of colour, due to the plate not being quarter-wave for all wavelengths simultaneously. Note that the fast axis of the $\lambda/4$ plate must be at 45° to the incident vibration. If 45° **clockwise,** looking along the direction of the light, the vector in the circularly polarised wave is rotating in the clockwise direction, and *vice versa.*

Demonstrate that a second $\lambda/4$ plate in front of the analyser, and crossed with respect to the first, restores the dark field for crossep polariser and analyser. Two $\lambda/4$ plates with axes parallel give a half-wave plate. Note the variations of colour and intensity as the analyser is rotated.

Expt. 8.—Cellophane in circularly polarised light.

Set up a slide between crossed quarter-wave plates, and rotate in the slide holder. The colours now remain constant upon the screen and no longer disappear every 90°. This circular polariscope has important applications in photoelasticity.

APPLICATION OF PLANE AND CIRCULARLY POLARISED LIGHT TO PROBLEMS OF STRESS DETERMINATION

The apparatus provides for the demonstration of the fundamental principles of photoelasticity and for a few simple measurements. The experiments may be first projected upon the screen and then repeated individually with the Bench Polariscope.

When a plane polarised wave falls upon celluloid under stress, two component waves, each changed in speed by an amount proportional to the stress, are transmitted with vibrations along the perpendicular directions of the two principal stress components P, Q. The waves thus acquire a phase difference proportional to the difference of the principal stresses, and interference colours are, therefore, shown, the colour being a measure of the difference P — Q. The colours will be brightest when P and Q make 45° with the incident vibration. They vanish when P or Q are parallel to this direction, since, in this case, the incident wave passes through unresolved.

Expt. 9.—Calibration Experiment and determination of stress-optical coefficient.

Insert the strip of celluloid D in the tension frame. The frame should be supported in a heavy stand, so that the specimen occupies the position formerly occupied by the slide holder. First show that, as stress is applied, colour appears, only when the direction of the strip is other than parallel or perpendicular to the incident vibrations; in other words, the axis acquired (the "fast") is along the lines of tensile stress. This fact may be established by crossing with a plate of Cellophane upon which the fast axis is marked.

[*continued overleaf*

A 56-305—385. The Microid Polarised Light and Photoelasticity Apparatus—*continued.*

To investigate the variation of phase difference acquired with the applied stress, cross the strip with the calibrated steps of Cellophane, and adjust the tension till each step in succession is black. The steps on either side of the black one show symmetrical colours, and this assists adjustment. Plot a graph of phase difference (or number of steps) against tension. A straight line is obtained, proving that phase difference acquired is *proportional* to applied stress. The celluloid may show slight initial colour due to permanent strain; take, therefore, the slope of the straight line to calculate the stress-optical coefficient C defined by the equation, $r = CTd$, where r = path retardation per thickness d of celluloid under tension T. Adopting, with Professor Coker, the unit for C of 10^{13} dynes/cm., the value for celluloid is about 13.

A typical set of readings is given below :—

Echelon Cellophane steps 0·30 λ (slide G or H) crossing celluloid specimen D in tension.

No. of steps	Tension (lbs.)
1	6
2	18
3	31
4	42
5	54

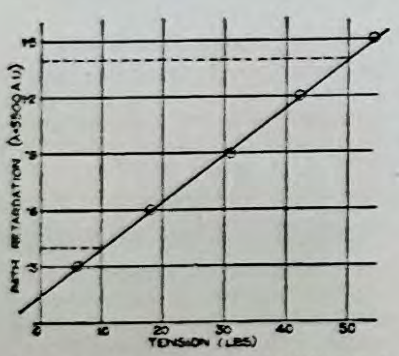


Fig. 19.—Curve showing that path retardation is proportional to tension.

These values are plotted (Fig. 19), and from the mean straight line, the slope, *or* tension per λ path retardation, = 40·0 lb. (Note that the strip in this experiment shows slight initial path retardation.)

Cross-section of strip = 0·21 × 0·44 cm.

$$\therefore C = \frac{5500 \times 10^{-4} \times 0{\cdot}21 \times 0{\cdot}44}{40{\cdot}0 \times 454 \times 981 \times 0{\cdot}21} = \mathbf{13{\cdot}6\ brewsters.}$$

The calibration curve may be interpreted in terms of colour. Thus a tension of 40 lb. produces the purple at the end of the first order. Therefore in any specimen of the same thickness and quality of celluloid this purple always indicates a difference of principal stresses of

$$P - Q = \frac{40 \times 2{\cdot}54^2}{0{\cdot}21 \times 0{\cdot}44} = 2790 \text{ lb./sq. in.}$$

The blue of the second order, for which the path retardation is 1·2 λ is equivalent to :—

2790 × 1·2 = 3350 lb./sq. in. and so on.

Expt. 10.—Distribution of stress in models.

The distribution of stress in a few typical cases may be shown qualitatively. Thus, specimen F may be subjected to tension in the frame, omitting the spring balance so that greater stresses may be applied with a few turns of the thumb-screw. Note the points of great stress concentration at either side of the hole, where the colours first appear, and rapidly run through several orders. The colour everywhere is an indication of the difference of principal stresses P — Q and, from the colour scale of the calibrated tension strip, the values of the difference may be roughly estimated. Some regions will appear black on the screen (with crossed polariser and analyser). This is for one or other of two reasons : Either (*a*) the stresses P and Q are equivalent, or (*b*) they are parallel and perpendicular to the incident vibration. If the latter, they will remain black. Now insert the two quarter-wave plates and note that the black areas disappear except where P and Q are equal. The colour everywhere now indicates the stress difference P — Q, whatever their directions.

The stress distribution in specimens B, C, E, G, etc., may be shown similarly.

Expt. 11.—Stresses in bent beams.

These are shown by supporting or clamping the ends between metal strips and, if measurement is required, deflecting the centre by means of weights or a spring balance. Note the bands of colour along the length, and the neutral axis revealed as a central black line. The stresses at a point of contra flexure may be easily shown by clamping both ends of a beam and deflecting the centre. Again, by supporting the beam at points one quarter of its length from the centre, and depressing the ends, circular bending is demonstrated, the bands of colour in this case running parallel throughout its length. By crossing the beam with a slide of known retardation and adjusting the deflecting force till the black line is at the extreme edge of the beam, the stress there is obtained from the calibration curve of path retardation against stress. This, together with the radius of curvature and the depth of the beam, gives Young's Modulus for celluloid.

The distribution of stress in the notched beams may, in a general way, be demonstrated similarly. So also the stress in the specimen K straining the free ends together and clamping. At any particular point, the directions of the principal stresses P and Q may be determined by rotating either the specimen or the polariser and analyser until, at the point in question, the field is black. Then the stresses are parallel to the planes of the crossed polariser and analyser. The magnitude of the difference P — Q may be estimated from the colour when the incident vibration makes 45° with the principal stresses; or, more exactly, by crossing with the calibrated strip D in the tension frame and adjusting tension for compensation.

Expt. 12.—Stresses in a jointed framework.

The stresses in the various members of a simple jointed framework may be determined photoelastically. The simplest of all, three meeting at a point, shows the method. Three strips, M, N, Q, are loosely bolted together at one end, the free ends attached to three different points of a rigid Meccano frame and a threaded rod with nut, employed to apply tension to one member. The stresses induced are easily measured by compensation with the calibrated strip in the tension frame, the angles between the members by drawing their trace on paper. Thus the triangle of forces may be verified in a novel way.

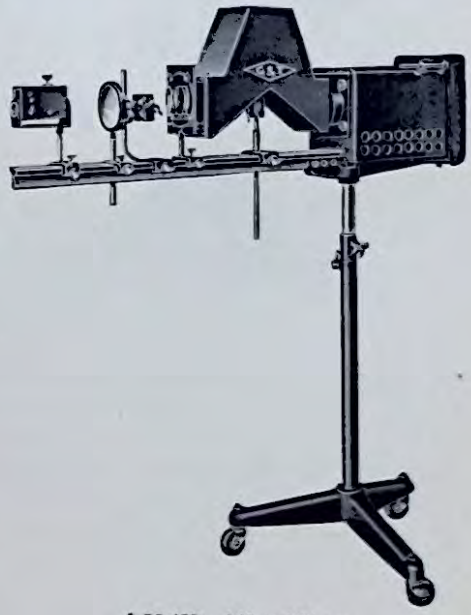
These experimental notes are by no means exhaustive. Many variations will present themselves at once to the teacher, as for example, the effect obtained by the rotation of polariser or analyser or both together; the use of circularly polarised light and of an additive sheet of Cellophane to brighten up all the colours in the photoelastic demonstrations; and the demonstration of methods of testing manufactured glassware for strain.

THE MICROID PROJECTION PHOTOELASTICITY APPARATUS

An efficient and convenient assembly for quantitative demonstration of the principles of photoelasticity

The Microid Polarised Light and Photoelasticity Apparatus described on pp. 193-202 aroused interest in the Engineering Departments of Universites and Colleges, where the need of simple and efficient apparatus for quantitatively demonstrating the principles of photoelasticity was long-felt. This present set-up, first introduced at the Physical Society's Exhibition in 1936, received very favourable notice (*J. Sci. Inst.* 1936, 13, 66). Since that time Polaroid has become generally available; and although, for its educational value, the apparatus is here listed in the form originally described, a note is given on p. 200 on the adaptation of it to employ Polaroid.

The phenomena of polarisation and of photoelasticity are projected with exceptional brilliance in images up to 5 ft. in diameter. A mercury vapour lamp has been employed for monochromatic quantitative work. If desired, a permanent record of the behaviour of interesting specimens under stress may readily be preserved by employing a photographically sensitised receiving screen suitably focussed to produce an image of the required size.



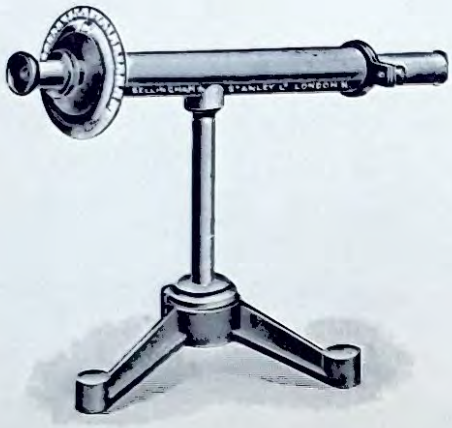
A 56-420.—140 × 130 cm.

SPECIFICATION

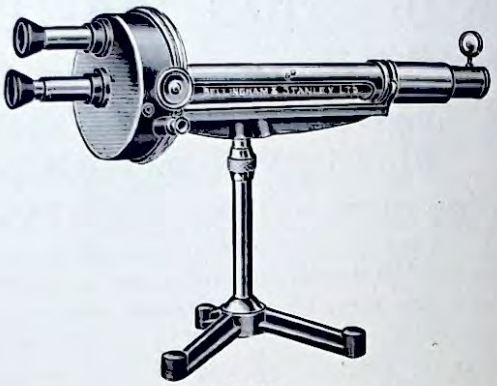
The light source consists of an arc lamp mounted in a well-ventilated lamphouse supported on a stem adjustable for height and transportable on ball bearing casters of generous dimensions. The lamphouse is fitted with a condenser and an asbestos curtain having a coloured transparent window for observation of the arc. An optical bench of special T-section extruded brass bar, 3 ft. long, attached to the lamphouse enables the optical accessories precisely to be located and easily adjusted on the bed. The components shown in the illustration are (left to right) double image analyser, projection lens, compression frame for stressed celluloid specimens, slideholder and rotator for Cellophane slides, and projection polariser. Each component is mounted on a sliding foot by which it may readily be clamped to, or moved along, the bed. These, and other, components are described in detail under the Microid Polarised Light and Photoelasticity Apparatus, see pages 193-202.

		£ s. d.
A 56-420. MICROID PROJECTION PHOTOELASTICITY APPARATUS, complete equipment for projection demonstration of polarisation and photoelastic phenomena as follows (see pp. 193-198 for detailed descriptions)		£74 8 0
A 56-420 a.	**MICROID Optical Lantern,** on tripod foot with casters, arc lamp, optical bench, etc.	£33 10 0
,, ,, **b.**	**Projection Polariser** with extra heavy sliding foot	£8 0 0
,, ,, **c.**	**Slide Holder** and Rotator	£3 12 6
,, ,, **d.**	**Sliding Foot,** extra heavy, with rod support for **A 56-420 n-t**	£1 12 0
,, ,, **e.**	**Projection Lens,** 20 cm. *f.* and holder with large light shield	£2 0 0
,, ,, **f.**	**Double Image Analyser,** without tripod foot	£6 15 0
,, ,, **g.**	**4 Sliding Feet** for optical bench	£2 8 0
,, ,, **h.**	**1 Set 12 Cellophane Slides**	£4 5 0
,, ,, **k.**	**2 Quarter Wave Plates**	£1 0 0
,, ,, **m.**	**1 Special Holder** for above	£0 18 0
,, ,, **n.**	**Tension Frame**	£4 0 0
,, ,, **q.**	**1 Set 12 Celluloid Specimens**	£1 15 0
,, ,, **t.**	**Compression Frame**	£1 12 0
	Universal Bosshead	See **B 19-750**
,, ,, **v.**	**1 Set 6 Celluloid Specimens**	£0 15 0
,, ,, **w.**	**Celluloid,** 2 sq. ft., 2 mm. thick	£0 12 6
,, ,, **x.**	**Celluloid,** 2 sq. ft., 5 mm. thick	£1 7 6

Any of the components in the above list may be omitted at a corresponding reduction in price.



A 56-530.

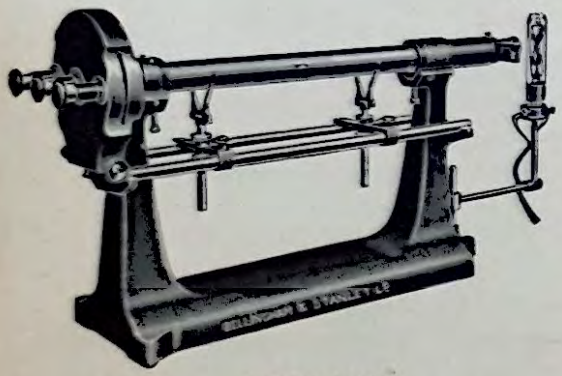


A 56-535.

£ s. d.

A 56-530. POLARIMETER, with circle reading by vernier to 0·1°. The polarising system can be supplied suitable for use with sodium light, or with a bi-quartz plate for use with white light. Tubes up to 200 mm. long can be used. Mounted on stand. **Without** tube *tx* **16 16 0**

A 56-535. POLARIMETER, Half-Shadow, for use with monochromatic light. Divided circle on glass, with small drum reading to 0·05°. A slow motion screw adjustment and clamp is provided. A revolving cover is fitted and the instrument is adjustable for height and direction. With one tube 200 mm. long .. .. *tx* **49 18 3**

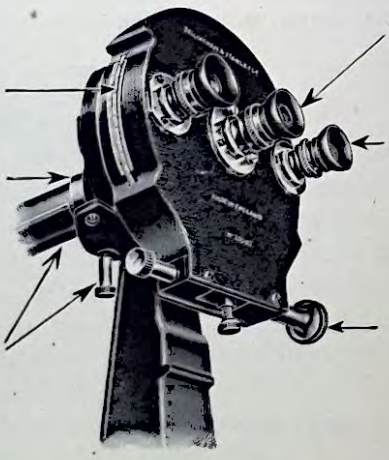


A 56-545 + 550 b.

Divided glass circle, reading to 0·01° by double vernier.

Circle centre on ball bearings.

Easily removable tube trough.



Stationary observation telescope arranged to take filter or spectroscopic eyepiece.

Circle reader giving enlarged image of scale and vernier by light transmitted through the circle.

Slow motion adjustment always in action without clamping circle.

A 56-545.

£ s. d.

A 56-545. POLARIMETER, with glass circle, of modern design, suitable for tubes up to 400 mm. long, as specified below .. .. *tx* **128 2 3**

A 56-548. Ditto, with illumination source attached.

With ..	Electric Sodium Lamp (and resistance).	Gas Sodium Lamp.	Electric Mercury Vapour Lamp (and choke) for A.C. only.
	tx **£141 18 6**	**£136 7 6**	**£141 16 6** *each*

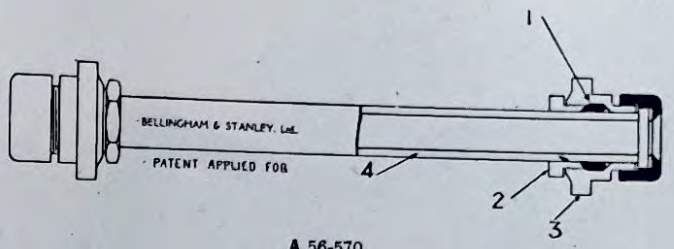
The instrument is solidly constructed and is fitted with glass circle and verniers reading to 0·01°, with scales etched indelibly into the glass.

The transparency of the scales allows the divisions of the circle and verniers apparently to touch, thus eliminating parallax and enabling readings to be taken more readily and with greater accuracy. The glass circle is incorrodible and is illuminated by transmitted light. It is carried on ball bearings, and so arranged that the slow motion adjustment can be brought into action without first clamping the circle.

The polariser is constructed without cement, and the instrument can therefore be used for ultra-violet investigations. The observation telescope does not rotate with the circle, a great advantage when rotatory dispersion measurements are being taken with a spectroscopic eyepiece.

Accessories for Polarimeters A 56-545—548

		£ s. d.
A 56-550 a.	**Levelling Screws** .. .. *tx*	3 16 0
„ „ **b.**	**Rods and Vee Supports,** as illustrated .. .. *tx*	8 8 0
„ „ **c.**	**Spectroscopic Attachment,** including polariser slit .. .. *tx*	11 0 0
„ „ **d.**	**Analyser,** for ultra-violet work, consisting of quartz fluorite objective and prism, in mount *tx*	16 15 2
„ „ **e.**	**Quartz Plates,** left and right, matched, for observation tubes .. .. .. *pair tx*	4 1 6

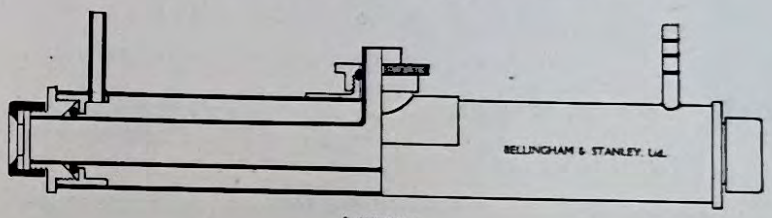


A 56-570.

A 56-570. Polarimeter Tubes, for use with **A 56-530—548.** Ends (2 and 3) easily detachable for renewal of glass tube (4). Fitted with packing glands (1), and hexagonal ends to prevent rolling.

Length ..	100	200	220	400	600	*mm.*
tx	£1 6 0	£1 6 0	£1 6 0	£1 8 0	£1 13 6	*each*
A 56-575. Spare Glass Tubes *tx*	12/9	12/9	12/9	14/6	20/3	*each*

Tubes with bulb for bubble 1/2 *each extra.*



A 56-580.

A 56-580. Inversion Tubes, cementless, water jacketed.

Length ..	100	200	220	400	600	*mm.*
tx	£6 13 6	£6 13 6	£6 13 6	£7 6 6	£8 12 0	*each*

	£ s. d.
A 56-590. Cover Glasses for polarimeter tubes, **A 56-570,** 15·5 mm. diam., not optically worked *dozen*	0 10 0
A 56-595. Rubber Washers, 15·5 mm. diam. .. .. *dozen*	0 1 6

A 56-805. EYE, Model, three times enlarged, 3½ in. high, showing muscles and optic nerve; mounted on pedestal; not dissectible .. *r* 2 0 0

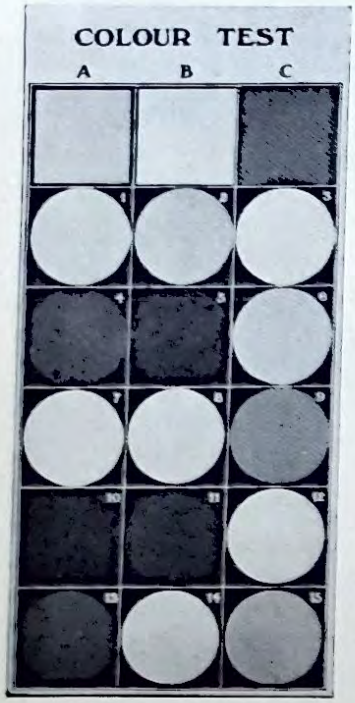
A 56-810. Ditto, fully dissectible, showing cornea, iris, lens, vitreous humour, sclerotic, choroid, retina, optic nerve, etc. .. .. *r* 6 5 0

A 56-815. EYE, Model, three times enlarged, 3½ in. high, with portion removable to show on the retina an inverted image of a small model, the ray paths being indicated by fine wires passing through the lens. Distance from object to image 12 in. .. .. .. *r* 4 0 0

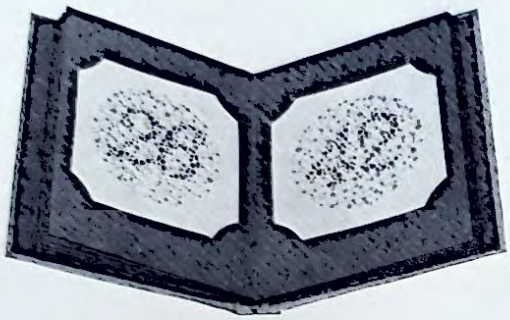


A 56-805—810.

Customers abroad indenting through an agent would oblige by quoting our name and address in full, and sending a copy of order direct to us.



A 56-840.



A 56-850.



A 56-860.

A 56-840. COLOUR TEST CHART (Jennings: *Colour Vision and Colour Blindness*), stout card 21 × 10 in. The method of procedure is printed on the reverse side of the chart as below .. .. £ s. d. 0 6 0

KEY TO COLOURS

A. Light Green.
B. Rose.
C. Bright Red.
1. Fawn or Brown Drab.
2. Grey-Drab.
3. Yellow.
4. Med. Blue.
5. Violet.
6. Green.
7. Orange.
8. Pink.
9. Brown.
10. Dark Blue.
11. Dark Red.
12. Yellowish Green.
13. Red.
14. Mauve.
15. Light Blue.

DIRECTIONS FOR USE

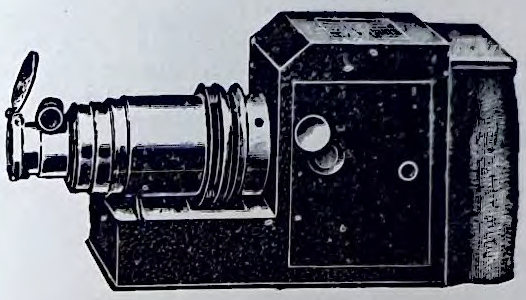
Test 1.—Those undergoing examination are requested to select the colours on the chart which resemble the colour marked A. Failure to do so correctly indicates defective colour perception. Those completely colour blind to red or green will choose in addition fawn, grey-drab, pink or yellow.

Test 2.—For this test, which determines whether red or green blindness is present, the colour marked B is used. The red-blind will select blue, violet or mauve. The green-blind will select green or grey. The blue-blind will select red or orange.

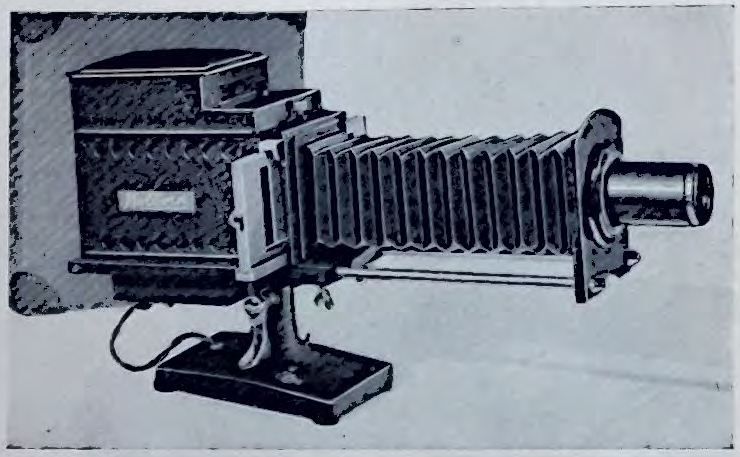
Test 3.—For this test the colour marked C is used. The red-blind will select the darker shades of red, brown or green. (Darker than the test colour.) The green-blind will select the lighter shades of blue or green. (Lighter than the test colour.)

A 56-850. COLOUR BLINDNESS TESTS, Ishihara. General principle:—Superimposed on a mosaic background of dots there is printed, also in mosaic form, a design, *e.g.* a numeral in another colour. The test consists in the ability to distinguish the numerals from the background. The series is of 32 plates bound in book form. Reveals quickly and accurately the most common form of colour blindness—congenital. Adopted as a standard test by Service authorities. The many colours used necessitate more than 60 printing operations. With booklet of instructions .. .. £ s. d. *tx* 2 10 0

A 56-860. COLOUR BLINDNESS TEST, Holmgren (Jennings: *Colour Vision and Colour Blindness*). Contains 49 skeins of coloured wool, 3 to be matched and 46 for matching. In box with full instructions .. .. *p* 0 15 0



A 57-210.



A 57-220.

£ s. d.

A 57-210. OPTICAL LANTERN, 6 in. centre. Welded steel body 16 in. long, 5½ in. wide, 10¾ in. high, finished in black crystalline enamel, with ventilated top and large door. Nickel plated sliding tube and objective with Petzval lens. Hinged door at back covers three-quarters of the opening so that the curtain shown in the illustration is not necessary and is not supplied. Condenser mount fitted with 4½ in. diam. optically worked plano-convex lenses.

Objective, focus	6 or 8	10, 12, 14, 16 *in.*
Without Purchase Tax	*t* £13 2 6	£13 17 6
(Purchase Tax, if chargeable, extra)	*tx* £2 18 4	£3 1 8

The above lantern is designed to take Focuslite Outfits **A 58-605—615** and is suitable for use with either 250 or 500 watt lamps.

A 57-220. PROJECTION OPTISCOPE, for lantern slide projection. Max. projection distance 50 ft. at which distance a picture approx. 10 ft. square is obtained. Metal body, well ventilated, hinged back, on solid cast base, with tilting and locking device, and switch. Complete with slide carrier, Petzval lens 8, 10 or 12 in. focus (*please state focal length required*), condenser 4½ in. diam., lead and plug, linen-lined leather bellows, pre-focus lamp holder adjustable for various foci lenses. Fibre carrying case with handle. **Without** lamp (Class A1 pre-focus, 250 or 500 watt projector type **A 58-450**). *Without Purchase Tax* *t* **19 11 9**

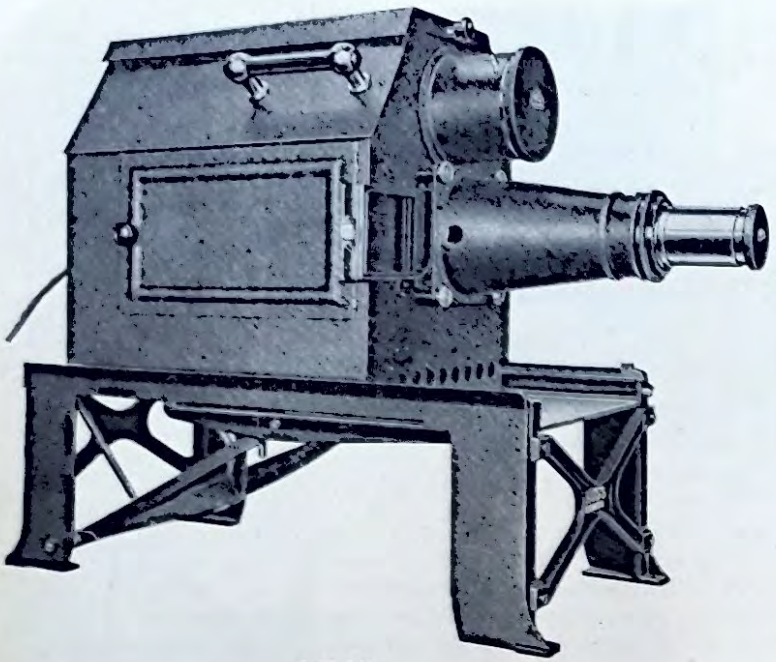
(Purchase Tax, if chargeable, extra *tx* **£3 16 9)**

LANTERN LENSES

Table showing at a glance the Focus of Lens required to give a certain size picture at a given distance from the screen

Screen Distance (feet)	Focal length of Lens (inches)							
	6	8	10	12	14	16	18	20
10	5·0	3·9	2·11	2·6	2·2	1·10	1·8	1·6
12	6·0	4·6	3·6	3·0	2·6	2·3	2·0	1·9
15	7·6	5·8	4·4	3·9	3·1	2·9	2·6	2·3
20	10·0	7·6	5·10	5·0	4·3	3·9	3·4	3·0
25	12·6	9·4	7·4	6·3	5·2	4·8	4·2	3·9
30	15·0	11·3	8·9	7·6	6·3	5·7	5·0	4·6
35	17·6	13·1	10·3	8·9	7·3	6·7	5·10	5·3
40	20·0	15·0	11·8	10·0	8·3	7·6	6·8	6·0
45	22·6	16·10	13·2	11·3	9·4	8·5	7·6	6·9
50	25·0	18·9	14·8	12·6	10·4	9·4	8·4	7·6
60	30·0	22·6	18·0	15·0	12·11	11·3	10·0	9·0
80	40·0	30·0	24·0	20·0	17·3	15·0	13·4	12·0
100	50·0	37·6	29·3	25·0	21·7	18·9	16·8	15·0

Size of Picture (feet and inches)



A 57-240.

A 57-240. PROJECTION EPIDIASCOPE, Ross, "Standard." Designed for operation at screen distances from 12 ft. to 50 ft., giving picture sizes from 3 ft. 9 in. to 17 ft. 2 in. Sheet metal lamphouse 16¼ × 12¾ × 16 in. high. With 17 in. focus wide aperture episcopic lens and 10½ in. diascopic lens. Slide carrier taking both English and Continental size lantern slides. 15 ft. 3-core rubber-covered cable. **Without** projection lamp.

No Purchase Tax .. .. *t* **£59 10 0**

A 57-243. Episcope only from above, i.e. **A 57-240** without diascopic lens and mount .. .. *tx* **£46 0 0**

A 57-245. Lamp, projection, 1000 watts.
(*Please state voltage when ordering.*)

No Purchase Tax .. .. *t* **£1 12 0**

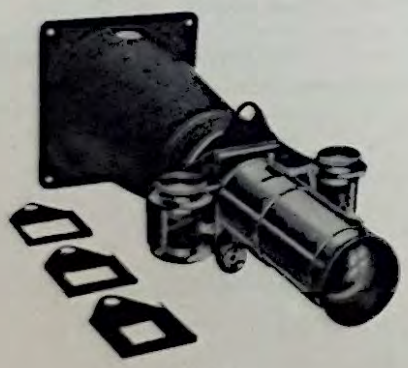
The large blacked sheet metal lamphouse has a specially designed system of ventilation, and is provided with a hinged door at side. Metal slide carrier fitted with automatic lifting action, and takes both English and Continental size lantern slides. Focussing adjustment is fitted to both lenses and a clamping device for lenses when their best positions have been found. The 1000 watt projector lamp, in adjustable lamp holder, is contained within a "light-house" unit consisting of pedestal mount carrying the reflectors, and two condenser lenses to give the utmost illumination to the opaque object. Removable heat-resisting glass plate, sliding in grooves under lamphouse keeps objects flat and in position. Object aperture 6 × 6 in. A tilting device actuated by screw in front of the epidiascope alters the angle of the mirror to correct the definition should it be necessary to tilt the epidiascope.

The undercarriage is of girder construction ensuring complete rigidity. The platform which can be raised and lowered by a lever, is of ample proportions to accommodate large or deep solid objects, exceptionally large objects can be placed directly on the table upon which the epidiascope stands.

A heavy black cloth curtain clips into position round the front half of the undercarriage and prevents stray light entering the room when the platform is lowered. A metal pointer with universal movement is fitted, by means of which the operator can draw attention to any part of the object.

The lamphouse with lamp, condenser lenses, mirrors and projection lenses forms a complete unit and is detachable from the undercarriage, a wood handle being attached to each side of the lamphouse for convenience in lifting. The body will slide along the undercarriage so that the full length of large pictures, maps, etc., can be projected.

The change over from epi- to diascopic projection and *vice versa* is very simple and is effected immediately by a small lever.

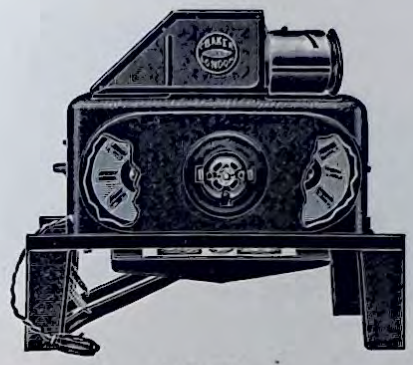


A 57-260.

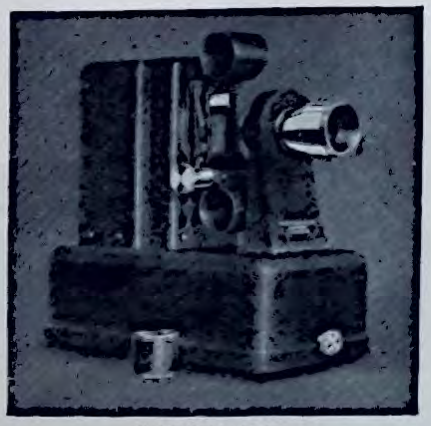


A 57-265.

	£	s.	d.
A 57-260. Film Strip Attachment, for **A 57-240,** for projecting pictures on 35mm. film strip. With 3¾ in. focus, *f* 2·75 projection lens in helical focussing mount, set of 4 masks to enable various picture sizes to be used and arrangement to take 2 × 2 in. slides. *No Purchase Tax* *t*	11	18	0
A 57-265. MICROSCOPE ATTACHMENT for A 57-240, with one Objective, either 1¼ or 2½ in. focus. (*We supply with 1¼ in. objective unless otherwise ordered.*) .. .. *No Purchase Tax* *t*	11	5	0
A 57-270. Microscope Objective, 1¼ or 2½ in. focus. .. .. .. *No Purchase Tax, each* *t*	2	9	0



A 57-280.



A 57-350—355.

EPIDIASCOPE, "British," for operation at 18–25 ft. range. The same objective is used for both epi- and diascopic projection so that its finely corrected qualities give exceptional results when projecting lantern slides. Two exhausting fans driven by a single electric motor, operate immediately the lamps are switched on, cooling the interior so that valuable subjects are not harmed. Two 500 watt silvered back projection lamps with condenser and mirror systems give even and concentrated illumination. Pointer in ball fitting enables attention to be directed to any part of the picture. Coloured glass window in side for viewing subject without danger to eyes. First-surface silvered mirror coated with protective emulsion, enclosed within epidiascope body.

Objects up to 6 in. square can be projected direct without any movement of the epidiascope over the under-carriage, the instrument is however capable of sufficient movement to cover illustrations up to 17 in. wide, with unlimited movement in length. The body can be removed from the under-carriage and moved about at will over exceptionally large areas. The under-carriage includes an adjustable platform which can be lowered 4 in. to enable the surfaces of large three-dimensional objects to be projected. The conversion from epi- to diascopic projection and *vice-versa* is by simple movement of a lever.

When operated on 200 volt mains supply the epidiascope takes only 5 amps, so that the ordinary lighting circuit can be used. The motor fitted is of the universal type.

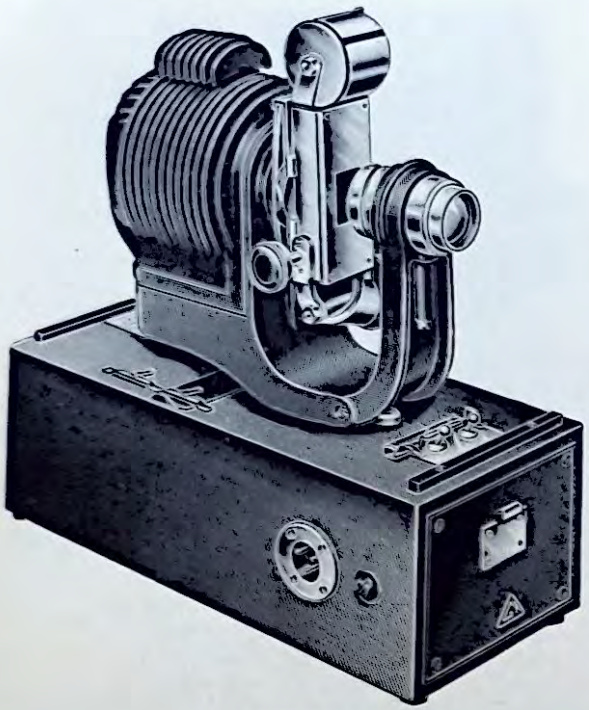
	£ s. d.
A 57-280. EPIDIASCOPE, "British," with motor driven dual exhausting fans, under-carriage with adjustable platform, etc., as described above. **Without** lamps. *No Purchase Tax* †	75 0 0
A 57-285. EPISCOPE, specification as for **A 57-280,** but without facilities for projecting lantern slides. **Without** lamps. .. .. *No Purchase Tax* †	60 0 0
A 57-290. Lamps, projection, for **A 57-280—285,** 500 watts. .. .. *Without Purchase Tax* †	1 15 0
(Purchase Tax, if chargeable, extra ‡x	0 9 1

A 57-350. FILM STRIP PROJECTOR, lightweight, portable instrument, of all-metal construction, for the projection of film strips up to 40 × 28 mm. With condenser, and 3 in. focus single achromatic objective giving a brilliant picture 7 ft. wide at a distance of 15 ft. from the screen, or 6 in. focus objective giving same size picture at double the distance. Fitted with 12 volt 24 watt lamp and resistance for operation on 100 and 250 volt A.C. and D.C. mains. Mounted on metal base with switch and screw adjustment for angle of inclination. Rotatable gate for projecting vertical or horizontal pictures.

Objective, focus	3	6	*in.*
Without Purchase Tax	† £10 10 0	£10 10 0	
(Purchase Tax, if chargeable, extra)	‡x £2 12 6	£2 12 6	

A 57-355. Ditto, as **A 57-350,** but with transformer for operation on 100 and 250 volt A.C. mains.

Objective, focus	3	6	*in.*
Without Purchase Tax	† £11 11 0	£11 11 0	
(Purchase Tax, if chargeable, extra)	‡x £2 17 9	£2 17 9	



A 57-400.

A 57-400. FILM STRIP PROJECTOR, Portable. New design, with special heat radiation and optical systems giving a particularly brilliant image. With rotating turret, which, in conjunction with the interchangeable masks, enables standard size Cine frames (24 × 18 mm.) and Leica frames (24 × 36 mm.) to be shown. The film is automatically rewound. In portable carrying case with built-in mains transformer, spare heat filter, flex and adapter, slide carrier (2 in.), lamp 10 volt 75 watt. *Without Purchase tax* .. ..*tx* **30 0 0**

Purchase tax (if chargeable) .. ..*tx* **4 0 0**

£ s. d

A 57-402. Lamps, spare, for above.

Volts × watts	10 × 7·5	100 × 100	200–250 × 100
Cap	A.S.C.C.	Prefocus.	Prefocus.
(*a*) *tx*	**9/5**	**14/10**	**13/7**

Please state voltage when ordering.

SPECIFICATION

The Film Strip Projector is mounted on a base, 15 × 6½ × 5½ in., provided at each end with drawers. A light wooden cover provided with a spring-loaded handle is supplied, to be placed over the instrument for convenience in carrying. Total weight 25 lbs.

The Projector is designed to operate on mains voltage either A.C. or D.C. In the front drawer a built-in transformer is provided, adjustable, 200–250 volts, stepping down to 12 volts and over-running the lamp by 2 volts. On D.C. the transformer is not used and the current supply is fed direct to a mains voltage lamp.

Switching.—On the front of the base two switches are provided equipped with a sliding bar engraved "12 volts" and "Direct." When operated from A.C. the bar should be slid to the position where the inscription "12 volts" is exposed, which will then leave the A.C. switch free for operation. The converse applies on D.C. If the instrument is operated on A.C. with the "Direct" inscription exposed, the fuse will blow.

Lamps.—A 10 volt, 75 watt sound film exciter lamp with A.S.C.C. prefocus cap is normally employed in an adapter, which can be removed to take a Class A1 projector mains voltage lamp of suitable type with cap. A car battery can be used to run the low voltage lamp. This lamp is recommended on the grounds of efficiency. Its approximate light output on 10 volts is 1,575 lumens; that of a 100 volt, 100 watt Class A1 lamp is 1,650 lumens and of a 200–250 volt lamp 1,300 lumens.

Film Strip Operating Mechanism.—This is a self-contained unit readily removable from a rectangular plate, which is rotatable on the condenser housing. The film to be projected should be loaded into the top cassette, fed between the two glass pressure plates in the gate, down the film track on to the sprocket wheels of the rotating spindle, through the reversing scroll and into the bottom cassette, where it is rewound.

Gate.—The glass pressure plates and film track retain the film in the correct position when the gate is closed. The winding knob is mounted on a spindle which can be slid along its axis to one of three positions:—(*a*) each click of the knob forward projects one frame, (*b*) each click projects two frames, (*c*) the clicking device is disconnected and the winding mechanism operates freely, so that the film can be correctly centred in the gate before the automatic control is used.

Picture Size.—The lens is mounted in a spring-loaded helical track for focussing. At a projection distance of 15 ft. with single frames the picture size is about 3 × 2¼ ft. A tilting device is mounted on the projector to enable the image to be raised or lowered on the screen.

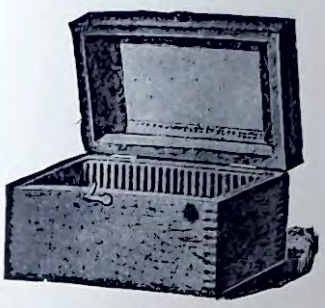
Condenser Lens.—4 lenses are mounted in a cell together with a tinted glass heat filter. The film can be projected for an indefinite period without danger of overheating.

Fuse.—A 3-amp. car type fuse is fitted in the side of the base. On mains voltage a 3-amp. fuse is used. When operating the lamp from 12 volt D.C., a 10-amp. fuse should be substituted.

Masks.—35 mm. film strips are available in both single and double frame size. Single frame is 24 × 18 mm., double frame is 36 × 24 mm. A much larger picture size is obtained from the double frame when projected from the same distance and this will, therefore, be found the most useful size when projection distance is limited. Two black metal masks are held in spring clips on the base, from which they may be readily removed and inserted in the film strip operating mechanism.

Case.—The cover is secured to the base by two clip fasteners. A drawer in the projector base accommodates slide carrier, spare lamp and spare fuse, and the adapter and flex issued with the projector.

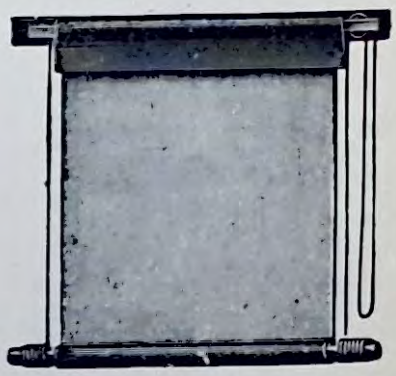
Slide Carrier.—By replacing the film strip mechanism with this attachment, 2 in. slides can be shown. The slide carrier is readily attached to the rectangular plate, in its horizontal position, so that the groove on which the slides rest is at the lower side.



A 57-605.



A 57-620.



A 57-630.

A 57-605. BOXES, Lantern Slide, Storage, for slides $3\frac{1}{4} \times 3\frac{1}{4}$ in., grooved, well made, dove-tailed, whitewood.

To hold	50	100 *slides*
	p 14/6	25/- *each*

£ s. d.

A 57-620. CARRIER, Lantern Slide, Double, mahogany, for slides $3\frac{1}{4} \times 3\frac{1}{4}$ in. The slides are automatically raised in the frame when the latter is withdrawn .. .. .. (*a*) *r* 0 18 6

A 57-630. SCREENS, Projection, Opaque White, of soft woven material, with specially prepared surface. Fitted with a roller at the bottom and a lath at the top and with pulley wheel and cords to roll up or down.

Can be fixed to any wall, window, etc., and when rolled up protected by a waterproof cover.

Dimensions	5 × 5	6 × 6	8 × 8	10 × 10	12 × 12 *feet*
	£4 10 0	£5 15 0	£7 15 0	£12 0 0	£15 0 0 *each*

A 57-650. STAND, Lantern. A useful light stand for lanterns, episcopes and small epidiascopes, can be folded and strapped together for transport. Height 4 ft., adjustable table top 20 × 12 in., shelf underneath. (*Purchase Tax, if chargeable, extra tx* £2 16 8) (*a*) *t* 4 5 0

A 58-170. LAMPS, Photometer, Standard, vacuum type, suitable for use as standards in horizontal photometers. Vacuum type, metal filament, B.C. cap. Height, including cap, 200 mm., diam. of bulb 77 mm.

Voltage	100	100	100
Candle-power	20	32	50
	t 20/-	20/-	20/- *each*
A 58-175. Ditto, with N.P.L. Certificate (*Price varies**) ..	*t* 53/4	53/4	53/4 *each*

A 58-180. LAMPS, Photometer, Standard, gasfilled type, with concentrated coil filament, B.C. cap. Height, including cap, 195 mm., diam. of bulb 77 mm.

Voltage	40	30
Candle-power	40	100
	t 20/-	20/- *each*
A 58-185. Ditto, with N.P.L. Certificate (*Price varies**)	*t* 53/4	53/4 *each*

The figures given for voltage and candle-power are purely nominal and will vary between the limits of manufacturing tolerance. Thus, if a lamp whose nominal rating is 100 volts, 50 candle-power is standardised at 100 volts, it will not necessarily have a candle-power of exactly 50 and if it is standardised at 50 candle-power it will not necessarily require to be run at exactly 100 volts. It is thus important, when ordering, to state whether the lamp is to be standardised at some particular voltage or at some particular candle-power.

* The N.P.L. fee includes cost of measurements during ageing of lamp, but the power used during ageing is charged extra.

The name MICROID is registered by Griffin and Tatlock Limited and is used to distinguish apparatus of special interest to you.



A 58-220.



A 58-230.



A 58-240.



A 58-260.

	£	s.	d.
A 58-205. CANDLES, Standard Sperm, 6 to the lb. .. .. *lb. t*	0	7	0
A 58-220. GAS BURNER, Incandescent, with stopcock, including mantle and glass globe ..	0	17	6
A 58-225. Metal Chimney for above, with round hole or slot	0	14	0
A 58-230. GAS BURNER, Fish Tail, with stopcock	0	14	0

A 58-240. SPOTLIGHT BULBS, 0·3 amp.

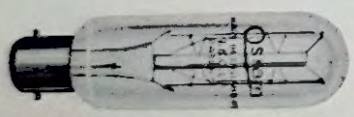
Voltage	2·5	3·5	6·2	
(*a*) *t*	4/4	4/4	5/6	*dozen*

A 58-260. LAMPS, low voltage, bulb 18 mm. diam., with 2 pole, S.B.C. caps. (Side and tail car lamps.)

Volts	4	6	6	12	
Watts	3	3	6	6	
(*a*) *tx*	2/2	1/4	1/7	1/4	*each*



A 58-280.



A 58-285.



A 58-295—297.

A 58-280. LAMPS, low voltage, gasfilled, line filament, bulb 38 mm. diam., with 2 pole, S.B.C. caps.

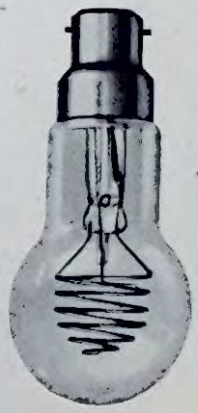
Volts	4	6	6	12	
Watts	8	12	24	24	
(*a*) *tx*	3/6	2/7	2/7	2/7	*each*

	£	s.	d.
A 58-285. LAMPS, tubular, 25 watts ; length 3½ in., diam. 1 in., S.B.C. 2 pole cap. In standard mains voltages .. .. *each* (*a*) *tx*	0	3	8
A 58-295. LAMP, Festoon, straight filament suitable for use on optical benches, 6 volt, 6 watt, length 44 mm., diam. 11 mm. .. .. (*a*) *tx*	0	2	2
A 58-297. Ditto, 12 volt, 6 watt .. .. (*a*) *tx*	0	2	2

Please state voltage when ordering.


A 58-350.


A 58-355.


A 58-380.

LAMPS, Osram, available in all standard voltages (*please state voltage when ordering*).

Cat. No.	Standard Watts →	25	40	60	75	100
↓		(*a*) *tx*	(*a*) *tx*	(*a*) *tx*	(*a*) *tx*	(*a*) *tx*
A 58-350	Pearl, Coiled coil ..	—	1/11	1/11	2/1	2/4
A 58-355	Clear, Gas filled (Single Coil)	—	1/7	1/7	2/-	2/3
A 58-360	Clear, Vacuum	1/7	—	—	—	—

£ s. d.

A 58-380. LAMP, Neon Discharge, Osglim, lighting type with wire spiral, current consumption 5 watts, standard B.C. cap. Available in any voltage between 200 and 250 (*please state voltage when ordering*) .. .. *tx* 0 3 1


A 58-405.

£ s. d.

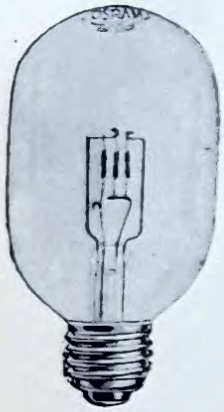
A 58-405. LAMP, Carbon Filament, radiator, for use in heating thermostatic baths, etc. Current consumption 250 watts, standard B.C. cap. Length 11¼ in., diam. 2¼ in. Available in all standard voltages (*please state voltage when ordering*) (*a*) *tx* 0 7 7

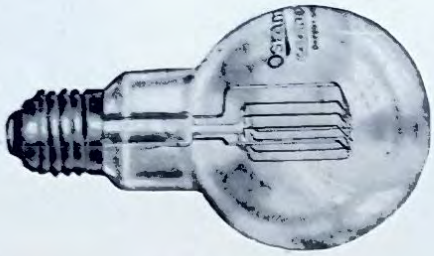
A 58-420. MICROID PROJECTOR LAMP. The lamp is carried in a metal housing about 3½ in. long and 2 in. diameter, with a focussing tube and lens, suitable for focussing the image of the filament at one to forty feet distance. The whole is supported on a tripod stand on which it may be raised and lowered. The housing may be tilted through an angle of about 180 degrees and locked in any position. **Without** lamp .. 2 15 0


A 58-420.

Lamps, for above, Class F, 6 v. 24 w. or 12 v. 24 w. S.B.C., see **A 58-495.**

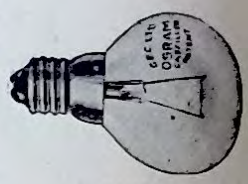
Griffin and Tatlock Limited are makers of Complete Laboratory Equipment, including furniture, fittings and apparatus.


A 58-450.


A 58-460.


A 58-475.


A 58-490.


A 58-495.

When ordering Projector Lamps, please state:— Cat. No., voltage, wattage, and type of cap required.

A 58-450. LAMPS, Projector, Class A1, tubular, grid filament, gas filled, **for vertical burning,** with cap down.

Watts →	100		250		500		1000	
Volts	Cap	£ s. d.	Cap	£ s. d.	Cap	£ s. d.	Cap	£ s. d.
		(a) tx		(a) tx		(a) tx		tx
30	E.S. . .	0 13 7	—	—	—	—	—	—
30	Prefocus .	0 14 10	—	—	—	—	—	—
100	B.C. or E.S.	0 13 7	E.S. . .	1 5 3	E.S. or G.E.S.	1 10 3	G.E.S. .	1 10 0
100	Prefocus .	0 14 10	Prefocus .	1 6 6	Prefocus .	1 11 3	Prefocus .	1 12 6
210–250	B.C. or E.S.	0 13 7	E.S. . .	1 5 3	E.S. or G.E.S.	1 10 3	G.E.S. .	1 10 0
210–250	Prefocus .	0 14 10	Prefocus .	1 6 6	Prefocus .	1 11 3	Prefocus .	1 12 6

A 58-460. LAMPS, Projector, Class A3, round bulb, grid filament, gas filled, **for horizontal burning.** Voltages 110, 210, 230, 240, 250 available.

Watts	100	250
Cap	E.S.	E.S.
	(a) tx 13/7	£1 5 3 each

A 58-465. Ditto, Prefocus Cap .. .. .. (a) tx 14/10 £1 6 6 each

£ s. d.

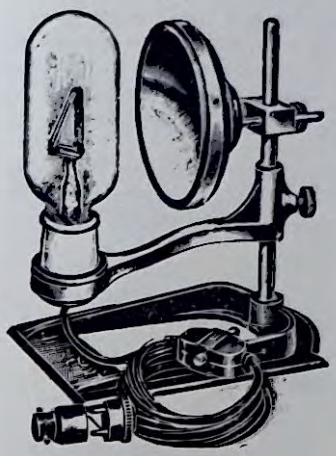
A 58-475. LAMP, Projector, Class E, round bulb, grid filament, gas-filled, **for vertical burning,** cap down. Specially designed for Epidiascopes. Voltages 100, 210, 230, 240, 250, 500 watts. Overall height 135 mm., diam. 100 mm., light centre 85 mm. E.S. cap (a) tx 1 17 10

A 58-480. Ditto, with prefocus cap .. .. (a) tx 1 19 1

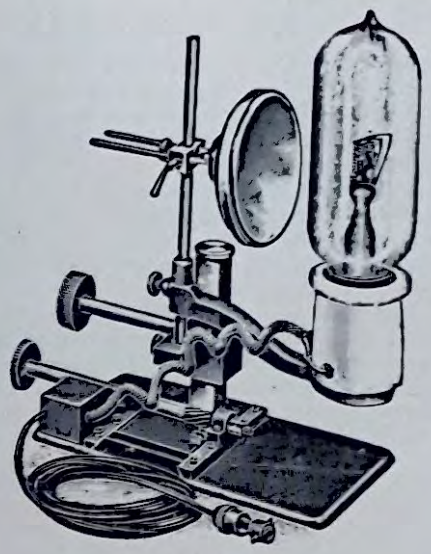
A 58-490. LAMPS, Projector, Class F, tubular bulb, concentrated filament, gas-filled, **for vertical burning,** cap down, 12 volts, 100 watts, E.S. cap, length × diam. 125 × 32 mm. (a) tx 0 13 7

A 58-495. LAMPS, Projector, Class F, round bulb, gas-filled, **for horizontal burning.** The 24 and 30 watt lamps have line filaments, the 48 watt lamp has grid filament.

Volts	6	6	6	12	12	12	
Watts	24	24	30	24	24	48	
Cap	S.E.S.	S.B.C.	S.E.S.	S.E.S.	S.B.C.	E.S.	
Overall length × diam. ..	60 × 38	60 × 38	65 × 35	60 × 38	60 × 38	70 × 50	mm.
	(a) tx 5/-	5/-	7/7	4/9	4/9	4/9	each



A 58-605+A 58-450.



A 58-610+A 58-450.

A 58-605. FOCUSLITE OUTFIT, for use on either D.C. or A.C., 100 to 250 volts. Complete on tray, finished black, with plated brass rod and fittings, reflecting mirror 4 in. diam., porcelain E.S. lampholder (except 1000 watt size, which is fitted with G.E.S. lampholder), 3 yds. 5-amp. flex with moulded switch and 2-pin B.C. plug. **Without** class A1 projector lamp (*see* **A 58-450**).

Consumption ..	100	250	500	1000	*watts*
r	£1 10 0	£1 10 0	£1 10 0	£1 14 0	*each*

A 58-610. Ditto, as **A 58-630,** but mounted on mechanical tray with lateral and vertical mechanical adjustments for lamp and with lacquered brass rod and fittings. **Without** class A1 projector lamp (*see* **A 58-450**).

Consumption ..	100	250	500	1000	*watts*
r	£3 14 0	£3 14 0	£3 14 0	£3 18 6	*each*

Please state voltage when ordering.

The 1000 watt outfit is suitable only for voltages 200 to 250. If required for voltages 100 to 110, this outfit must be supplied with 10-amp. flex and D.P. switch but without plug adapter, at an extra cost of **6/-**.

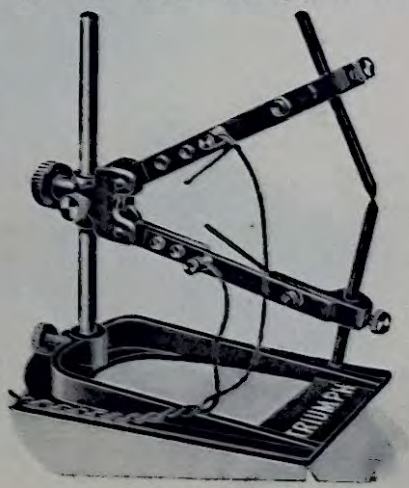
A 58-615. FOCUSLITE OUTFIT, as **A 58-605** but fitted with special holder to take Projector Lamps, **A 58-450,** with prefocus caps, 100 to 500 watts, 100 to 250 volts. **Without** lamp *r* **2 5 0**

	£ s. d.
A 58-630. ARC LAMP OUTFIT, scissors pattern, for 5 amperes, with resistance regulating all voltages up to 250 volts, flex and adapter. On plain tray *p*	**8 10 0**
A 58-635. Ditto, on mechanical tray .. .. .. *p*	**11 5 0**
A 58-640. Arc Lamp and Tray only, plain as illustration *p*	**2 17 0**

A 58-645. CARBONS, Arc Lamp, 6 in. long, solid or cored. The 5 mm. carbons are 4 in. long.

Diam.	5	6	8	12	14	17	*mm.*
tx	11/2	16/10	22/6	36/-	42/-	51/-	100
tx	1/6	2/3	3/-	4/10	5/7	6/9	*dozen*

On D.C. circuits the larger (cored) carbon should be placed in the top or positive holder and the smaller (solid) carbon in the lower holder. When used on A.C. circuits, both carbons must be of the same diameter and both should be cored.



A 58-640.

THE POINTOLITE LAMP for Direct or Alternating Currents.

The **Direct Current** Pointolite Lamp consists of a special starting device known as the "ioniser," which, in the case of the two electrode lamps, also acts as a negative electrode, and one or two fused tungsten electrodes, the whole being enclosed in a glass bulb filled with an inert gas at a low pressure.

Two distinct types of D.C. lamp are manufactured :—

Type A, a two-electrode lamp in which the arc is formed between the ioniser, as negative electrode, and a tungsten bead, as positive electrode. The source of light in lamps of this type is the tungsten bead. Lamps of 30 and 100 c.p. are of type A.

Type B, a three-electrode lamp in which the arc is first formed between the ioniser and a bead of tungsten and is then "changed over"; the bead becoming a new negative and a tungsten plate the new positive electrode. The source of light in lamps of this type is mainly the tungsten plate and partially the tungsten bead. Lamps of 500 and 1000 c.p. are of type B.

The **Alternating Current** Pointolite Lamp is similar to the three-electrode direct current type. It possesses an "ioniser" starting electrode and two tungsten beads. In this lamp an arc is formed first between the ioniser and one of the tungsten beads, and is then "changed over" so that the two beads act as the new arc electrodes. Both beads are equally brightly incandescent.

The Alternating Current Pointolite Lamp is made **only in the 150 c.p. rating.**

The lamp has an unique combination of advantages. The light source is of a point nature, far superior in intense concentration and uniformity to anything previously obtainable in incandescent lamps.

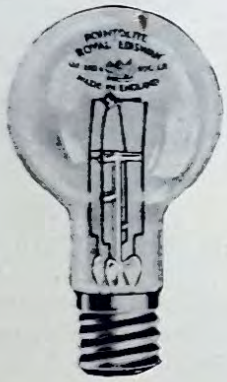
The light is perfectly steady, ideal for focussing and requires no attention when in use; a fact that makes it superior to various types of arc lamps used for projection purposes.



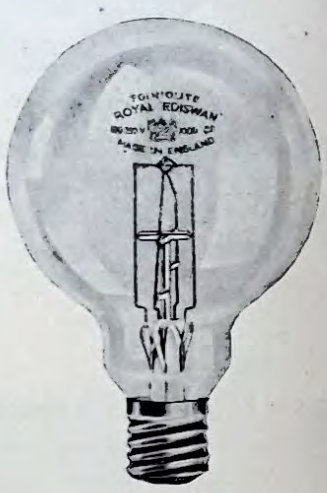
A 58-660.



A 58-665.



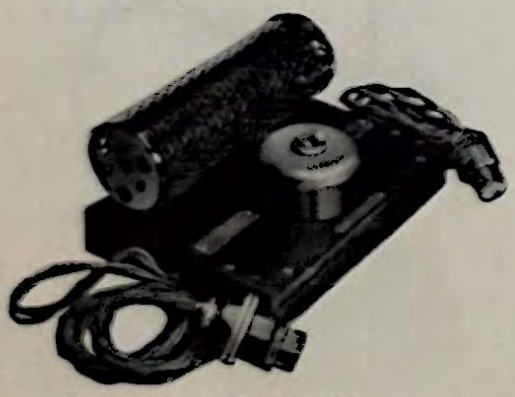
A 58-670.



A 58-675.

		£	s.	d.
A 58-660.	**LAMP, Pointolite, for D.C., 30 c.p.,** galvanometer type, 0·45 amps., 2 electrodes, ionising current 4·5 amps. .. .. (*a*) *t*	1	17	10
A 58-665.	**Ditto, 100 c.p.,** specially suitable for small projection, microscopic, oscillographic work, etc. 1·35 amps., 2 electrodes, ionising current 7 amps. .. .. .. (*a*) *t*	1	17	10
A 58-670.	**Ditto, 500 c.p.,** 5 amps., 3 electrodes, ionising current 7 amps. .. .. .. *t*	2	10	0
A 58-675.	**Ditto, 1000 c.p.,** 8 amps., 3 electrodes, ionising current 7 amps. Specially suitable for projection work owing to its high candle power, cool beam and high efficiency .. *t*	3	10	0

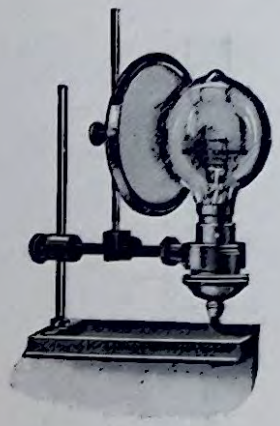
All Pointolite lamps are suitable for use on any voltage 100–260.



A 58-680—695.

		100–120	200–260 volts
A 58-680.	**RESISTANCE** for **30 c.p.** Pointolite Lamp, with 5 ft. flexible cord on either side, switch, plug and lampholders, for voltages 100-120 and 200-260 .. *t*	£5 10 0	
A 58-685.	**Ditto,** for **100 c.p.** .. .. .. *t*	£5 10 0	
A 58-690.	**Ditto,** for **500 c.p. Lamp** *t*	£9 10 0	£12 10 0 *each*
A 58-695.	**Ditto,** for **1000 c.p. Lamp** *t*	£13 10 0	£14 15 0 *each*

Resistances are not universal. Please state exact voltage and candle-power when ordering.



A 58-705—720.

Accessories for use with Pointolite Lamps

		For	100	500	1000 *c.p. lamps.*
A 58-705. **Reflectors**	.. ..	*t*	£1 17 6	—	— *each*
A 58-710. **Trays**	.. ..	*t*	4/-	4/-	4/3 *each*
A 58-715. **Clips** (Lamp bracket)	.. ..	*t*	9/6	6/6	6/6 *each*
A 58-720. **Lampholders**	.. ..	*t*	9/-	15/-	15/- *each*
			Twin.	Triple.	Double Twin.
A 58-725. **Flexible Cord** (*see note below*)	..	*t*	1/-	1/6	2/- *yard*

Twin cord is used for all Pointolite lamps for connection from Mains to Resistance.
Triple cord is used for connection of 30 and 100 c.p. lamps from Lampholder to Resistance.
Double twin cord is used for connection of 150 c.p. A.C., 500 c.p. D.C. and 1000 c.p. D.C. lamps from Lampholder to Resistance.

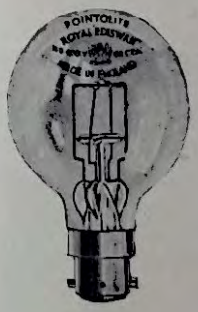
		£ s. d.
A 58-730. **POINTOLITE OUTFIT for D.C.**, with 100 c.p. lamp, reflector, tray, clip, lampholder, resistance, plug and 5 ft. flexible cord on either side	(*a*) *t*	9 18 10

Please state voltage when ordering.

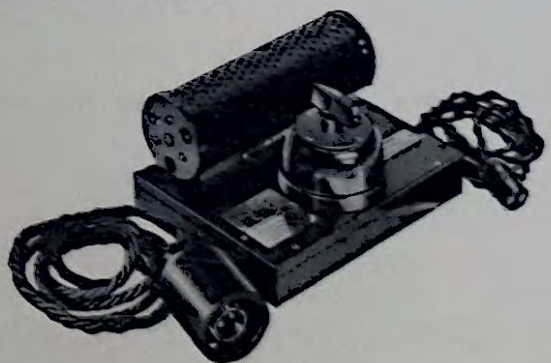
POINTOLITE OUTFITS for D.C., with lamp, tray, clip, plug, switch, lampholder, adapter, and 5 ft. flexible cord on either side. **Without** reflector—none required.

		100–120	200–250 *volts*
A 58-735. **For 500 c.p. Lamp**	*t*	£12 10 6	£15 10 6
A 58-740. **For 1000 c.p. Lamp**	*t*	£17 10 9	£18 15 9

Please state voltage when ordering.



A 58-745.



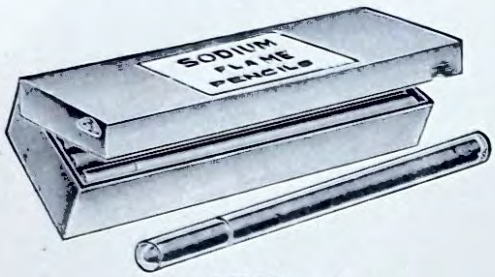
A 58-750.

		£ s. d.
A 58-745. **POINTOLITE LAMP for A.C. only, 150 c.p.**, 2 amps., three electrodes, ionising current 7 amps.	(*a*) *t*	1 17 10
A 58-750. **RESISTANCE** for above, with switch, plug, lampholder, and 5 ft. flexible cord on either side	*t*	6 0 0
A 58-755. **Lampholder, spare**, for above	*t*	0 15 6

Other accessories for the 150 c.p. A.C. model are the same as for the 100 c.p. D.C. model, see **A 58-705—725.**

A 58-760. **POINTOLITE OUTFIT for A.C. only**, with 150 c.p. lamp, reflector, tray, clip, lampholder, resistance, plug, and 5 ft. flexible cord on either side	(*a*) *t*	10 8 10

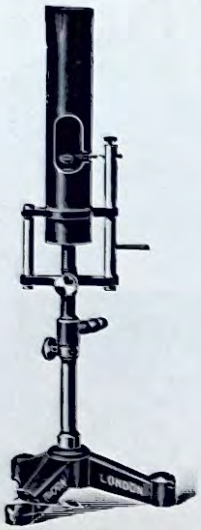
When ordering please state exact voltage of supply on which lamp will be used.



A 59-150.



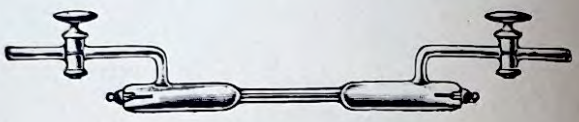
A 59-160.



A 59-180—185.



A 59-190—195.



A 59-210.

	£	s.	d.
A 59-150. SODIUM FLAME PENCILS, for use in the production of monochromatic light of high intensity with Spectrometers, Polarimeters, etc. Prepared in accordance with a formula devised by T. McLachlan and A. W. Middleton (*Analyst*, 1927, **52**, 639) *dozen* *t*	0	7	6
A 59-160. SODIUM FLAME. For students' use. To fit the standard $\frac{7}{16}$ in. diam. No. 1 Bunsen burner. A collar with fixing screw supports an arc of heavy-gauge Nichrome wire which is wound into a close, flat spiral at the top. This spiral when coated by heating to redness in a flame and dipping into powdered rocksalt, will give a steady, intense sodium flame lasting many hours. Only one-half the area of the spiral should be in the flame ..	0	4	6
A 59-180. LAMP, Sodium, for burning gas, on adjustable tripod	3	0	0
A 59-185. Ditto, without tripod, stem $\frac{3}{8}$ in. diam. for use on Optical Benches **A 53-120, A 53-185**	2	7	6
A 59-190. SPOONS, iron, ring-shaped, with groove for holding the salt .. .. *each*	0	1	3
A 59-195. Ditto, platinum .. .. *Price on application.*			
A 59-210. SPECTRUM TUBE, with two stopcocks and capillary tube, overall length 16 cm., for filling with gases .. .. *r*	2	0	0

GAS DISCHARGE LAMPS for use with Spectroscopes and Interferometers.

On a direct current supply of suitable voltage these lamps give a steady glow suitable for spectrum work. They are superior to most ordinary vacuum tubes on the grounds of convenience, steadiness and length of life. The radiating area is small ; the necessity in most spectroscopic work being that the source should have great intrinsic brightness. The tubes are cylindrical, 1 in. diam., $3\frac{1}{2}$ in. long overall, and have standard bayonet catch fitting. The consumption of the lamps is between 5 and 15 milliamperes so that they may be run off high tension batteries.

	£	s.	d.
A 59-250. Helium Discharge Lamp for 220 volts D.C. .. .. *tx*	1	17	0
A 59-255. Argon Discharge Lamp for 220 volts D.C. giving the " blue " spectrum *tx*	1	17	0
A 59-260. Neon Discharge Lamp for 200-220 or 220-250 volts D.C. .. .. *tx*	2	0	0

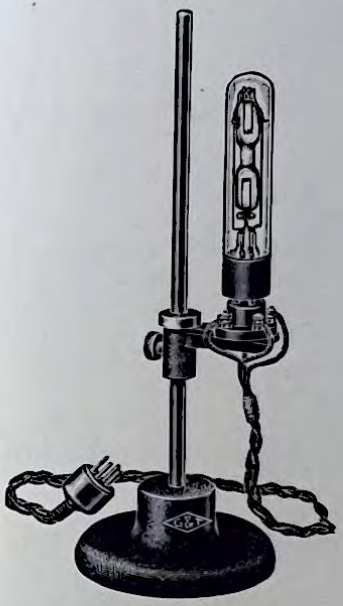


A 59-250.

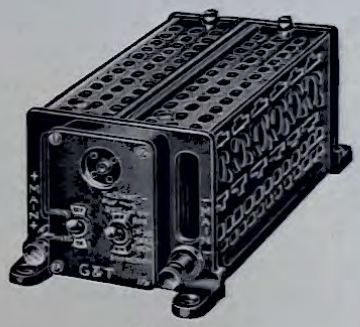
ELECTRIC SODIUM LAMP

The lamp has the following advantages:—

1. Monochromatic radiation without perceptible heat radiation.
2. Constant high light intensity.
3. No regulation necessary during running.
4. Operation from ordinary lighting circuit by means of suitable resistance.



A 59-310—315.



A 59-320.



A 59-325.

	£ s. d.
A 59-310. LAMP, Sodium, Electric, of the type generally described on page 220, giving monochromatic light suitable for use with spectrometers, polarimeters, refractometers and in optical measurements. Lamp about 160 × 35 mm. with four-pin radio cap. Is available for operation from 100–250 volts, either A.C. or D.C., consumption 1·3 amps, but requires a special resistance **A 59-320** supplying ionising and running currents.. .. .. *Ex*	3 12 0
Please state whether for use on A.C. or D.C. when ordering.	
A 59-315. Stand for above, heavy base with rod, approx. 18 in. long, adjustable bracket carrying lamp holder, double twin flex and special plug connector to resistance .. .. *t*	2 7 6
A 59-320. Resistance, Universal Voltage, for above, adjustable any voltage 100–250, 1·3 amp. A.C. or D.C. with separate switches for ionising and for maintaining the lamp and with attached switching-instruction panel. (This resistance is not suitable for operating the Spectrum Lamps on next page) .. .. *t*	4 15 0
A 59-325. Shield for **A 59-310** (and for **A 59-355** on next page). Metal tube about 2 in. diam., adjustable on rod of supporting stand, with aperture 25 mm. diam. Specially for use in polarimetric work .. .. *r*	0 15 0

The light is practically monochromatic. When purely monochromatic radiation is absolutely essential a bichromate filter or monochromator may be used to remove the lines 5680 and 6160. The intensity of these together is only about 1 per cent. of that of the D lines.

The size of illuminating surface is about 16 × 14 mm. The very high light intensity—about 7 Hefner candles per square cm.—is about thirty times that of the sodium light sources hitherto in use.

Maximum light intensity is reached in 2 to 3 minutes and then remains constant.

The lamp fitting is the usual radio four-pin base and is so attached that the anode pin denotes the direction of maximum radiation.

On account of the high visual acuity obtained when this monochromatic source is employed, it is finding application in microscopy, metallography, precision engraving, etc.

Our Technical representatives will be glad to assist you in the choice of Apparatus.

LABORATORY SPECTRUM LAMPS

Electrically operated sources of high intensity and known wavelength

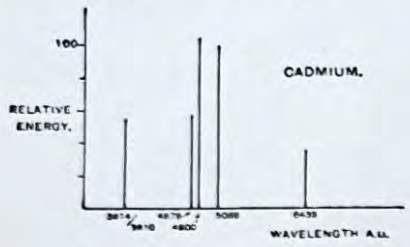


Fig. 1.

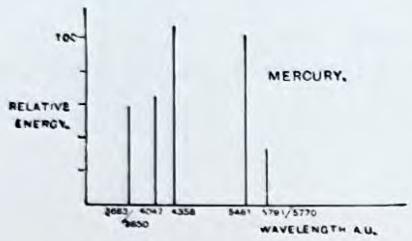


Fig. 2.

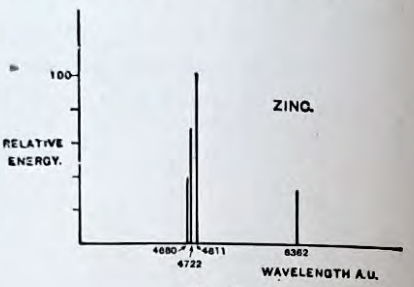


Fig. 3.

No correlation is intended between the energy scales for the three metals.

Many operations which are carried out in physical and chemical laboratories require the use of a light source giving a line spectrum which can be used as a source of known wavelengths for calibration purposes, or from which a single line can be isolated for work requiring monochromatic radiation. To cover these fields the range of spectrum lamps described below and illustrated on p. 219 has been developed. They have the following advantages:—

(*a*) Silent in operation.
(*b*) Constant high intensity.
(*c*) Always ready for use.
(*d*) Low current consumption.
(*e*) Require no attention.
(*f*) No bare flames or fumes.
(*g*) Little heat generated and therefore no risk of damage to or corrosion of valuable optical apparatus.

SPECIFICATION

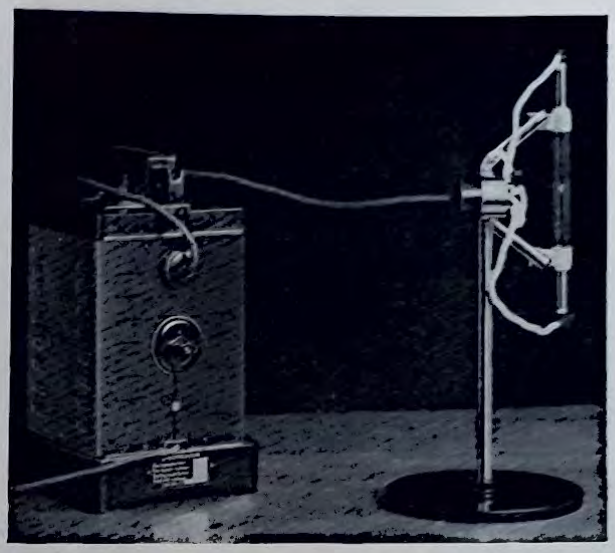
The lamps consist of an evacuated cylindrical glass tube mounted on a four-pin radio cap. A small inner tube is mounted concentrically and contains the metal which is vaporised and of which the spectrum is excited by the passage of an electric discharge between electrodes situated at its ends. A small quantity of inert gas is included to facilitate the initial discharge. The lamps each consume 2 amps.

The lamps require a special, calibrated resistance, **A 59-360**, for their operation. The resistance (illustrated on p. 219) is suitable for use on both A.C. and D.C. circuits. The lamps, however, are not suitable for use on *both* A.C. and D.C. but can be supplied for *either* A.C. or D.C. By closing the switches the electrodes of the lamp are heated and become thermionically active. At the end of a predetermined period (stated on the instruction plate attached to the resistance) one switch is opened thus applying the mains potential across the electrodes and initiating the discharge in the gas filling of the lamp. The heat generated vaporises some of the metal, the spectrum of which is soon emitted and that of the inert gas filling suppressed. A steady state corresponding to maximum intensity is reached after a few minutes' operation, following which the lamp requires no attention. The characteristic arc spectral emission of the metals used in the lamps is shown in Figs. 1, 2 and 3 above.

	£ s. d.
A 59-340. SPECTRUM LAMP, Laboratory, Cadmium. Lamp about 240 × 50 mm. Area of light source 60 × 20 mm. *Voltages* 200–250 *A.C. or D.C.* Consumption 2 amps	*t* 7 4 0
A 59-345. Ditto, Mercury. Lamp about 240 × 50 mm. Area of light source 60 × 20 mm. *Voltages* 100–250 *A.C. or D.C.*	*t* 3 12 0
A 59-350. Ditto, Cadmium-Mercury. Lamp about 240 × 50 mm. Area of light source 60 × 20 mm. *Voltages* 200–250 *A.C. or D.C.*	*t* 7 4 0
A 59-355. Ditto, Zinc. Lamp about 210 × 38 mm. Area of light source 60 × 20 mm. (Shield **A 59-325** is suitable for this lamp.) *Voltages* 220–250 *A.C.* ..	*Price on Application*

When ordering please state whether for use on A.C. or D.C.

A 59-360. Resistance, Variable, for all above, when a high intensity of illumination is required (illustrated on previous page), adjustable from 1–3 amps. and suitable for use on any voltage between 100–250 A.C. or D.C., with separate switches for ionising and for maintaining the lamps and with attached switching-instruction panel. (This resistance is not suitable for operating the Sodium Lamp, **A 59-310**, on preceding page)	*t* 5 15 0
A 59-365. Ditto, fixed resistance, 2 amps., for general use where meters are not available for controlling light output of the lamps	*t* 5 10 0
A 59-370. Shield to cut off extraneous light from lamps **A 59-340—350.** Metal tube, about 2½ in. diam., adjustable on rod of supporting stand, with aperture about 50 × 25 mm. ..	*r* 0 17 6
Stand for any of above.	see **A 59-315**



A 59-420.

£ s. d.

A 59-420. LAMP, Mercury U.V., Hanovia, with 250 watt straight arc tube. A simple unit for all applications of ultra-violet rays where high specific intensity is not required. Complete with control unit incorporating mains and starting circuits, switch, etc., and 17 ft. earthed lead with plug adapter. For A.C. and D.C. voltages from 200 to 260. **Without** stand and clamp shown in illustration .. .. *t* **17 0 0**

Please state voltage when ordering.

A new type of mercury arc ultra-violet generator in the form of a very powerful high pressure electronic discharge arc tube, operated with a single pair of solid activated electrodes in a straight quartz tube. The tube contains a minute quantity of mercury, sufficient when vaporised to produce correct vapour pressure, thus allowing stable operation under varying thermal conditions. An additional advantage is the automatic starting without tilting, when the potential is applied. The tube gives an arc 11·5 cm. long with a measured output, at 40 in. distance, of 70 microwatts per cm.^{2} (UV < 3200 Å) with a consumption of 240 to 260 watts on A.C. circuits 200 to 260 volts and 390 to 510 watts on D.C. circuits 200 to 260 volts. The bench mounting is 12 in. high and allows operation in vertical or horizontal positions.

£ s. d.

A 59-425. Ditto, with 500 watt straight arc tube, a very **powerful source** for all applications of unfiltered ultra-violet rays. General specification as **A 59-420,** but with a larger tube giving an arc 12·5 cm. long and generating a measured intensity of 175 microwatts per cm.^{2} (UV < 3200 Å) at 40 in. distance from the naked tube, with a consumption of 450 to 550 watts on A.C. circuits 200 to 260 volts and 700 to 950 watts on D.C. circuits 200 to 260 volts. The control unit is cylindrical, 12 in. high, 14 in. diam., on ball-bearing casters, and can be conveniently accommodated below a table. Complete with 17 ft. earthed lead and plug adapter. **Without** stand and clamp shown in illustration. .. *t* **28 0 0**

Please state voltage when ordering.

A 59-450. LAMPS, Ultra-Violet, "Philora," with special **"black" glass** filter bulbs which absorb most of the visible light radiations from the inner quartz tube source, but transmit 91 per cent. of the ultra-violet emission in the 3650–3663 Å region. Reflectors of silvered glass or polished metal, particularly aluminium, are suitable for use with these lamps. Fitted with 3-pin B.C. cap, for vertical burning with cap up. Length overall 7 in., diam. 3½ in. These lamps can only be operated on A.C. mains, with ballasts, for 110–250 volts, 40–60 cycles.

Consumption ..	80	125	*watts*
	t £2 2 6	£2 10 6	*each*



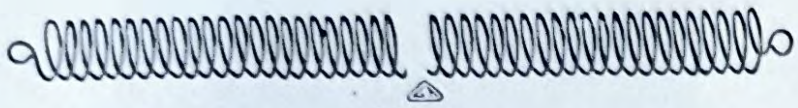
A 59-450.

Accessories for above

A 59-450 a. Choke Coil ..	80	125	*watts*	
	t £2 8 0	£2 10 0	*each*	
„ „ **b. Condenser** ..	8	13	*mfd.*	
	t 12 6	17 6	*each*	
„ „ **c. Lampholder,** 3-slot, batten type, for above lamps				*t* 0 1 6
„ „ **d. Ditto,** 3-slot, b.c., for conduit entry				*t* 0 1 6

Please give full particulars of current when ordering.

Sound



A 61-120.

	£	s.	d.
A 61-120. HELIX, brass wire, to demonstrate wave motions, 5 ft. long, 1⅛ in. diam. ..	0	5	0



A 61-150—155.



A 61-160—165.

	£	s.	d.
A 61-150. CHESHIRE DISC, printed on cardboard, 10 in. diam., with printed slit and instructions for use	0	3	6
A 61-155. Ditto, glass, transparent, 8 in. diam., with central hole for spindle	1	15	0
A 61-160. CROVA DISC, printed on cardboard, 10 in. diam., with printed slit and instructions for use	0	3	6
A 61-165. Ditto, glass, transparent, 8 in. diam., with central hole for spindle	1	15	0

Cheshire's Disc represents the motion of the particles in **stationary** waves, due to longitudinal vibrations, in a similar way to that in which Crova's Disc represents **progressive** waves. By rotating the disc and projecting different parts and lengths of a radial slit the vibrations corresponding to the fundamental or first overtone of an open organ pipe, or a stopped pipe, can be beautifully shown on the screen. The vibrations of rods clamped in various ways can be similarly shown. For the method of drawing Crova's Disc see A. Wood: *Acoustics*, p. 18; Poynting and Thomson, *Sound*.

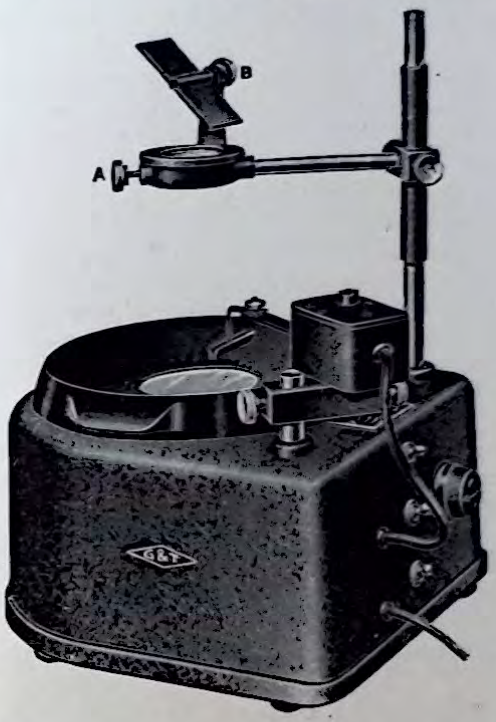


A 61-180.

	£	s.	d.
A 61-180. PENDULUM, Wilberforce (*Phil. Mag.*, 1894, **38**, 386; Sutton: *Demonstration Experiments in Physics*), for showing the periodical transfer of energy of translational into that of rotational vibration. A long, closely-wound steel spring is suspended from a suitable support and carries a weight, the moment of inertia of which can be varied, by means of weights threaded on transverse rods, until the period of torsional vibration is equal to that of the vertical oscillation. When the latter motion is imparted to the spring the torsional impulse introduced by the contraction of the spring sets up rotation of the suspended mass until the energy is completely rotational; but by the converse process it resumes vertical oscillations again, the cycle continuing until the energy has been dissipated. The apparatus can also be used for determining Young's Modulus and modulus of rigidity *vide* Worsnop and Flint: *Advanced Practical Physics for Students*, pp. 107, 113	1	7	6

THE MICROID RIPPLE TANK

Brilliant stroboscopic illumination of variable frequency in a most compact projection model operated from A.C. mains



A 61-220.—Fig. A. Base about 25 × 25 × 15 cm. high.

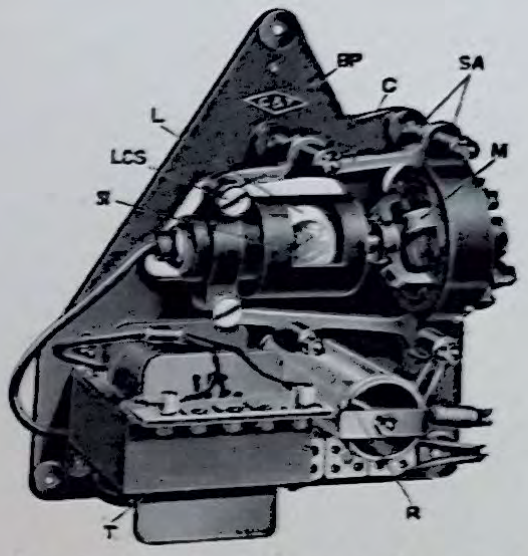


Fig. B. Interior, mounted on bed plate, removed to show construction.

The wave motion phenomena of light and sound are notoriously difficult to describe. Their easy and complete comprehension is possible only if they are treated objectively. Realistic pictures of wave behaviour, stationary and progressive, directly illustrating reflection, refraction, interference and diffraction, can be secured only by the use of a ripple tank. These vivid representations of the actual phenomena are conveniently obtainable by no other means and make an ineffaceable impression on the mind of the student.

The tank must incorporate stroboscopic illumination so that the transient phenomena can be arrested for observation at leisure. On the other hand, the student's mental picture becomes unreal if phenomena normally in a state of motion are studied only when apparently at rest. The apparatus must therefore include means for variation of the frequency of stroboscopic interruption so that the ripples can be shown either stationary or in motion.

The Microid Ripple Tank satisfies all these conditions. It enables reflection, refraction, interference and diffraction phenomena to be demonstrated more conveniently and impressively than has previously been possible. Utilising transmission of light *through* water, in preference to reflection at a mercury surface, it projects ripple images incomparably more brilliant than those obtained from mercury tanks. It is clean and modern in design, compact in size, easy to set up and simple to operate. The effects obtained with it are visible embodiments of the theories and are certain, therefore, to be immediately understood. On p. 226 photographs of some of the phenomena are reproduced.

SPECIFICATION

The apparatus is operable from A.C. mains of usual domestic voltage (100–110 or 200–250) and frequency. The current consumption is about 60 watts so that the apparatus can be worked from the lighting circuit. The base measures about 10 × 10 × 6 in. and carries a stainless steel rod about 12 in. long. The complete apparatus weighs about 35 lbs. and is readily transportable.

The design has been evolved to obtain the utmost simplicity, convenience and accessibility. The tank can be lifted off the base for easy adjustment to, or replacement of, a lamp, the only attention that will normally be required over long periods.

The mechanism (Fig. B) is mounted on a cast metal base plate BP roughly triangular in shape, standing on rubber feet and secured to a cast metal case at three points. The motor M, which is carried in a cradle C, is provided with self-lubricating bearings containing sufficient oil for many hours' continuous running. The

[*continued overleaf*

A 61-220—The Microid Ripple Tank—*continued*

cradle is mounted on four rods in such a manner that the shock absorbers SA damp out any motor vibration and prevent distortion of the projected ripple pattern from this cause.

*The lamp L, 12 volts 24 watts, is of a design specially selected as suitable for this apparatus. Its filament is U-shaped, mounted at the centre of curvature of a highly silvered, spherical bulb. The inverted image of the filament coincides with its object, producing a sensibly point source of great intrinsic brightness. The silvering is backed by a heavy aluminium covering. New lamps are inserted by removing the lamp centring screws LCS and lifting the lampholder from the cradle.

The stroboscopic interrupter SI is noteworthy as it is largely to its design that the compactness of the Microid Ripple Tank is due. It takes the form of a balanced cylinder, attached to the motor spindle, and completely surrounding the lamp. It contains two rectangular slots through which light passes at each revolution.

The electrical equipment includes a transformer T, suitably tapped to supply the low voltages for the lamp and the rippler, and a resistance R connected in series with the rheostat visible in Fig. A for controlling the motor speed. Three switches are mounted on the case for controlling the rippler, motor and lamp.

The tank, in which the ripples are generated, is about 8 in. diam. It is of the " beach " type, with gently shelving sides on which the ripples are damped out after passage across the condenser, 3 in. diam. It is of heavy cast gun-metal and is provided with two finger grips for ease in handling. It is cushioned on a vibration-absorbing rubber ring on the case. To prevent the possible entry of spilled water into the motor compartment the case is provided with a vertical lip beneath the tank. The condenser forms part of the base of the tank and is therefore covered by water when the apparatus is in use.

The ripple generator operates at a constant frequency equal to the frequency of the A.C. mains. It is carried in a cast box, which is mounted on a stem clamped in a universally-adjustable bar. The amplitude of vibration is adjustable by means of a screw containing a slot wide enough for a small coin. Various dippers are available for generating plane, circular, and other waves, etc.

The projection lens A is mounted in a casting carrying a pillar which supports the projection mirror. The lens is rotatable about a vertical axis and the mirror is rotatable about a horizontal axis B so that the image may be directed to any convenient screen. This assembly is adjustable vertically (for focussing) on a stainless steel rod 12 × ¾ in. diam.

The dippers supplied comprise plane and circular wave generators and a twin circular-wave generator for use in interference experiments.

The obstacles supplied comprise plane and circular reflectors and two L-shaped pieces to provide an aperture for use in diffraction experiments.

A 61-220. MICROID RIPPLE TANK. With motor, transformer, rheostat, rippler, projection lens and mirror, and dippers and obstacles described above. To operate from A.C. mains, both 100–110 and 200–250 volts, any commercial frequency. **Without** lamp .. £ 22 10 0

Please state voltage when ordering.

***Lamps**, for above, Class F, 12 volt 24 watt, S.B.C., see **A 58-495**. (As soon as they are available, lamps of the type described above will be supplied.)

EXPERIMENTAL NOTES

The Microid Ripple Tank is extraordinarily easy to set up and to operate. It should be placed on the lecture demonstration bench with the control panel, which contains the switches and rheostat, towards the lecturer. A plug is supplied, at the end of a length of flex, for insertion into a lamp holder. This operation makes all the necessary electrical connections. **The apparatus can be operated from alternating current only.**

A suitable screen distance is 6–8 ft. at which distance images 2 ft. 6 in. to 3 ft. 6 in. in diameter are obtained.

Set up the apparatus as shown in the illustration, Fig. A. Before placing the tank in position inspect the voltage plate of the transformer inside the case and see that the U-shaped shorting-bar is placed with one leg in the socket labelled " C " on the voltage plate and the other leg in the socket labelled with the voltage of the supply mains.

Introduce water into the tank to a depth of about 1 cm. Select from the dippers supplied with the instrument, one suited to the experiment. It is usual to commence with a demonstration of plane waves and the straight dipper will therefore generally be selected. Attach the dipper to the vibrating rod of the rippler unit. Adjust the height of the rippler unit so that the lowest part of the dipper is just below the water surface. Depress the switch labelled " Rippler " and set the reed vibrating. If necessary, adjust the amplitude of the reed by turning the screw on the top of unit with a coin inserted into the slot in its head. The reed should vibrate almost inaudibly when it is correctly adjusted. A large amplitude and vigorous disturbance of the water surface are unnecessary except in some of the diffraction experiments.

Depress the other two switches and put the motor and the lamp into operation. Centre the light source by slight lateral movement of the tank and adjust the height of the projection lens to about the vertex of the cone of light. See that the axis of the cone is on the axis of the lens. Slacken screws A and B (Fig. A), rotate the lens holder, and tilt the mirror until the beam is received on the screen. Focus the projected image by moving the lens up or down on the rod.

It will usually be found that the lens can focus the ripple image in either of two positions. The lower position produces an image larger and less intense, than the upper position. It is from the upper lens position that the data of image size above are derived. The room need not be completely darkened during projection.

[continued overleaf]

A 61-220—The Microid Ripple Tank—*continued*

The speed of the motor which drives the stroboscopic interrupter is variable by means of the rheostat placed at the right of the switches. Synchronism between the constant frequency rippler and the variable frequency stroboscope can usually be effected at three positions of the rheostat. At the lowest synchronous speed there is obtained an image, the apparent wavelength of the ripples of which is greater than at the next higher speed at which synchronism can be effected: similarly for the next higher multiple.

This system of variable rate of stroboscopic interruption has the great advantage that it enables an apparent change of rippler frequency to be made with a corresponding change in the apparent wavelength of the projected ripples. The motor speed may be selected to give the best definition of the particular phenomenon being demonstrated.

In all the following experiments it is desirable to manipulate the accessories by forceps in order to avoid the distortion which is brought about by the use of greasy obstacles.

The scope of the demonstrations here suggested can be extended by the construction of a range of obstacles from lead, nickel or aluminium sheet about 1 mm. thick, made to individual requirements. Such obstacles are easy to make and the demonstrations will gain in interest. References to text-books and other publications likely to be helpful are given below.

Suggested demonstrations are conveniently summarised below. By hand manipulation of the vibrating reed they can in all cases be carried out with either single pulses or short trains of waves. For single pulses the reed is moved up or down slowly between the thumb and forefinger, while for short trains of waves the reed is gently displaced and then allowed to oscillate freely. Its motion can be stopped when desired. All the experiments can be carried out with either progressive or with stationary waves, by variation of the speed of the stroboscope.

REFLECTION.

(*a*) **Plane Waves**: straight dipper and ⌊⌋-shaped obstacle standing on base of tank so that one edge makes an angle of about 45° with the wave front. Weiner's fringes can be seen without difficulty. Using ⌒-shaped obstacle, the focus of the cylindrical reflector can be shown.

(*b*) **Circular Waves**: Point dipper immersed to depth of about half radius of hemispherical end. Conjugate focus of cylindrical mirror used above shown by placing it with dipper to one side.

REFRACTION.

(*a*) **Plane Waves**: Straight dipper. Refraction demonstrations depend on the fact that the velocity of ripples in shallow water is lower than in deep water. A glass slab (as used for fractional weights) should be immersed to a depth of about 1 mm. The displacement of the wave front can be clearly seen. A similar effect can be demonstrated by the use of a glass prism cut from plate glass about ¼ in. thick. A plano-convex lens of long (about 30 cm.) focal length can also be used. The curvature of the upper surface accentuates the retarding effect and illustrates the action of a lens upon light.

(*b*) **Circular Waves**: Point dipper and glass slab. Alteration of radius of curvature, visible after the circular waves have passed over the obstacle, illustrates the phenomenon.

(*c*) **Doppler Effect**: Can be illustrated by hand-traversing the tank with the rippler, thus causing the source to be in motion.

INTERFERENCE.

(*a*) **Plane Waves**: See Reflection (*a*) above and Weiner's fringes.

(*b*) **Circular Waves**: Use double point dipper. One of the easiest experiments of all to demonstrate. Standing waves are seen as lines of light between the dippers. Interference bands shown clearly. An elliptical reflector with the single point dipper placed at one of its foci shows the phenomenon in an analogous manner.

DIFFRACTION.

(*a*) **Plane Waves**: Straight dipper. Place one of the L-shaped obstacles on its flat side on the base of the tank and the edge of vertical face parallel to the dipper. A diffraction pattern will be seen due to the train of waves spreading round each edge of the barrier.

Two such obstacles, supported edge-wise, can be placed thus, ⌊⌋ to form an aperture whose width is readily variable. The plane waves will be seen, spreading as circular waves, through the aperture. The change of the wave form as the width of the aperture is varied, should be noted.

OTHER USES FOR THE MICROID RIPPLE TANK.

Although the Microid Ripple Tank has been designed primarily to supply the definite need for a compact apparatus for the demonstration of wave phenomena, attention is drawn to a great variety of other applications in which it may be found of service by the ingenious user. It may be used, for example, for the projection of lantern slides, placed upon the base of the empty tank; for the projection of the field due to various arrangements of bar magnets; for demonstration of dissections of biological specimens; for many types of chemical experiments. In all these demonstrations the stroboscopic interrupter should, of course, be stopped in such a position that the rotating shutter does not cut off the light to the condenser. It can readily be brought into the required position by momentarily starting the motor by means of the controlling switch.

EXPLANATORY KEY TO ILLUSTRATIONS.

Interference.

Figs. 1, 2 and 3 show interference between waves from two point sources operated by the same vibrating reed. Figs. 2 and 3 illustrate the apparent decrease of wavelength caused by successive increases of the rate of stroboscopic interruption by means of the rheostat which controls the motor speed.

Reflection.

Fig. 4.—Reflection of plane waves from a plane boundary. Weiner's fringes can be seen. Reflected wave front shown thus ——— ———.

Fig. 5.—Circular waves reflected at a plane boundary and showing Lloyd's fringes. A reflected wave trough is indicated by the arrow from A.

Fig. 6.—"Object" and "Image" produced by reflection at a concave cylindrical surface.

Refraction.

Fig. 7.—Refraction of plane waves. The retardation, observed particularly near the base of the prism, is caused by reducing the depth of water in the tank by means of a plate glass prism.

Fig. 8.—Refraction by a convex lens. The retardation of the centre of the wave results from the greater length of its path in water shallower than that traversed by all other parts of the wave front.

Fig. 9.—Refraction and reflection due to the introduction into the tank of a glass block submerged to a depth of 1–2 mm. and supported in a slightly inclined position.

Diffraction.

Fig. 10.—Diffraction of plane waves through a wide (8–10 mm.) aperture in a metal barrier.

Fig. 11.—Diffraction of plane waves through two narrow (3–5 mm.) slits and consequent interference of resultant circular waves, *cf.* Figs. 1–3.

Fig. 12.—Diffraction of plane waves round an obstacle about 20 mm. wide and production of diffraction fringes.

Reproductions, on stout art board, of the illustrations on p. 226 can be supplied at £2.- each.

continued overleaf



FIG. 1



FIG. 2



FIG. 3

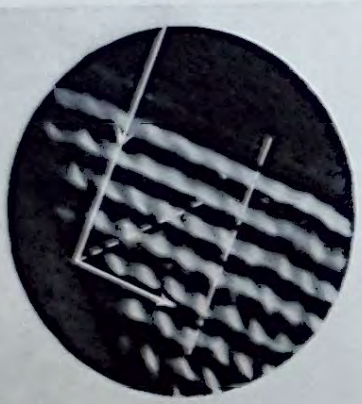


FIG. 4



FIG. 5



FIG. 6



FIG. 7



FIG. 8



FIG. 9



FIG. 10



FIG. 11



FIG. 12

Reproductions of screen images obtained with the Mitchell Ripple Tank A 61-238. Taken on Ilford Backed Rapid Process Panchromatic Plates at f 11 with f 5·6 lens. Exposures 5-15 secs. Explanatory key to illustrations on previous page.



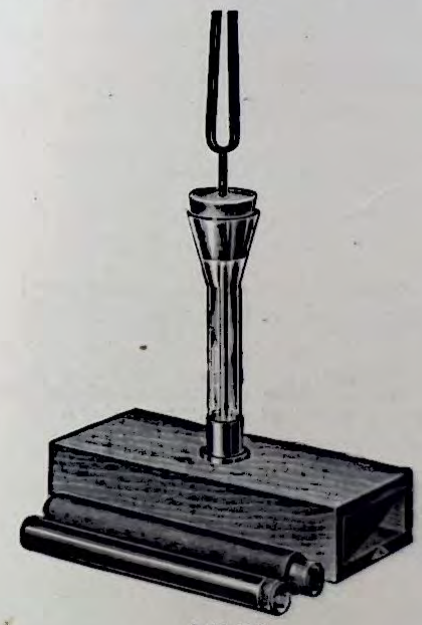
A 61-280.



A 61-290.

	£	s.	d.
A 61-280. ELECTRIC BELL to ring in vacuo, supported by circuit wires from rubber stopper, inside a glass receiver, 6 in. diam. over flange ; for fitting on an air-pump plate. **Without** battery	1	5	0
A 61-290. PROPAGATION OF SOUND APPARATUS (Barton: *Text Book on Sound*, p. 5), comprising tinned iron tube 6 ft. long, 4 in. diam., in two parts, telescoping into each other, with cone and small aperture at one end, complete with two iron supports	1	15	0

Smoke (from smouldering paper or chemically produced) is introduced into the wide end of the tube. On sharply striking together two wooden blocks B, B′, the candle flame C flickers, but no smoke issues from the cone, demonstrating that the sound is transmitted by the longitudinal vibration of the air particles and not their translatory motion.



A 61-320.



A 61-330.

	£	s.	d.
A 61-320. TYNDALL'S APPARATUS, showing that sound is transmitted by liquids and solids. Tuning fork **A 61-725, A** (428) resonance box, rods of wood and metal, 9 in. long, and a glass tube ending in a funnel. The rods and tube are made to screw on to the resonance box	2	15	0
A 61-330. VORTEX RINGS BOX (Preston: *Theory of Heat* ; Wagstaff, *Properties of Matter*), metal box, 8 × 6 × 6 in., with rubber sheet diaphragm at one end and small round aperture at the other for producing smoke rings	0	7	6

To generate the rings introduce a little ammonia solution (0·880) into the box and let the fumes unite with hydrogen chloride evolved from a dish containing common salt and sulphuric acid. A dense white cloud is formed and a sudden tap on the membrane causes the emission of a vortex ring due to friction of air at the orifice.

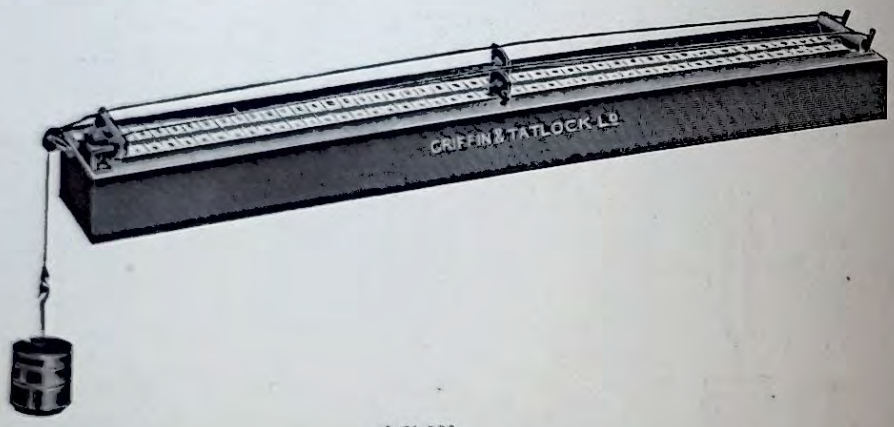
Various interesting properties may be demonstrated. Thus, on collision, two rings rebound and vibrate. Vibration also occurs if the rings are not circular. One ring ejected close behind another contracts and accelerates, while that in front expands and undergoes retardation allowing the other to overtake and pass through it.



A 61-350.

A 61-350. **SOUND LENS** (Sutton: *Demonstration Experiments in Physics*, p. 176), for demonstrating refraction of sound waves. Two sheet rubber discs 30 cm. diam. mounted vertically in a circular frame upon a tripod base. The admission of a gas, such as carbon dioxide, through the side tube inflates the rubber discs so that they assume the shape of a bi-convex lens the focal length of which can be varied by the pressure of the gas. Sound waves from a Galton whistle or other source are brought to a focus by means of the lens, the focal point being found by means of a sensitive flame. The choice of a gas for filling the lens may be based on the relationship:—refractive index from one medium to a second equals ratio of velocity of sound in first to that in second medium. See discussion in A. Wood: *Acoustics*, p. 159 .. .. £ 3 15 0

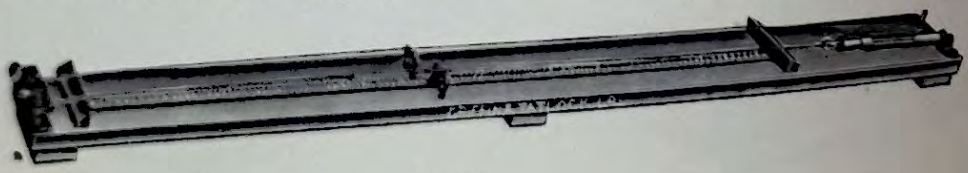
A 61-365. **Rubber Discs, spare,** cemented edge to edge .. 1 5 0



A 61-500.

A 61-500. **SONOMETER** (Allen & Moore: *Text Book of Practical Physics*, p. 221 *et seq.*), constructed throughout of best wood with the sides stained and polished. With four wires and two movable bridges. **Without** weights .. .. £ 3 15 0

Two heavy oak bridges are fitted at the ends between which a scale one metre long is fixed. Two wires are attached to one end of the board by means of piano pins; at the other end one of the wires is stretched over a brass pulley by suspending weights, the other wire is put under tension by a worm and cog fitting, giving a fine adjustment which is particularly smooth in action.



A 61-520.

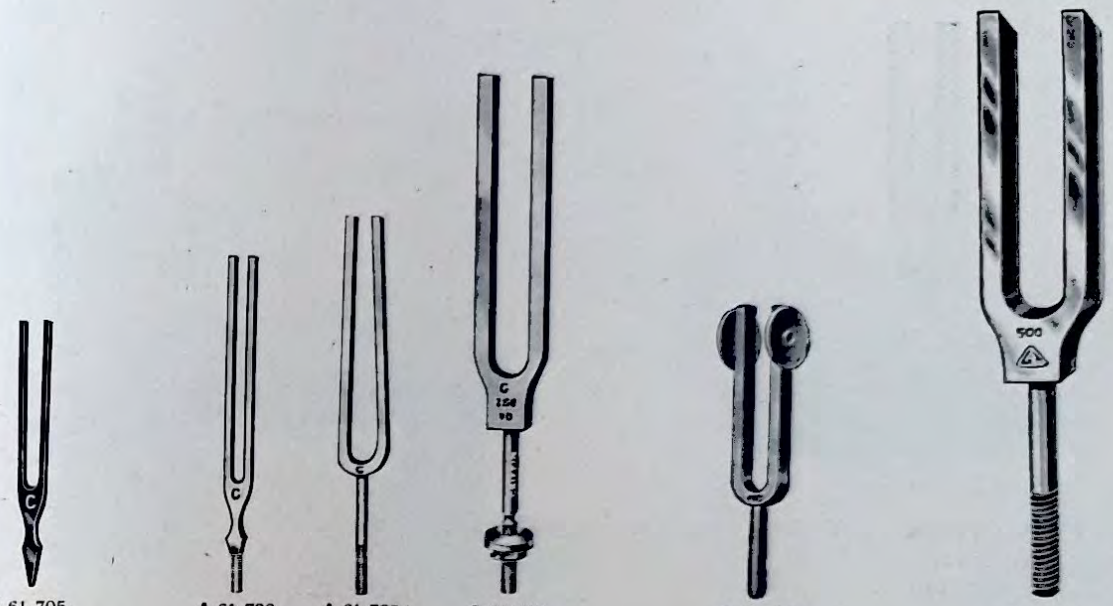
A 61-520. **SONOMETER,** wood board with spring balance reading to 20 kilos × ½ kilo. With four wires and two movable bridges. May be used vertically .. .. £ 4 5 0

A boxwood metre scale is fitted between the two fixed bridges. At one end of the board one wire is attached to a piano pin, another wire to the spring balance both wires being put under tension by worm and cog fittings, giving a fine adjustment which is particularly smooth in action.

A 61-525. **SONOMETER WIRES,** Set of 4, thin, two each brass and steel .. .. *set* 0 1 3

A 61-530. Ditto, thicker gauges .. .. *set* 0 1 3

WEIGHTS, SLOTTED, suitable for Sonometers, see Index.



A 61-705. A 61-720. A 61-725. A 61-730. A 61-745. A 61-755.

A 61-705. TUNING FORKS; Blued Steel, G, A or C″ (512), plain shank, length of prong about 3¼ in. .. .. *each* **2 9** ; *dozen* **1 9 0**

A 61-710. Ditto, with frequency marked. C′ (256), D, E, F, G, A, B, C″ (512) *each* **4 5** ; *dozen* **2 8 0**

TUNING FORKS, Nickel-plated, with frequency marked and with screwed shank for fixing into resonance boxes.

Dimensions.

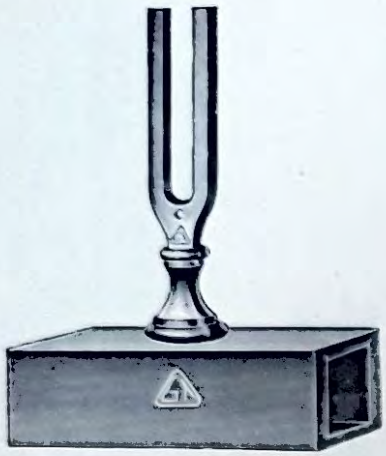
	C′ (256)	C″ (512)
Small size—length of prong	4¼	3 *in.*
Medium " "	4¼	3⅜ *in.*
Large " "	6¼	4¼ *in.*

Note	C′	D	E	F	G	A	B	C″	
Frequency ..	256	288	320	341	384	428	480	512	
A 61-720. Small	5/6	5/6	5/6	5/6	5/6	5/6	5/6	5/6	*each*
A 61-725. Medium ..	12/-	12/-	12/-	12/-	12/-	12/-	12/-	12/-	*each*
A 61-730. Large	44/-	44/-	40/-	40/-	36/-	36/-	36/-	36/-	*each*

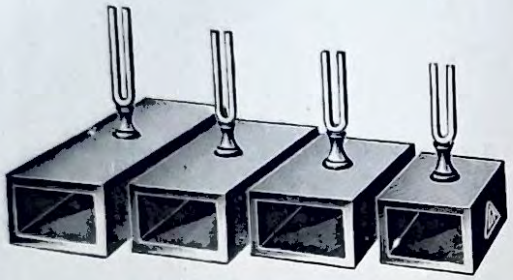
A 61-745. TUNING FORKS, Medium Size, nickel-plated, with frequencies marked. Each prong is fitted with a metal disc about ⅞ in. diameter in a plane perpendicular to the direction of motion of the prong. These forks have been found very satisfactory for resonance jar experiments as the attached discs set in motion a larger volume of air and enable more critical adjustment of the resonating length to be made. C′, D, E, F, G, A, B, C″ *each* **1 0 0**

A 61-755. TUNING FORKS, Nickel-plated, with screwed shank. Of carbon steel having a temperature coefficient of change of frequency of 0·00011 per ° C. and adjusted to an accuracy of ± 0·1 %. Unmounted.

Frequency	100	200	300	400	500	
Length prong, approx.	8½	6	5½	5	4½	*in.*
p	£3 15 0	£3 7 6	£3 5 0	£2 10 0	£2 10 0	*each*
Frequency	600	700	800	900		
Length prong, approx.	4½	4½	4	3½		*in.*
p	£2 15 0	£2 15 0	£3 5 0	£3 5 0		*each*
Frequency	1000	2000	3000	4000		
Length prong, approx.	3	2½	2	1¾		*in.*
p	£3 7 6	£3 7 6	£4 0 0	£4 15 0		*each*



A 61-805—815.

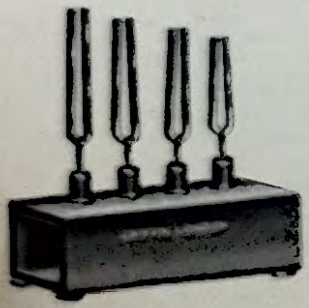


A 61-840—845.

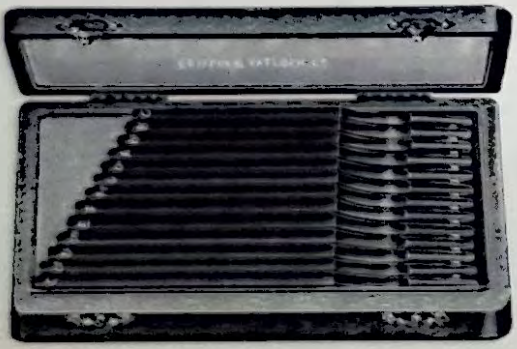
TUNING FORKS, A 61-720—725, mounted on resonance boxes.

Note	C′	D	E	F	G	A	B	C″	
Frequency ..	256	288	320	341	384	428	480	512	
A 61-805. Small	r 20/6	20/6	20/6	20/6	20/6	20/6	20/6	20/6	*each*
A 61-810. Medium	r 27/6	27/6	27/6	27/6	27/6	27/6	27/6	27/6	*each*
A 61-815. Large	r 63/-	63/-	63/-	63/-	57/6	57/6	57/6	57/6	*each*

	£	s.	d.
A 61-825. TUNING FORKS, Set of 3, small size, A 61-720, two in unison C′ (256), and one an octave higher C″ (512), each mounted on resonance box	r 3	0	0
A 61-830. Ditto, large size, A 61-730	r 9	0	0
A 61-840. TUNING FORKS, Set of 4, medium size, A 61-725, C′ (256), E, G, C″ (512), mounted on resonance boxes	r 5	10	0
A 61-845. Ditto, large size, A 61-730	r 12	10	0
A 61-855. TUNING FORKS, Set of 8, medium size, A 61-725, C′ (256), D, E, F, G, A, B, C″ (512), mounted on resonance boxes	r 10	18	0
A 61-860. Ditto, large size, A 61-730	r 24	10	0



A 61-880.



A 61-890—895.



A 61-920.



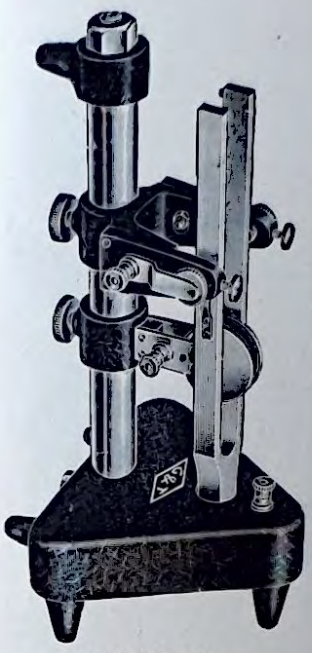
A 61-940.

	£	s.	d.
A 61-880. TUNING FORKS, Set of 4, medium size, A 61-725, C′ (256), E, G, C″ (512), mounted on a single resonance box, with hammer **A 61-940**	r 3	7	6
A 61-890. TUNING FORKS, Chromatic, Set of 13, from C′ to C″, in velvet lined leatherette case	r 3	10	0
A 61-895. Ditto, with frequency marked on each tuning fork	r 4	5	0

A 61-920. SLIDING WEIGHTS, for attaching to prongs of tuning forks, for use in lowering frequency to show beats, etc.

For tuning forks	Small or Medium	Large	
	r 2/9	6/9	*each*

A 61-930. BRISTLES, Hog, for use as styles with tuning forks	*bundle*	0	1 3
A 61-940. HAMMER, with double head, felt covered		0	4 0



A 62-120—125.



A 62-160.



A 62-190.



A 62-240.

	£	s.	d.
A 62-120. STAND, Tuning Fork (Smith: *Intermediate Physics*, 2nd edn., p. 564; Barton: *Text Book on Sound*, p. 361), for electrically maintaining fork. The stand is fitted with contacts of an improved type, one pair being used for maintaining a fork by 2 volt or 4 volt accumulator, the other for controlling phonic motor, etc. The base is of very heavy construction and can be used in either a vertical or horizontal position. **Without** fork *r*	9	0	0

A 62-125. TUNING FORKS, fitted with contacts, for use with above.

Frequency	100	200	300	
r	£5 0 0	£4 12 6	£4 10 0	*each*

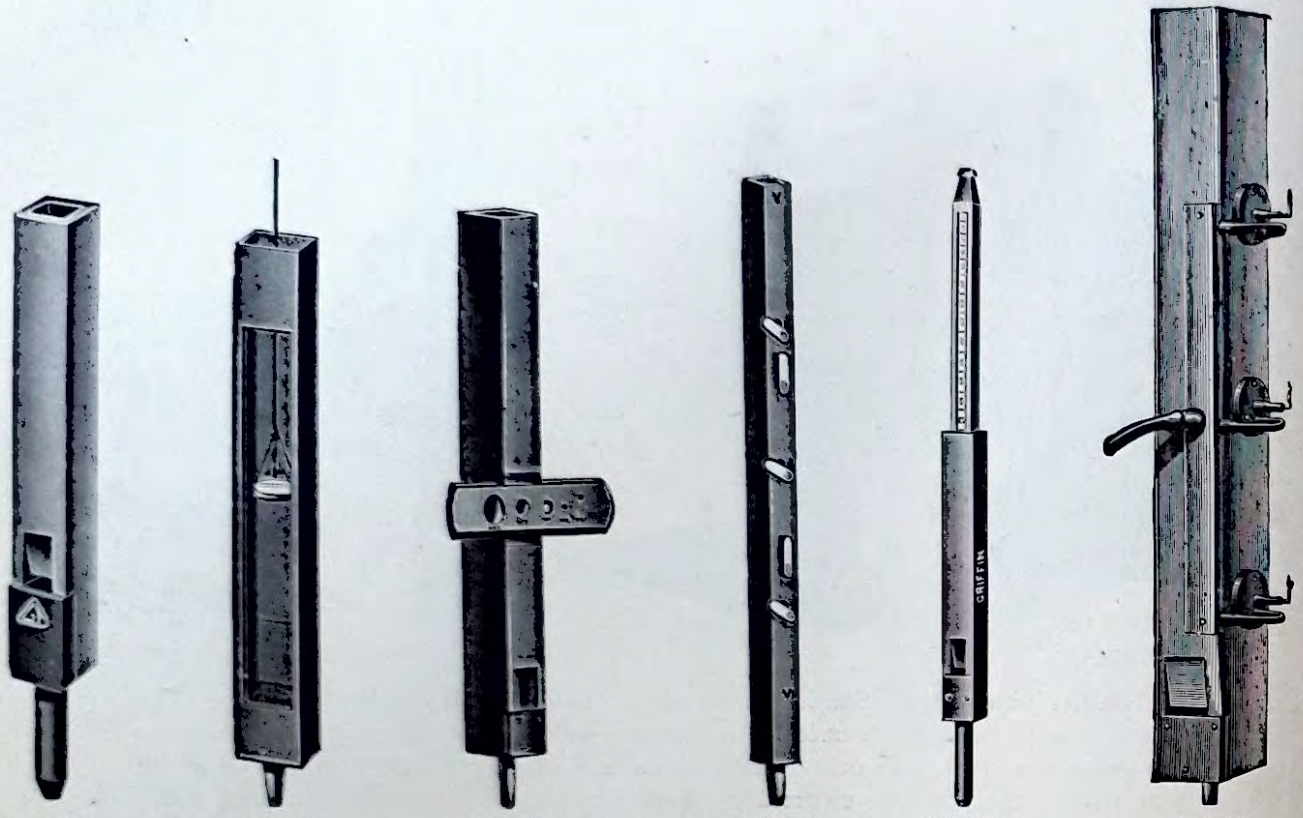
A 62-160. FALLING PLATE APPARATUS (Allen & Moore: *Text Book of Practical Physics*, p. 212), **for comparison of frequencies of two tuning forks** as well as for direct determination of frequency. A stout wood stand grooved to take a plate of smoked glass adjustable by means of clamping screw at back, and block to which two tuning forks are firmly screwed. Traces are recorded on the smoked glass plate as it falls, by means of a stylus attached to each tuning fork 2 0 0

A 62-190. GYROSCOPE, Hand, with six vibrating reeds of different frequency (A. Wood: *Acoustics*, p. 77). In case .. .. *r* 3 5 0

The small flywheel, 2½ in. diam., is slightly out of balance, so that when it is spinning the frame in which it is mounted vibrates. Six thin steel reeds of different lengths are fixed to the frame, and as the speed of the gyroscope declines it becomes coincident with the frequency of each reed in turn. The reeds are therefore thrown successively into vigorous vibration. The gyroscope is spun with a short length of twine.

A 62-240. CHLADNI'S PLATE, hard rolled metal, 12 in. square, mounted on heavy iron foot. For use in the delineation of nodal lines by sand figures, and for demonstration of interference. Solid CO_2, held against the edge of the plate, sets it into vibration more easily than does the conventional bowing 1 15 0

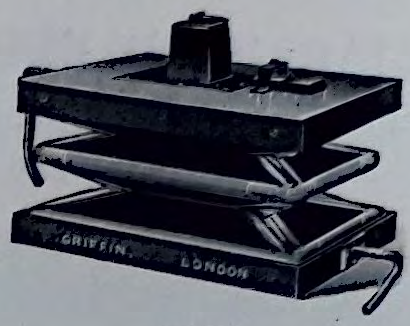
Griffin and Tatlock Limited from their five centrally situated Houses, provide a unique organisation for the supply of Complete Laboratory equipment.



A 62-250. A 62-260. A 62-265. A 62-270. A 62-280. A 62-290.

	£	s.	d.
A 62-250. ORGAN PIPE, Open, wood, varnished	1	1	0
A 62-255. ORGAN PIPES, Open, Set of 4, wood, giving a chord	4	0	0
A 62-260. ORGAN PIPE (Barton: *Text Book on Sound*, p. 247), wood, varnished, with glass front and membrane for loading with sand to show position of nodes and antinodes ..	3	0	0
A 62-265. ORGAN PIPE, wood, varnished, with a slide at the node in which are four openings of different sizes. The pitch rises as the size of the aperture is increased	3	0	0
A 62-270. ORGAN PIPE, Long, wood, varnished, with five valves by means of which the first four harmonics may be produced. With long piston for stopping the pipe at the nodes	3	10	0
A 62-275. Ditto, with six valves by means of which the first four odd harmonics may be produced	4	0	0
A 62-280. ORGAN PIPE, Stopped, wood, varnished, with movable piston marked with the chromatic scale from C″ (512) to C‴ (1024)	2	15	0
A 62-285. ORGAN PIPES, Set of 8, from C′ (256), giving the diatonic scale. With adjustable tuning pieces	7	10	0
A 62-290. ORGAN PIPE, Koenig (Barton: *Text Book on Sound*, p. 247), wood, varnished, with three manometric capsules to indicate nodes and antinodes	4	10	0

The General Index at the end of this Catalogue is a complete guide to its contents. Please consult it.

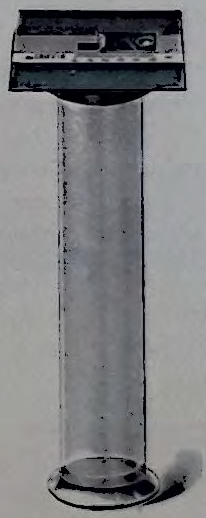


A 62-320.

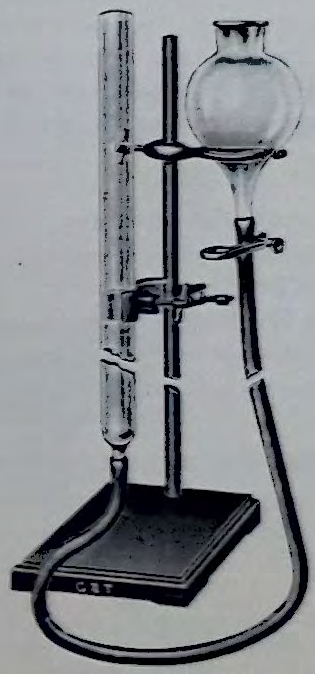
A 62-320. WIND REGULATOR, for obtaining a uniform pressure when blowing organ pipes with foot-bellows. A 4 lb. weight is required to bring wind pressure to about 2 in. on water gauge. **Without** weights .. .. *Price on application*



A 62-400.



A 62-410.



A 62-420—425.

A 62-400. RESONANCE JARS, Glass.

Height	12	16 *in.*
Diam. inside	2½	2 *in.*
	£ s. d. 3,9	7,3 *each*

A 62-410. RESONATOR. A tall glass jar, 16 × 2 in., closed at the top by a loose brass plate in which is cut a slot for the aperture. The size of the aperture is varied by means of a brass slider and the opening is measured on a graduated scale reading 0–40 mm. .. **1 15 0**

A 62-420. RESONANCE APPARATUS. Glass tube about 33 in. long with reservoir supported on split iron ring with collar, rubber tube with spring clip, retort stand and clamp .. **1 15 0**

A 62-425. Ditto. Glass tube, split iron ring with collar, rubber tube with spring clip and reservoir only. **Without** retort stand and clamp **1 5 0**

This apparatus is particularly suitable for use with tuning forks and manipulation of the formula $v = n\lambda$. The water levels at the two positions of resonance ($\lambda/4$ and $3\lambda/4$) may conveniently be marked by means of rubber bands. From measurements so made the end-correction may be eliminated.

THE MICROID JACKETED RESONANCE TUBE

An interesting apparatus for performing an unusual and important experiment



A 62-450.

The effect of change of temperature on the velocity of sound in air is an interesting phenomenon seldom dealt with experimentally. The Microid Resonance tube has been designed for the purpose. The resonating length is easily altered by means of a piston, the head of which gives a rigid reflecting surface and provides a well-defined boundary from which accurate measurements may be made. Water vapour being excluded, as it frequently is not in other types of resonance tube, observations are made on a sample of gas which is truly representative of the ambient atmosphere. The apparatus can, of course, also be used for the standard resonance tube experiments.

SPECIFICATION

A metal tube about 105 × 3·5 cm. is fitted with a jacket having inlet and outlet tubes, which enable a current of steam to be circulated through the jacket. The tube is supported in a slightly inclined position on metal legs fitted with rubber feet, the open end being the lower so that undue convection of the air in the open tube may be avoided. The resonating length of the tube is varied by means of a closely fitting piston arranged so that fine adjustment may be carried out from the open end of the tube. A specially designed tuning fork **A 61-745**, is recommended which, having metal discs affixed to the prongs, facilitates location of the resonance points.

	£	s.	d.
A 62-450. MICROID RESONANCE TUBE, jacketed metal tube, internal dimensions about 105 × 3·5 cm., supported on legs fitted with rubber feet and provided with piston and auxiliary rod for fine adjustment of resonating length	5	10	0

EXPERIMENTAL NOTES

Set up the resonance tube on the bench and place a suitable block to support the projecting end of the piston rod. Measure the temperature θ_1 of the air inside the tube and then, with a tuning fork held near the mouth of the tube, obtain two positions of resonance. Take the mean of several settings of the piston in each position. Measurement of the resonating length can most conveniently be made by means of a metre rule inserted in the tube.

In order conveniently to adjust the resonating length a fine adjustment is fitted to the piston. The adjustment is carried out by moving the projecting end of the piston rod, from the closed end of the tube, until a position of approximate resonance is obtained. The clamping screw **A** is then tightened and fine adjustment carried out from the open end of the tube by moving the milled, heat-insulated head **B** and at the same time holding the tuning fork near the open end of the tube and listening for maximum intensity.

After having connected a steam generator to the inlet tube and a waste pipe to the sink from the outlet tube, the experiment should now be repeated. Pass a current of steam through the jacket until thermal conditions are steady and take the temperature θ_2 of the air in the tube. Obtain the two positions of resonance as before.

SPECIMEN RESULT

Frequency of tuning fork . . . . = 288 vibs./sec.

Mean temp. of air in tube at θ_1 = 14° C. . = 287° K.

Mean temp. of air in tube at θ_2 = 99·5° C. = 372·5° K.

Length of tube for resonance at θ_1:

$\lambda/4$ = 28·2 28·1 28·05 29·1 28·1 cm.
Mean = 28·11 cm.

$3\lambda/4$ = 86·2 87·0 87·2 87·0 86·6 cm.
Mean = 86·82 cm.

$\therefore \lambda_{\theta_1}$ = 2(86·82 − 28·11) = 117·42 cm.

$\therefore V_{\theta_1}$ = 117·42 × 288 = **33870 cm./sec.**

Length of tube for resonance at θ_2:

$\lambda/4$ = 31·3 31·2 31·3 31·2 31·2 cm.
Mean = 31·24 cm.

$3\lambda/4$ = 99·5 98·7 98·0 98·6 98·9 cm.
Mean = 98·74 cm.

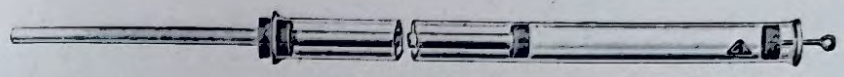
$\therefore \lambda_{\theta_2}$ = 2(98·74 − 31·24) = 135·0 cm.

$\therefore V_{\theta_2}$ = 135 × 288 = **38860 cm./sec.**

Ratio of velocities = $\frac{V_{\theta_2}}{V_{\theta_1}} = \frac{38860}{33870}$ = **1·147**

Ratio of $\sqrt{\text{absolute temperatures}}$ = $\sqrt{\frac{372·5}{287·0}}$ = **1·140.**

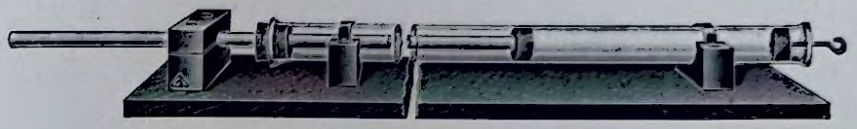
The velocity is thus shown, within the limit of experimental error, to be proportional to $\sqrt{K}$.



A 62-480.

£ s. d.

A 62-480. KUNDT'S APPARATUS, glass tube 5 ft. long × 1¼ in. diam., glass piston rod with cork ring fitted in one end and cork piston in the other 1 0 0



A 62-485.

A 62-485. KUNDT'S APPARATUS, A 62-480 mounted on baseboard with supports for the glass tube and clamp for the glass piston rod 2 10 0

A 62-490. PISTON RODS, for Kundt's Apparatus, A 62-480—485, Glass .. .. *pair* 0 7 6

A 62-495. Ditto, long piston only.

Glass	Wood	Steel	Brass
4/6	2/6	7/6	8 6



A 62-500.

£ s. d

A 62-500. KUNDT'S APPARATUS for determining the velocity of sound in different gases. Tube 5 ft. long × 1¼ in. diam. ; glass piston rod. With brass stopcocks and fittings. **Without** clamps 5 10 0

A 62-505. LYCOPODIUM, powder .. .. *oz.* 1 2 1 ; *lb.* 1 5 0



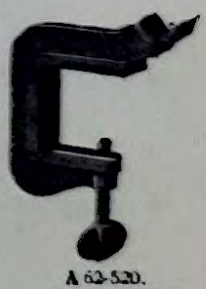
A 62-510.

£ s. d.

A 62-510. CLAMP, Iron, to screw to bench, with horizontal clamp for tubes, rods, etc. .. .. .. *r* 0 17 6

A 62-520. CLAMP, Iron, with a V-shaped trough in which to support centre of long tubes .. .. .. *r* 0 15 0

Illustration **A 62-500** *shows how the clamps* **A 62-510** *and* **A 62-520** *are used for setting up a Kundt's Tube.*



A 62-520.

Please use our Catalogue Numbers in your requisitions and orders. They are a complete specification of your requirements.

£ s. d.

A 62-720. RIJKE'S TUBE (A. Wood: *Acoustics*, p. 92), glass, with wire gauze diaphragm **0 12 6**

If the wire gauze diaphragm is placed about one-third the length of the tube from the bottom end, and is made red hot by a small gas flame, a loud note is sounded when the tube is removed from the flame, due to vibrations set up by the motion of air through the gauze.

A 62-730. SINGING TUBES, Knipp, Silica (Knipp: *Physiol. Rev., Series* 2, 1918, **12**, 491; Sutton: *Demonstration Experiments in Physics*, p. 160). To demonstrate (*a*) the direct conversion of heat energy into sound, (*b*) production of sound by means of a vibrating air column, (*c*) relation between pitch and length of a vibrating air column, and (*d*) phenomena of beats. Length 6 in. .. .. *each tx* **0 7 6**

A 62-735. Ditto, length 3 in. .. .. *tx* **0 4 0**

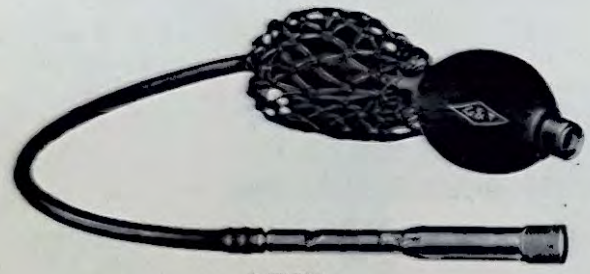
Heat the closed end of the tube by a Bunsen burner. A very penetrating note is emitted, of such purity that it has been suggested as a possible standard source. Frequency can be changed and powerful beats demonstrated by providing one of the two tubes with a glass sleeve fitted by rubber tubing, and by heating two tubes simultaneously. Resonators can be made from glass flasks by cutting neck short, blowing on a short tube diametrically opposite and attaching by rubber tube to the Knipp tube.



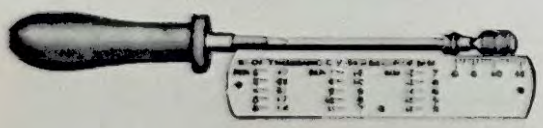
A 62-720.



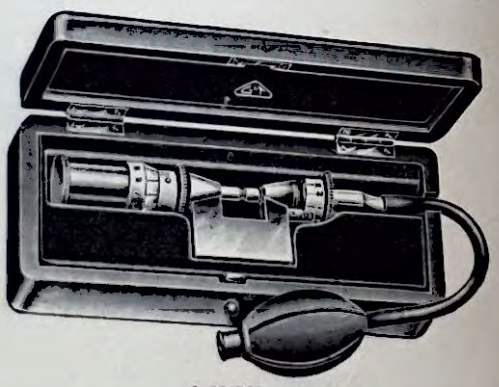
A 62-730—735.



A 62-750.



A 62-760.



A 62-765.

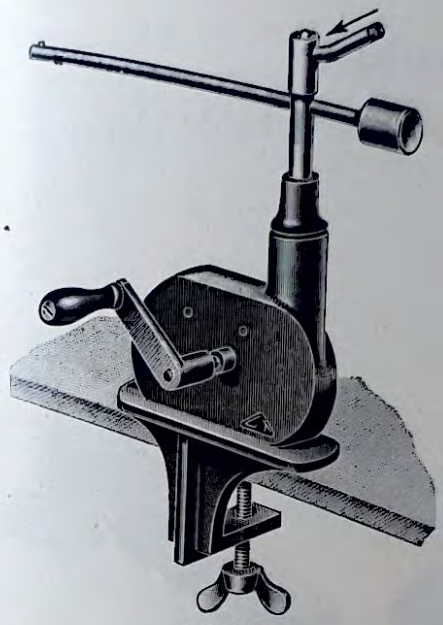
£ s. d.

A 62-750. WHISTLE, Galton. Nickel-plated pipe graduated in mm. with plunger head divided in ten divisions enabling pipe-length of whistle to be read to 0·1 mm. With hand bellows provided with constant pressure bulb **2 2 0**

A 62-760. WHISTLE, Galton, with very fine bore pipe for producing notes up to the limit of audibility. With scale showing the pipe-length of the whistle and the equivalent frequency. In case .. .. *t* **3 15 0**

A 62-765. WHISTLE, Galton. Pipe length adjustable by micrometer screw calibrated 0–25 mm. and reading to 0·1 mm. Air supply from a rubber hand bulb; adjustable jet, range 0–3 mm. reading to 0·1 mm. Nickel plated, white ivory scales, in polished wood case *t* **10 0 0**

Particular attention is given to the production of apparatus designed for special purposes by our customers.



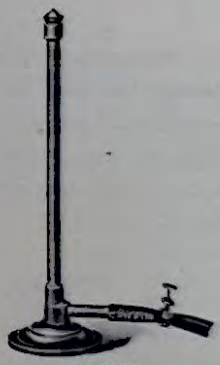
A 63-140.

£ s. d.

A 63-140. DOPPLER EFFECT APPARATUS, to demonstrate the apparent change of frequency due to relative motion between the source and the observer. A reed is mounted at one end of a tube attached to a hand centrifuge, the other end of the tube being counterbalanced. Air from a foot bellows is conducted to the reed through the (stationary) tube marked with an arrow. As the reed tube is rotated the source alternately approaches and recedes from the observer. Rapid rotation produces sounds resembling beats .. .. *r* 6 0 0



A 63-180.



A 63-190.



A 63-195.



A 63-210.

£ s. d.

A 63-180. MANOMETRIC CAPSULE, on iron foot, with receiver for directing sounds on to membrane 3 0 0

A 63-190. SENSITIVE FLAME (Barton: *Text Book on Sound*, p. 363), for high notes and sibilants. With screw-clip 0 15 0

This flame will work only with a good gas pressure and is insensitive to a pressure less than 3 in. of water. With a pressure of 3½ to 5 in. it is extraordinarily sensitive to sound waves of short length. The hissing of sibilants, rattling of keys, blowing of whistles, tinkling of glass, etc., will cause the flame to shorten and roar. By means of the screw clip the flame should be so adjusted that it is just on the point of roaring.

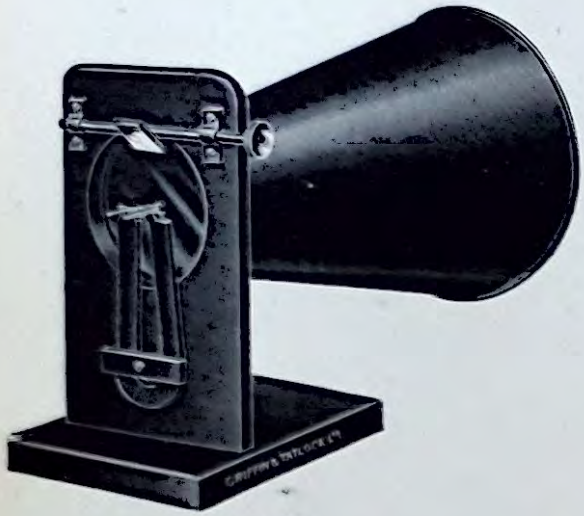
A 63-195. SENSITIVE FLAME, Rayleigh (Barton: *Text Book on Sound*, p. 364), for sounds of the wavelength of the human voice. With screw-clip .. .. *p* 2 10 0

This flame, which works at ordinary gas pressures, should be so adjusted as to be unstable. The gas is delivered through a jet into the interior of a small box, which is closed on one side with mica. On issuing from the vertical tube the gas is lighted. The clip is screwed up until the flame just leaves the top of the tube, apparently issuing from the interior in a lop-sided form.

A 63-210. ROCKER, Trevelyan (Barton: *Text Book on Sound*), p. 348, with lead block .. 0 17 6

THE MICROID PHONODEIK

A new apparatus for projecting wave forms with remarkable clarity



A 63-240.



A 63-245.



A 63-250.

The study of sound has long suffered from a lack of simple apparatus with which visually to demonstrate wave forms. Almost the only instrument available has been the manometric capsule, and although this has given fairly satisfactory results, yet, because of the labour and time involved in its setting up, many lecturers may have felt tempted to omit important demonstrations from their curricula. The Microid Phonodeik is readily set up and provides a means of demonstrating acoustical phenomena in a convincing and interesting manner. (Saunders: *A Survey of Physics*. Miller: *Sound Waves, their Shape and Speed*.)

SPECIFICATION.

A wood upright about 8 × 5 in. contains a circular aperture about 3½ in. diam. and is carried on a firm base. On one face of the upright is mounted a horsehoe magnet whose poles are in the form of knife edges. On the other face is fixed a flange holding a thin, sensitive, glass diaphragm between resilient washers. The flange carries a removable metal cone 12 in. long having a maximum diameter of about 8 in. At the centre of the glass diaphragm is cemented a fork of soft iron wire, the arms of which are the same distance apart as the knife edges and bear on a short spindle of steel wire carrying a small rectangular mirror, this being supported on the knife edges. A mirror 1 × ⅝ in. is mounted on a rod above the small mirror and is adjusted by a milled head attached to the rod.

	£	s.	d.
A 63-240. MICROID PHONODEIK, with magnet, oscillating and stationary mirrors, glass diaphragm and metal cone, mounted on wood base	4	15	0
A 63-245. Octagonal Rotating Mirror, 5½ in. high, on metal base 6 in. diam., for use on gramophone turntable	2	5	0
A 63-250. Projector Lamphouse, with clamp for fitting to stand. **Without** lamp	6	15	0
Lamps, 12 volt 24 watt, S.B.C., for use with **A 63-250**, .. see **A 58-495**.			

EXPERIMENTAL NOTES

The phonodeik operates as follows. With the metal cone fitted into its socket, sound waves are collected and impinge on the glass diaphragm, causing it to vibrate. As it vibrates the fork attached to it moves over the circumference of the steel wire carrying the mirror, thus rolling it along its supporting knife edges. This rolling of the wire rocks the mirror through a small angle and a beam of light directed on to it is reflected and can be received on a screen as a spot which moves up and down as the diaphragm oscillates. By using a revolving mirror in the path of the reflected beam a horizontal line is traced on the screen when the diaphragm is at rest.

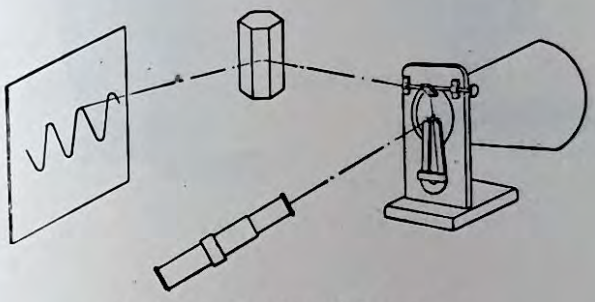
A 63-240—The Microid Phonodeik—*continued*

The combination of the vertical and horizontal movements produces on the screen a reproduction of the wave form, the amplitude of which, depending upon the distance of projection, is 5–10 cms.

In practice it has been found that the optimum screen distance (*i.e.* length of path of the reflected beam) is about 2 metres. The attempt to obtain higher magnifications by increasing the screen distance then results only in a larger, fainter, and more blurred trace in which the " cusps " cannot be seen with such good definition as at 2 metres.

The best results have been obtained with projection lamp **A 63-250**, which is specially adapted for this purpose. A very intense, narrow pencil of light, covering the small mirror, is obtained.

The revolving mirror may be of any standard design, but we recommend the octagonal mirror (**A 63-245**) which is constructed for use on the turntable of a gramophone. The fact that it has eight faces enables a trace to be produced which is steadier and in which less flicker is apparent than with the type which has only four faces.



Phonodeik : Experimental Arrangement.

The experimental arrangements are very simple (see diagram). The beam from the projector lamp is directed on to the small mirror, which is then adjusted to reflect it on to the mirror vertically above it. This mirror, though it may be omitted and the beam reflected direct on to the revolving mirror, serves, by tilting, for convenient and easy adjustment of the height of the spot on the screen. From this mirror the beam is reflected on to the revolving mirror and from thence on to the screen. In many rooms which are not too brightly lighted, projection on to a ground glass or translucent (tracing) paper screen will obviate the necessity for darkening the room.

The phonodeik is a sensitive instrument and the only control exerted over the small mirror is that due to the force of attraction between the arms of the fork and the magnetic knife edges. It may, therefore, happen that the angular momentum of the mirror will overpower this magnetic control, if the amplitude of the diaphragm is too great, and result in a lack of zero stability of the spot. For this reason it will be found that a suitable distance for the sound source from the cone is about 3–4 ft. For sounds of small amplitude, shorter working distances may be adopted.

A few of the more obvious demonstrations possible are indicated below :—

1. Frequency.

Blow or sound fairly high and fairly low pitched organ pipes or tuning forks in turn and observe the effect of frequency. Note also the wave form (sinusoidal) of the pure notes.

2. Amplitude.

Sound a note about 3–4 feet from the mouth of the collecting cone and observe the amplitude of the resultant curve. Sound the same note with the same loudness about 1–2 feet from the cone and note the difference between this amplitude and that of the first note.

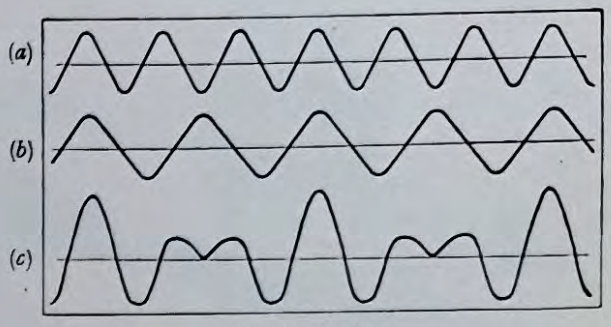


Fig. 1.—Beats.

3. Beats.

Sound in turn notes whose frequencies differ but little (*a*) and (*b*). Sound them together and note the periodic increased maxima and destructive interference of the resultant curve (*c*).

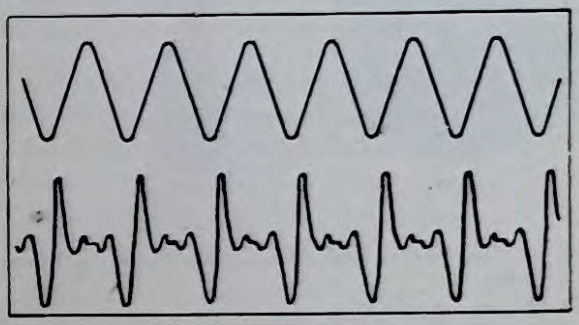


Fig. 2.—Harmonics.

4. Harmonics and Quality.

Blow an organ pipe and note the form of the trace and then overblow it. Whereas the first produces a pure sinusoidal curve the second produces a curve containing many " cusps." The dependence of quality upon the presence of harmonics and overtones should be pointed out.

5. Resonance.

With some suitable key note and at a convenient distance from the cone sing the notes of the musical scale, keeping the sounds of an equal loudness. Note the great increase in the amplitude of the trace when the diaphragm is vibrating in resonance with the voice.

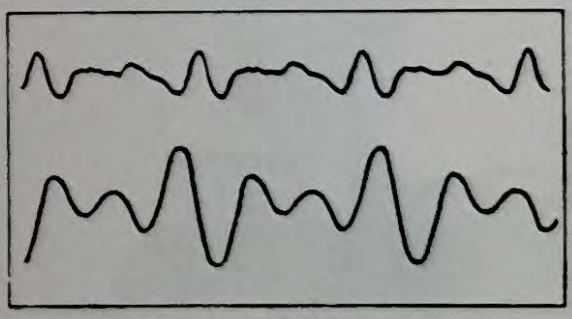


Fig. 3.—Vowel form.

6. Vowel form.

Speak any of the vowels distinctly at 1–2 feet from the cone, sustaining the sound as long as possible. Note the characteristic form of the vowel and compare it with the explosive effect of the dental sounds. It is instructive to compare the wave forms resulting from similar sounds made by different voices.



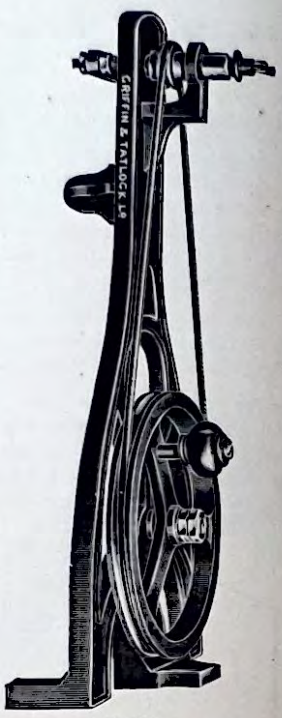
A 63-405.



A 63-420.

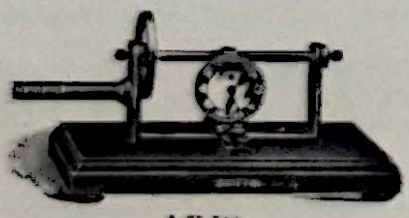


A 63-430 + 405.

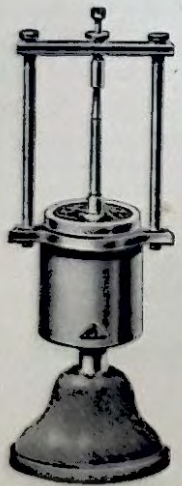


A 63-440.

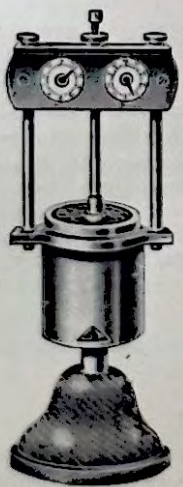
	£	s.	d.
A 63-405. DISC, SAVART, 6 in. diam., with four rows of holes and toothed edge	2	5	0
A 63-420. ROTATOR, hand, for above or similar discs .. .. *r*	1	10	0
A 63-430. WHIRLING TABLE, suitable for spinning disc **A 63-405. Without** disc .. .. *r*	3	0	0
A 63-440. WHIRLING TABLE. Frame of cast iron built to stand either horizontally or vertically. The driving wheel is adjustable for belt tensioning .. .. *r*	3	5	0



A 63-510.



A 63-520.

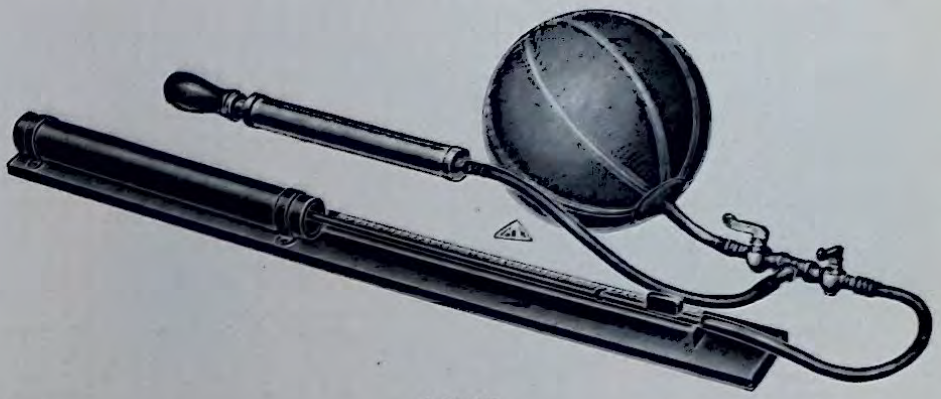


A 63-530.

	£	s.	d.
A 63-510. SIREN, Cagniard de la Tour, brass, with revolution counter	3	10	0
A 63-520. Ditto, vertical pattern, brass, with wind chest and removable wood stand ..	3	15	0
A 63-530. Ditto, as A 63-520, fitted with revolution counter	7	10	0



A 63-720.



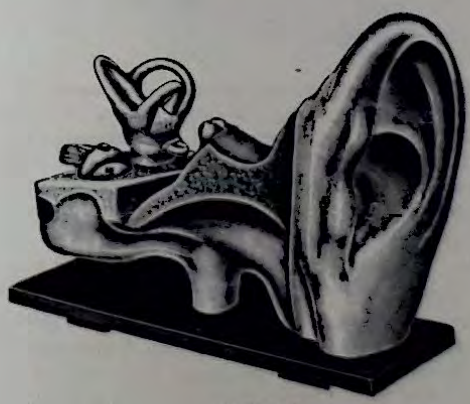
A 63-740.

	£	s.	d.
A 63-720. **INTERFERENCE TUBE, Quincke,** for use with tuning fork of 512 d.v.s.	0	7	6

If the tuning fork be held at the open end of one of the tubes, no sound will be heard at the other end, when the difference between the length of the two paths is equal to half the wavelength of the note emitted by the tuning fork. Upon closing the longer path by nipping the rubber tubing, the note is at once heard.

A 63-740. **SOUND INTERFEROMETER, West** (West: *J. Sci. Instr.*, 1929, **6**, 254). Demonstrating destructive interference by the superposition of two waves out of phase, and measuring wavelength. Apparatus comprises a whistle, mounted in a metal tube 30 cm. long, virtually constituting a closed organ pipe of variable length and frequency. Mounted on baseboard 66 × 5 cm. with boxwood scale 31 cm. long, reading directly wavelengths in cm. A brass hand pump with barrel 24 × 3 cm. and air bladder with metal T-piece with two taps form a satisfactory air supply .. .. r 3 10 0

A source of sound situated at some point on the axis of a closed tube sends out waves which can reach the open end by two paths—directly, or by reflection from the closed end. Two sets of waves thus issue from the tube, and their phase relationship can be controlled by the position of the source. The latter can be so placed that, in the issuing disturbance, the crest of the direct wave falls on the trough of the reflected wave. In this case the sound is almost completely obliterated. On the other hand, when the source is moved one quarter wavelength along the tube, the crest of the direct wave falls on the crest of the reflected wave, and the sound is then at a maximum. It is again reduced to a minimum when the whistle is moved yet another quarter wavelength. The wavelength is thus easily determined from the distance between two minima.



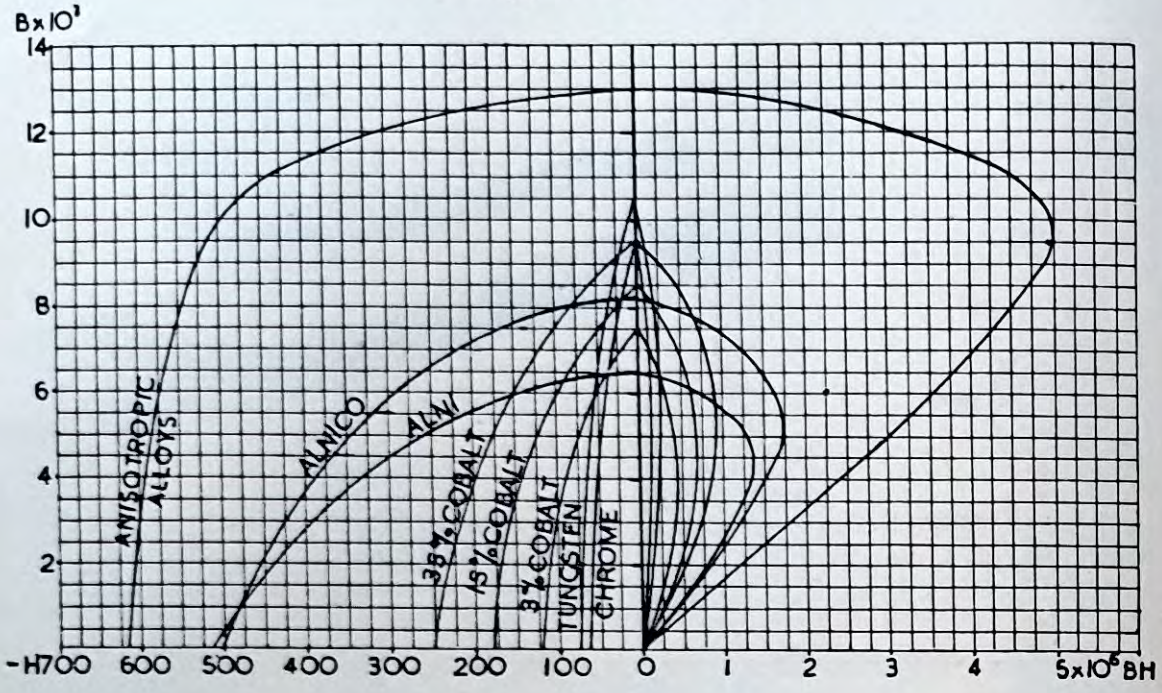
A 63-810.



A 63-815.

	£	s.	d.
A 63-810. **EAR, Model,** enlarged approximately five times, 15 × 7 in. high. Inner ear opens to show vestibule, cochlea, semi-circular canals, etc., which are removable. Middle ear shows stapes, incus and malleus, also tympanum .. .. r 7 10	0		
A 63-815. **LARNYX, Model,** enlarged three times, on base, epiglottis and vocal chords removable r 5 15	0		

Magnetism



TUNGSTEN AND CHROMIUM MAGNETS (W + Fe and Cr + Fe).—These are the earliest steels specially manufactured for use as permanent magnets. They are forgeable and machinable and the resultant permanent magnet after hardening is still relatively tough and strong. Their performance is in the region of $BH_{max} = 0{\cdot}3 \times 10^6$. They were extensively used until cobalt magnets were produced about 1920.

COBALT MAGNETS (Co, Fe).—The performance and magnetic characteristics of these magnets vary with the cobalt content. The magnets are made with various cobalt contents. For example, a magnet with 3 % cobalt has a performance of approximately $BH_{max} = 0{\cdot}35 \times 10^6$. The maximum cobalt content normally employed is 35 % with a performance of approximately $BH_{max} = 1{\cdot}0 \times 10^6$. The steels, in common with the earlier types, have the useful property of being machinable and are well adapted to the production of magnets, where intricate shapes machined to close tolerances are required.

NICKEL-ALUMINIUM RANGE OF MAGNET ALLOYS.—These isotropic (non-directional) magnet alloys, introduced into this country in about 1923, were based on the work of Mishima in Japan. They are extremely hard and crystalline and therefore comparatively brittle and are not generally machinable other than by grinding, although with careful heat treatment they may, under certain conditions, be drilled and machined, after which re-heat treatment is necessary for the development of their magnetic properties.

They will give a magnetic performance up to $BH_{max} = 1{\cdot}7 \times 10^6$ and the chemical analysis may vary between the following approximate limits :—

6–12 % Al, 12–28 % Ni, 0–25 % Co, 0–6 % Cu, + balance Fe.

Small amounts of other metals may be added to obtain special characteristics. The alloys are variously known by such trade-names as Alnico and Alni in this country, and as Alnico I–IV in America.

The alloys have a considerably higher coercive force than earlier magnetic alloys and their length-to-section ratio for a given purpose is therefore much smaller than is required with the older steels. In designing magnet systems using Alnico, earlier conceptions based on alloys then available must be discarded and a new approach made to the particular design problem. Magnet designs using Alnico are therefore dimensionally much different from earlier designs.

Alnico withstands the effects of heat and vibration to a much greater extent than earlier steels.

ALCOMAX AND TICONAL.—These anisotropic (directional) magnetic alloys are the latest and most powerful permanent magnets. They were introduced in 1938. Their directional magnetic properties result from heat treatment in a magnetic field of about 2000 gauss during their manufacture. These Ni-Al alloys are even harder than the earlier alloys and are subject to similar physical limitations, *i.e.* they are not generally machinable except by grinding.

Published figures for the chemical analysis of this type of alloy are :—

8 % Al, 14 % Ni, 24 % Co, 3 % Cu + balance Fe.

The alloys are known under trade names such as Alcomax and Ticonal in this country and as Alnico V in America. Their performance may attain under commercial manufacture $BH_{max} = 5{\cdot}7 \times 10^6$.

The published performance data is as follows :—

	B_r (gauss).	H (oersted).	BH_{max}.
ALCOMAX II	12,400	575	$4{\cdot}3 \times 10^6$
ALNICO V	12,500	600	$4{\cdot}5 \times 10^6$
TICONAL	13,480	583	$5{\cdot}7 \times 10^6$

The stability of these materials with respect to time and temperature is very high. Ticonal magnets, not specially aged or stabilised, have been maintained at a temperature of 500° C. for a period of 24 hours. The diminution in pole strength after this treatment was less than 0·5 %. They are also unaffected by conditions of severe vibration, *e.g.* repeated dropping, provided that fracture does not occur.

An informative paper entitled " Modern Hard Magnet Materials " by Hoselitz is to be found in *J. Sci. Instr.*, 1946, **23**, 65.

Precautions in handling Magnets.—If the pole strength of a magnet is required to be maintained unimpaired, ferro-magnetic objects should not be allowed to come into contact with it at other than the pole faces. The intense field induced at the area of contact is sufficient to disturb the orientation in the vicinity of this area with a consequent reduction of total flux at the pole face. Similarly, magnets in repulsion can effect such a mutual disturbance of each other's fields that serious demagnetisation can result if the magnets are in close proximity.



A 71-105.



A 71-120.



A 71-130—150.

A 71-105. MAGNETIC IRON ORE, demonstration specimens .. .. *each* £ s. d. 0 2 6

A 71-120. MAGNETS, Bar, Tungsten Steel (see p. 242), in pairs, well-polished, with keepers, strongly magnetised.

Length ..	2	3	4	5	6	8	12	*in.*
	2/-	2/3	2/9	3/-	4/-	5/9	10/-	*pair*

A 71-130. MAGNETS, Bar, 15 % Cobalt Steel. In pairs with keepers.

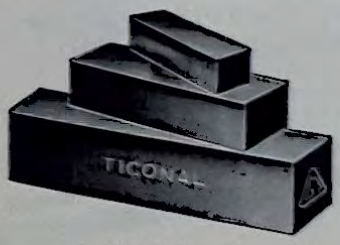
Length ..	2	3	4	6	6	8	10	12	*in.*
Cross Section ..	$\frac{1}{4} \times \frac{1}{2}$	$\frac{1}{8} \times \frac{3}{8}$	$\frac{3}{16} \times \frac{1}{2}$	$\frac{3}{16} \times \frac{5}{8}$	$\frac{1}{4} \times \frac{3}{4}$	$\frac{1}{4} \times 1$	$\frac{1}{4} \times 1\frac{1}{4}$	$\frac{1}{4} \times 1\frac{1}{4}$	*in.*
p	2/-	2/6	3/-	5/-	7/6	15/-	25/-	35/-	*pair*

A 71-150. BOXES, to contain a pair of bar magnets. **Without** magnets.

To take magnet length	3	4	5	6	8	10	12	*in.*
	3/6	4/-	4/6	5/-	5/6	6/-	6/6	*each*



A 71-190.



A 71-205.

A 71-190. MAGNETS, Bar, 15 % Cobalt Steel (see p. 242), single rectangular bars.

Length	1	3	4	5	6	8	*in.*
Cross Section $\frac{1}{4} \times \frac{5}{16}$ in. *p*	10d.	1/3	1/7	2/-	2/5	3/7	*each*
,, ,, $\frac{3}{16} \times \frac{3}{8}$ in. *p*	1/3	1/7	2/2	2/10	3/3	4/5	*each*
,, ,, $\frac{3}{8} \times \frac{3}{8}$ in. *p*	1/6	2/-	2/8	3/3	4/-	5/3	*each*
,, ,, $\frac{3}{16} \times 1$ in. *p*	1/11	2/8	3/6	4/-	5/3	6/5	*each*

A 71-205. MAGNETS, Bar, Ticonal (see p. 242), the new anisotropic alloy. In a correctly-magnetised and designed circuit, the 1 in. magnet below will give the equivalent performance of an energised solenoid of 1,000 amp.-turns.

Length ..	$\frac{1}{2}$	$\frac{7}{8}$	1	$1\frac{1}{2}$	$2\frac{1}{2}$	*in.*
Cross Section	$\frac{3}{16} \times \frac{3}{16}$	$\frac{1}{4} \times \frac{1}{4}$	$\frac{1}{4} \times \frac{3}{8}$	$\frac{3}{8} \times \frac{3}{8}$	$\frac{3}{8} \times \frac{1}{2}$	*in.*
p	1/6	2/-	2/6	3/-	4/-	*each*



A 71-230—245.



A 71-260.

A 71-230. MAGNETS, Bar, Alni and Alnico, Laboratory Set (see p. 242), one each 2 in. and 3 in. long in correctly-designed case with sliding lid .. .. *tx* £ 0 15 9

Magnets only, for above, single rectangular bars, cross-section $\frac{7}{16} \times \frac{3}{4}$ in.

Length	2	3	*in.*
A 71-240. Alni	*tx* 3/6	4/-	*each*
A 71-245. Alnico	*tx* 4/6	5/6	*each*

The set contains one each magnets 2 in. and 3 in. long of ALNI and ALNICO—four magnets in all, in a specially-designed case about $4\frac{1}{4} \times 3\frac{1}{2} \times 1$ in. fitted with a sliding top. The case is so designed that the magnets are stored at their correct distances apart. The base of the case is painted with spots to agree in colour with the markings of the poles (N-seeking red, S-seeking blue). The external field from the magnets in the box is shown on page 249.

The highly coercive properties of these magnets render them relatively immune to the effects of demagnetising forces, and they are suitable for use as laboratory standards, if handled with proper care.

The magnets should not be allowed to come into contact with one another.

As they are sufficiently powerful to affect magnetometers and compass needles at distances of the order of three feet, these magnets are particularly suitable for general laboratory experiments.

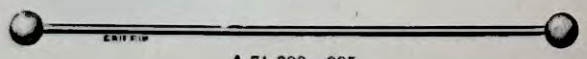
A considerable proportion of the magnetism is retained at temperatures up to 600° C.

A 71-260. MAGNETS, Cylindrical, Tungsten Steel (see p. 242), $\frac{3}{8}$ in. diam.

Length	4	6	8	*in.*
	1/6	2/6	3/6	*each*



A 71-275—285.



A 71-300—305.

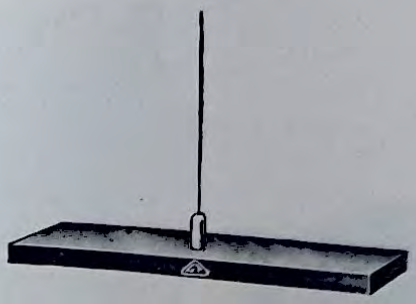
MAGNETS, Cylindrical, 15 % Cobalt Steel (see p. 242), with a coercive force three or four times as great as that of tungsten steel magnets, single bars.

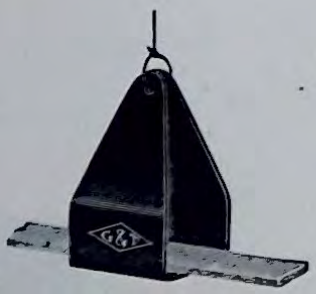
Length ..	1	2	3	4	5	6	8	10	12	*in.*
A 71-275. Diam. $\frac{3}{16}$ in. .. *p*	4/-	5/6	6/6	8/-	9/-	10/9	14/6	18/-	21/6	*dozen*
A 71-280. Diam. $\frac{1}{4}$ in. .. *p*	5/6	7/-	9/-	12/-	15/6	18/-	22/-	26/-	30/-	*dozen*
A 71-285. Diam. $\frac{1}{8}$ in. .. *p*	8/-	13/6	18/6	24/9	31/6	37/6	39/6	61/6	75/-	*dozen*

MAGNETS, Ball-ended, Robison (*Proc. Camb. Phil. Soc.*, **12**, 30 ; **14**, 185), with true poles. For theory of use in magnetometry experiments see *loc. cit.*

Length	15	20	25	30	35	*cm.*
A 71-300. Tungsten Steel ..	7/-	8/-	9/-	10/-	11/-	*pair*
A 71-305. 15 % Cobalt Steel ..	21/-	22/-	23/-	24/-	—	*pair*


A 71-340.


A 71-350.


A 71-360.


A 71-380.

	£	s.	d.
A 71-340. MAGNETS, Suspension 15 % Cobalt Steel (see p. 242), 1¼ in. long, with hole for suspension as used in oscillating magnetometer .. .. .. *each* 1/-; *dozen*	0	10	0

A 71-350. MAGNETS, Suspension 15 % Cobalt Steel (see p. 242), with brass stud in centre for suspension.

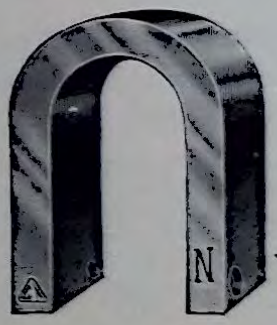
Length	3	4	6 *in.*
Cross Section	⅛ × ⅜	3/16 × ½	¼ × ¾ *in.*
	p 1/9	2/6	4/6 *each*

A 71-360. STIRRUP, Brass, for suspending magnets of maximum width 1¼ in.	0	2	3
A 71-380. MAGNET, Disc, Carbon Steel, 4 in. diam., with brass stud in centre for suspension with either face upward, for determining the magnetic meridian	0	5	0


A 71-440.


A 71-445.


A 71-460.


A 71-470.


A 71-480.

A 71-440. MAGNETS, Horseshoe, Tungsten Steel (see p. 242), **single,** with keepers.

Length	2	3	4	5	6	8 *in.*
	8d.	9d.	1/6	2/6	3/6	6/9 *each*

	£	s.	d.
A 71-445. MAGNET, Horseshoe, Compound, Tungsten Steel (see p. 242), Triple, length 5 in. ..	1	2	0
A 71-460. MAGNET, Horseshoe, Alnico (see p. 242), small and powerful, can be slipped into the waistcoat pocket. Useful for many practical purposes. 1 in. long, ⅞ in. across poles *tx*	0	1	6
A 71-470. MAGNET, U-shape, 15 % Cobalt Steel (see p. 242), with parallel limbs. Width 3 in., depth 1¼ in., height 4½ in., cadmium plated finish. Useful for experimental work and for the construction of small motors and generators, moving coil instruments, etc. Each limb drilled with hole for convenience in mounting and for attaching pole pieces .. *p*	0	16	0
A 71-480. MAGNET, U-shape, Alnico (see p. 242), an exceptionally powerful magnet for experimental work and demonstration. Width 2⅛ in., depth 1⅛ in., height 1⅜ in. .. *p*	0	6	0



Small. Medium. Large.

A 71-490.



A 71-500.

A 71-490. MAGNETS, U-shape, Ticonal (see p. 242), the new anisotropic alloy. Each magnet supplied with nickel-plated keeper.

Size	Small.	Medium.	Large.	
Width across limbs	1	$1\frac{3}{4}$	$2\frac{3}{8}$	*in.*
Thickness	$\frac{3}{8}$	$\frac{3}{8}$	$\frac{3}{4}$	*in.*
	p 2/-	5/-	15/-	*each*

A 71-500. HAND MAGNET, Alnico. Self-contained permanent magnet, overall height $8\frac{1}{4}$ in., weight 5 lb., with lifting handle, on-off " switch," detachable curved pole pieces to give high density gap. **Without** plate, stirrup and weight .. .. *tx* **3 0 0**

£ s. d.

This is a hand version of the large lifting magnets used in industry for detecting minute quantities of magnetic material, determining ferrous content of mixed scrap metal, magnetic lifting, etc. It employs a powerful, self-contained, permanent magnet system, its chief feature being the ability to switch " on and off " by rotating the cylindrical magnet within the outer casing by means of a lever. Turning through 90° releases the load, turning through a slightly larger angle reverses the polarity, thus throwing off the smallest particles which might otherwise adhere to the pole pieces. The magnet can support a 60 lb. weight. The high density gap is attached to the pole pieces by means of dowel pins and screws.



A 71-520.

A 71-520. MAGNET, Galvanometer, Tungsten Steel (see p. 242), outside diam. 6·5 cm., inside diam. 4·5 cm., height 4 cm., with air gap 14 mm. wide, bright polished finish **0 13 6**

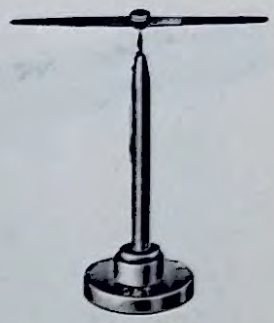
Customers abroad may be assured that their orders will receive particular and individual attention. Orders for Export are handled in a department organised for the purpose, and packing is carried out with special care. Orders for goods other than our own may be included and will be charged at makers' prices.



A 71-615—620.



A 71-630.



A 71-650.



A 71-640.

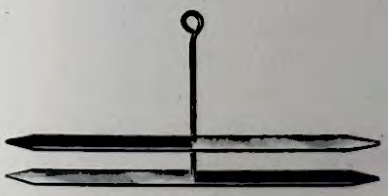
MAGNETIC NEEDLES, 15 % Cobalt Steel, for pivoting.

Length	1	2	3	4	6	*in.*
A 71-615. Brass centre	3/-	3/6	4/-	4/6	5/-	*each*
A 71-620. Agate centre	4/-	5/-	5/6	6/-	7/-	*each*

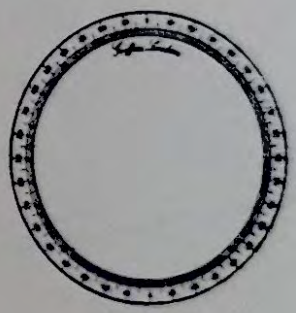
A 71-630. MAGNETOMETER or GALVANOMETER NEEDLE (*Regd. No.* 769144), **Cobalt Steel,** air damped, 1 in. long, with agate centre and very light aluminium pointer 4 in. long, specially ribbed for strengthening and air damping .. .. £ 0 7 0

A 71-640. MAGNETOMETER or GALVANOMETER NEEDLE, Cobalt Steel, 1½ in. long, with agate centre and aluminium pointers 7 in. long .. .. £ 0 9 0

A 71-650. MAGNETIC NEEDLE SUPPORT, brass pillar with weighted foot about 4 in. high, steel point. **Without** needle .. .. £ 0 2 0



A 71-670.



A 71-690.



A 71-695.

A 71-670. ASTATIC NEEDLES, Cobalt Steel, for suspension .. .. *pair* £ 0 10 0

A 71-690. COMPASS CARDS, for galvanometers and magnetometers. Divided circle of four quadrants in degrees.

Diam.	3	4	6	7½	*in.*
	7d.	8d.	1/1	1/6	*each*

A 71-695. COMPASS CARDS, divided circle in degrees, with all compass points marked, stout card.

Diam.	3½	5	7	*in.*
	9d.	1/3	1/6	*each*

If the apparatus you require is not found in this catalogue, please write to us for quotations and specifications.



A 71-800—805.



A 71-815—820.



A 71-840.

	£	s.	d.
A 71-800. **BAR, Soft Iron,** to show **magnetic induction,** 8 in. long, 1¼ in. wide, ¼ in. thick	0	1	9
A 71-805. **BAR, Steel,** unmagnetised, 8 in. long, 1¼ in. wide, ¼ in. thick	0	1	3
A 71-815. **ROD, Soft Iron,** 6 × ⅜ in.	0	1	0
A 71-820. **ROD, Steel,** unmagnetised, 6 × ⅜ in.	0	0	9
A 71-830. **PLATE, Soft Iron,** about 14 × 10 in., 20 s.w.g., to act as magnetic screen ..	0	1	6
A 71-840. **RING, Soft Iron,** 4 in. diam., ¼ in. thick with 3 in. hole, to show the effect of a magnetic screen	0	3	0



A 71-910.



A 71-935.



A 71-950.

	£	s.	d.
A 71-910. **WIRES, Steel (Knitting Needles),** 9 in. long, polished .. .. (*a*) *dozen*	0	2	0
A 71-915. **NEEDLES, Steel, Sewing** .. .. (*a*) *dozen*	0	0	9
A 71-925. **STRIP, Steel (Clock Springs),** about ¼ in. wide .. .. *foot*	0	0	6
A 71-930. **WATCH-SPRINGS,** for making magnetic needles .. .. *each*	0	3	6
A 71-935. **WATCH or CLOCK SPRINGS,** broken pieces .. .. *dozen*	0	4	0
A 71-950. **WIRES, Soft Iron,** 20 s.w.g., 6 in. long. Suitable for constructing cores for induction coils, etc. .. .. 4 *oz. bundle*	0	0	9



A 71-970—975.

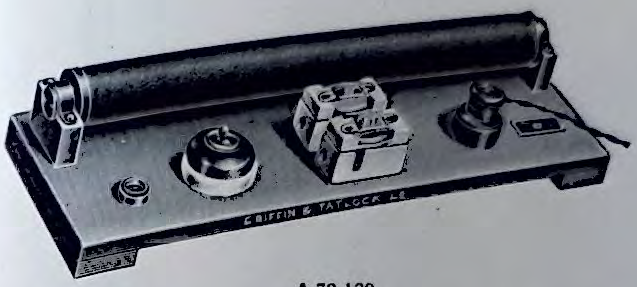
MUMETAL. A nickel-iron-copper alloy of phenomenally high permeability used extensively for transformer cores, magnetic shields, telegraphic equipment and in modern instruments where high efficiency and low electrical losses are required. At low values of D.C. magnetisation Mumetal has the highest permeability of any magnetic alloy.

	£	s.	d.
A 71-970. **Mumetal rod,** 36 × ¼ in. diam.	0	7	6
A 71-975. **Ditto,** 36 × ½ in. diam.	1	10	0
A 71-980. **Mumetal Strip,** 6 in. wide × 0·015 in. thick, for laminated cores, magnetic shields, etc. .. .. *lb.*	0	16	0

A comparison of the magnetic properties of Mumetal with those of silicon iron, used hitherto, is instructive.

	Mumetal.	Silicon Iron.
Initial permeability (D.C.)	up to 30,000	500
Maximum permeability (D.C.)	up to 130,000	7000
Field strength (oersteds) for max. permeability (D.C.) (oersteds)	0·025 to 0·040	0·75 to 1·0
Hysteresis loss ergs/cm. cycle for B_{max} = 5000	30 to 50	500 to 1000
Coercive force (oersteds) for B_{max} = 5000	0·03	0·60
Remanence (lines per sq. cm.)	4000 to 5000	8000 to 9000
Density (gms. per cm.)	8·60	7·2 to 7·6

It is an interesting experiment to place a pivoted compass needle on the retaining bench and to hold a rod of Mumetal horizontally in the plane of the meridian and the plane of the compass needle. The needle is undeflected. Merely inclining the rod to the angle of dip (slightly magnetises it in the earth's field and on approaching the end of the rod to the appropriate pole of the compass needle deflection occurs.



A 72-130.



A 72-160.



A 72-165.



A 72-185.

£ s. d.

A 72-130. SOLENOID, Magnetising and demagnetising (Fairbrother, Nightingale and Wyeth: *General Science, Part III*). Coil 12 in. long, wound in layers with d.c.c. copper wire, mounted on base board, number of turns marked. With 2-pin plug connection, fuses, switch with spring action returning to "off" when finger pressure is removed, small compass for testing rod for magnetism, soft iron rod .. .. *p* 4 10 0

Please state voltage when ordering.

For use direct on A.C. mains for both magnetising and demagnetising, and, with resistance in series, on D.C. mains, for magnetising only. Current should be switched on and off once, with the bar to be magnetised within the solenoid. To demagnetise a bar (with A.C. only), the bar is withdrawn along the axis of the coil with the current switched on. This motion along a diminishing field, of polarity reversing with the mains frequency, completely demagnetises the bar.

A 72-160. IRON FILINGS .. .. (*bottle extra*) *lb.* *t* 0 0 10

A 72-165. STEEL FILINGS .. .. (*bottle extra*) *lb.* *t* 0 0 9

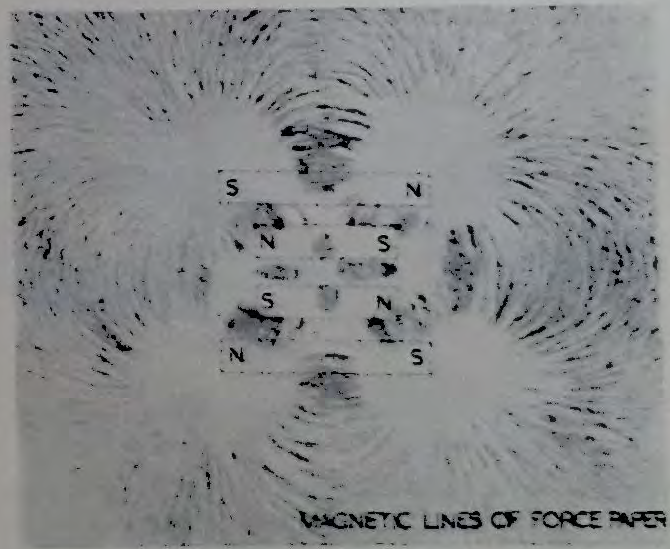
A 72-180. SIFTER, iron filings, metal, about 6 × 2 in., with push-on lid 0 2 3

A 72-185. **Ditto,** about 1½ in. diam. × 3½ in. high, with rubber stopper and gauze top, 20 mesh 0 3 6

A 72-200. MAGNETIC LINES OF FORCE PAPER, for readily making permanent prints of lines of force fields obtained from magnets with iron filings. The prints so obtained are exact replicas in black and white, which can be pasted into students' note books. In packets containing dozen sheets.

Sheets ..	12 × 10	24 × 15 *in.*
	2/-	5/6 *packet*

A 72-205. Developer, special powder sufficient to make one pint liquid developer with water. Made-up developer should be kept in amber bottle. Instructions on tin .. *tin* £ s. d. 0 2 0



A 72-200. Reproduction of print (½ full size) of lines of force from a set of ALNI and ALNICO Magnets in Box A 71-230.

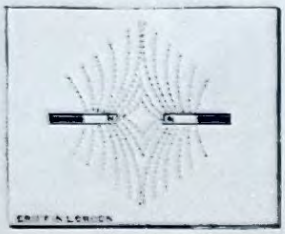
Method of Use.—A sheet of stout cardboard is placed over the magnets and a sheet of the Lines of Force Paper laid upon it, sensitised surface uppermost. Iron filings are then sifted over the paper and the paper tapped in the usual way. This can be carried out in the laboratory in diffused daylight or under artificial light, it being only necessary to shield the paper from direct sunlight.

The paper is then exposed, without disturbing the iron filings, in bright daylight or under a carbon arc lamp or other source of U.V. light. The duration of exposure is judged by the tint of the paper turning from a pale yellow to a bluish-white. The iron filings are then removed and the paper dusted.

Development is carried out by damping the surface of the paper with a sponge moistened with developer. The sponge should carry just sufficient developer to cover the whole area of the paper at one operation working across from top to bottom; too much developer will swamp the paper and result in over-development. Pin the paper up to dry quickly. No fixing or washing is required.

Note.—*The paper should be used within one month of purchase.*

The reproduction illustrated was obtained with an exposure of 7 mins. under 4 × 400 watt Osira U.V. lamps at a distance of 3 ft. Loss of contrast has occurred in reproduction.



A 72-280.



A 72-320—325.

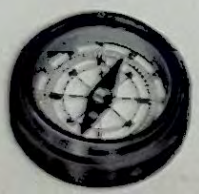


A 72-330.



A 72-335.

	£	s.	d.
A 72-280. MAGNET COMBINATIONS, Small, for lantern projection, fixed upon glass plates, 3¼ × 3¼ in. To show, by means of fine iron filings sprinkled upon the slide, the magnetic field surrounding the magnets. (*a*) Single magnet. (*b*) Two magnets, N facing S. (*c*) Two magnets, N facing N, or S. facing S. (*d*) Two magnets, N facing S with small piece of soft iron in field .. .. *each* 4/6 ; *set*	0	17	6
A 72-320. COMPASS, Plotting, ⅝ in. diam., with card dial, glass one side only *each r* 2/- ; *dozen*	1	1	0
A 72-325. Ditto, without dial, with two clear glass faces .. .. *each r* 2/6 ; *dozen*	1	7	0
A 72-330. Ditto, jewelled centre, and brass pointers at right angles to needle for plotting equipotential lines .. .. *r*	0	10	6
A 72-335. PLOTTING COMPASS, Parkes, with two perpendicular lines engraved on glass face, for plotting lines of force and equipotential lines. Mounted in handle, with two needle points	0	5	6



A 72-405.



A 72-410.



A 72-420—425.

	£	s.	d.
A 72-405. COMPASS, Pocket, 1½ in. diam., card dial with compass points and graduated in degrees, in Bakelite case with screw cover .. .. *t*	0	4	6
A 72-410. COMPASS, Pocket, plastic case, hermetically sealed, unbreakable, 2 in. diam., with cobalt steel needle 1¼ in. long, N pole painted red with luminous spot. Dial marked with compass points and degrees	0	12	6

A 72-420. COMPASSES, Mariner's, brass bowl in gimbals and mounted in oak box.

Diam. of card × side of box	4 × 7	6 × 9	in.
	£2 15 0	£3 5 0	*each*

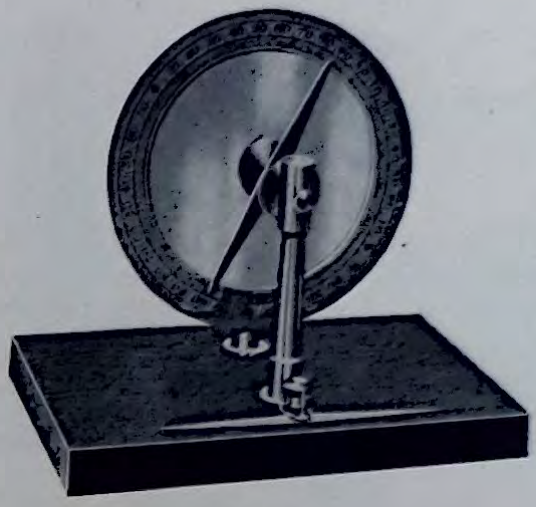
A 72-425. Ditto, without gimbals and without box.

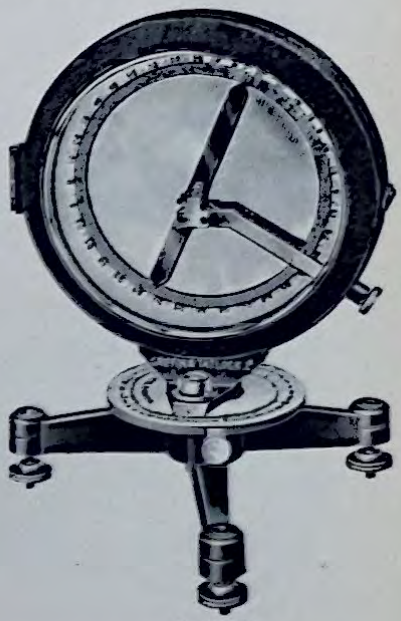
Diam. of mounting	6½	8½	in.
	£1 1 0	£1 5 0	*each*


A 72-530.



A 72-540.


A 72-550.


A 72-570.

	£	s.	d.
A 72-530. DIP NEEDLE, with graduated arc, cobalt steel needle 4 in. long, and capable of rotation. On lacquered brass base divided at each 45°	1	5	0
A 72-540. Ditto, without graduated arc and with needle 6 in. long	1	1	0
A 72-550. DIP NEEDLE, with silvered metal divided scale 4 in. diam., accurately balanced cobalt steel needle on hardened steel points, brass uprights, teak base. With one magnetised cobalt steel needle and one brass needle	2	10	0

THE MICROID DIP CIRCLE

A well made accurate students' type

The magnetic needle is made from cobalt steel, 5 in. long by $\frac{3}{8}$ in. wide, and is accurately balanced about the axis of rotation.

Whilst observations are being made it is supported on agate knife edges. When not in use it is removed from contact with the knife edges by means of a lifting device operated by a knurled screw on the right hand side of the metal case. The lifter not only holds the needle but by means of its two V supports accurately centres it with the scale. Being controlled by a fine pitch screw, it enables the movement of the needle to be regulated nicely and ensures that the latter is lowered on the knife edges without shock or damage either to the spindle or agates. The needle can readily be removed from the support for reversal in its bearings, or for magnetic reversal.

The case is of light metal with hinged door, and windows back and front. The vertical circle is divided into degrees and is numbered 0-90-0-90-0, the graduations and figures being black upon a silvered background. The azimuth circle, which may be rotated independently of the case and tripod, is divided in degrees. It can be fixed in any desired position by a clamp which is carried on the base and which bears against its milled edge. The reading is taken against an arrow on the lug carrying the spirit level, attached to and rotating with the case. The whole is supported on a gunmetal tripod base provided with three levelling screws.

For method of determining angle of dip and systematic elimination of errors, see Hadley: *Magnetism and Electricity*, p. 99; Starling: *Magnetism and Electricity*, 6th Edn., p. 33.

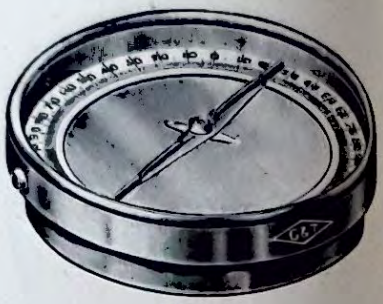
	£	s.	d.
A 72-570. MICROID DIP CIRCLE, with cobalt steel needle, silvered scales, circular spirit level and levelling screws	13	10	0



A 72-630.

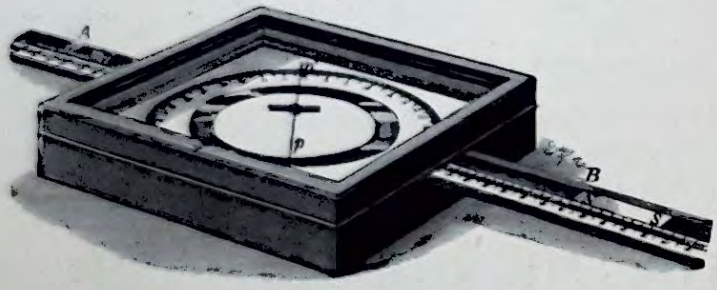


A 72-640.



A 72-650.

	£	s.	d.
A 72-630. MAGNETOMETER, Deflection, compass box, about 5 in. square, fitted with agate centre, cobalt steel needle (*Regd. No.* 769144), aluminium pointer and graduated silvered metal dial. The pointers are specially ribbed for strengthening and air damping ..	1	1	0
A 72-640. MAGNETOMETER, Deflection, circular polished wood base, 6 in. diam., with silvered metal dial divided in single degrees 0–90 (4 times), agate centre, cobalt steel needle with aluminium pointer, complete with glass cover and two half-metre boxwood scales fitting into wood base and removable when desired for other experiments. The pointers are specially ribbed for strengthening and air damping	1	5	0
A 72-650. MAGNETOMETER, Deflection, air damped, in brass case 4 in. diam., with cobalt steel needle, agate centre and light pointers specially ribbed for strengthening and air damping. In well finished case with angular scale and glass anti-parallax mirror ..	1	7	6



A 72-660.

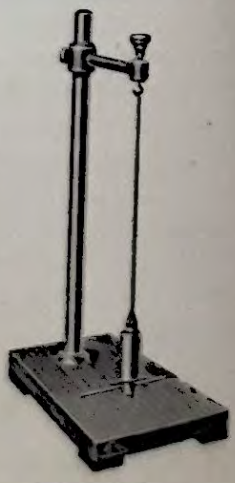
A 72-660. MAGNETOMETER, Deflection, wood box 8½ × 8½ in., with hinged lid, agate centre, cobalt steel bar needle with aluminium pointer. The two arms are fitted with boxwood scales divided in mm. A number of experiments with this apparatus is given in the chapter devoted entirely to magnetometry in Allen and Moore: *Text-Book of Practical Physics.* **Without** magnets **4 0 0**

Magnets, 15 ⅛ Cobalt Steel, for above .. .. see **A 71-130.**



A 72-680.

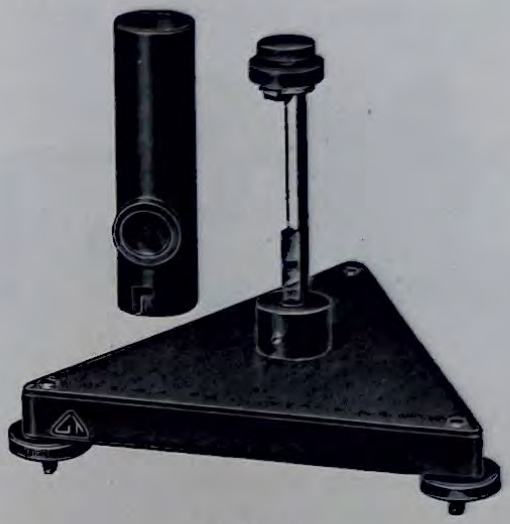
	£	s.	d.
A 72-680. MAGNETOMETER, Oscillation, simple form, with 1¼ in. cobalt steel magnet in glass tube draught shield	0	8	6
A 72-690. MAGNETOMETER, Oscillation, Searle form (*Proc. Camb. Phil. Soc.*, **12**, 27). Cobalt steel magnet with aluminium pointers and brass plumb-bob, suspended by unspun silk from stand with adjustable arm, wood base	0	5	6
A 72-695. Stand only, for above	0	8	6



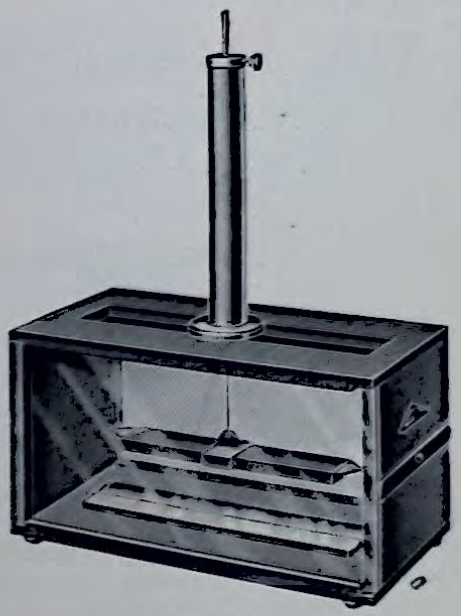
A 72-690—695



A 72-750.



A 72-760.



A 72-770—775.

£ s. d.

A 72-750. MAGNETOMETER, Reflecting, oil damped. Small bar magnet and mirror suspended by unspun silk in glass cylinder, with height adjustment, 3·5 volt S.E.S. bulb in housing, and switch, mounted on metal box arranged to take dry battery. In use the damping vane is to be submerged in light oil 1 15 0

Bulbs, spare, for above, ... see **A 58-240.**

A 72-760. MAGNETOMETER, Reflecting, Sucksmith (*J. Sci. Instruments*, 1945, **22**, 129). Two Alcomax II bar magnets, 5 mm. × 1 mm. × 1 mm., similarly oriented, and two small mirrors, are fixed one on each side of a thin mica strip. The system is suspended by unspun silk in a conical copper dash-pot 5-6 mm. bore, with a magnet clearance of 0·5 mm. for critical damping. Mounted on triangular brass base with three levelling screws, cylindrical cover with glass window, milled head for orienting and for height adjustment of the moving system, which regulates the damping 3 0 0

One of the chief shortcomings in the use of the mirror magnetometer is the long period of oscillation, which, together with low damping, makes any extended set of readings an unduly long procedure. This is largely due to the fact that the moving system is usually constructed of small pieces of watch spring or steel needles, the low coercivity of which (∿ 25 Oe), and the high demagnetising factor for the short lengths employed, result in a small ratio of magnetic moment to moment of inertia so that the period of oscillation is generally not less than 5 sec. When adequate air damping is added to this, the time for the suspended system to come to equilibrium may be as much as 30 sec.

In the design of the above magnetometer the use of the newer anisotropic magnet materials of coercive force 500–600 Oe. (*see descriptive notes*, p. 242), provide a means of considerably decreasing the time of oscillation while currents induced by the motion of the magnet produce greatly improved damping.

The conical dash-pot enables the amount of damping to be controlled by adjustments of the height of the magnet system. At critical damping the magnets are usually 1–2 mm. from the bottom of the dash-pot.

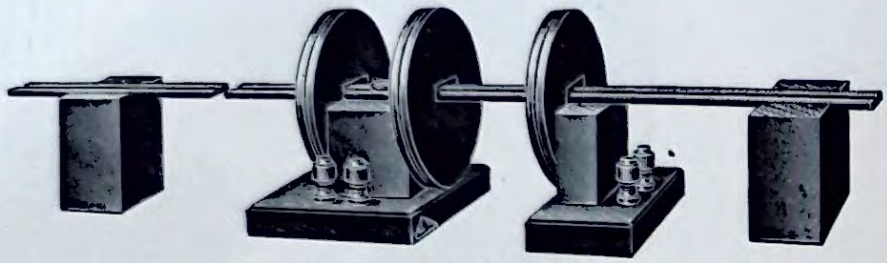
£ s. d.

A 72-770. MAGNETOMETER, Vibration (Allen and Moore: *Text-Book of Practical Physics*, pp. 428–9). Bar magnet fitted with pointer at each end, suspended in a stirrup at its centre by means of unspun silk, within a draught-excluding box 15 × 10 × 10 cm., having removable glass front and back and brass suspension tube. Length of suspension adjustable. Slots in the top of the box enable the oscillations of the magnet to be observed against an index line ruled on a mirror glass plate on the base of the box. **Without magnet** 2 5 0

A 72-775. Bar Magnets and Brass Bars, one each 2 and 4 in. long, for above *set of four* 0 8 0

THE MICROID DOUBLE COIL MAGNETOMETER

An instructive magnetometer using null point methods



A 72-825.

This instrument enables rapid determinations of magnetic fields to be made by the method of producing an equal and opposite field. This field is arranged to be numerically equal to the current in amperes passing through the double coil, and the balance point is detected by a jewel-mounted plotting compass. The uses of the instrument include: measurements of the earth's magnetic field, the moments of magnets, and the variation of field strength on the axis of a single coil. The apparatus may find a useful application for determining rapidly the strength of the earth's field at different points in the laboratory.

SPECIFICATION

Two coaxial coils, 9 cm. diam., are mounted, at a distance apart equal to their radius, on a stable base provided with terminals. Through the centre, along the axis of the coils, provision is made to pass a metre rule, graduated 50–0–50 cms. A jewelled plotting compass can be placed in a hole in the centre of the rule. A single coil, of similar construction is supplied, which can be placed at different distances from the compass for the investigation of the variation of the field on its axis.

A 72-825. MICROID DOUBLE COIL MAGNETOMETER, comprising pair of mounted coils, metre rule graduated 50–0–50 cms., single coil on base with terminals, and pair of wood blocks to support ends of metre rule. **Without** compass needle .. .. £ 3 10 0

EXPERIMENTAL NOTES

Theory.

The magnetic field is very uniform at the centre of the pair of coils over a volume of several cc. A current of I amperes flowing in the coils produces a field $= \dfrac{2 \times 2\pi n I r^2}{10\left[r^2 + \left(\frac{r}{2}\right)^2\right]^{\frac{3}{2}}}$ and since $n = 5$ and $r = 4{\cdot}5$ cms., this expression simplifies to I. Thus the field in gauss is numerically equal to the current in amperes.

Expt. I.—Determination of H, the Horizontal Component of the Earth's Field.

Set up the instrument in the magnetic meridian, as shown by the compass needle. Connect a cell, a rheostat, and a sensitive ammeter in series to the terminals, using twisted leads long enough to avoid disturbance of the magnetometer field by proximity of the ammeter. Switch on the current and adjust its value until the field is strong enough to make the needle turn through 180° and point south. (The cell connections may need reversal.) A sensitive means of determining the balance point is to set the needle spinning by means of a magnet. If nothing to rest the needle should rotate uniformly and not irregularly. The method enables a rapid survey of the field in the laboratory to be made, such as is useful for examination purposes.

Result.

Current to produce a null point .. .. = 0·164 amps.
Intensity of earth's magnetic field .. .. = 0·164 oersted.

Expt. II.—Determination of the Magnetic Moment of a Magnet.

Pass the metre rule through the coils and place the compass at the centre. Lay the magnet on the rule at a suitable distance from one coil. Measure the current to produce a null point as in Expt. I. The earth's field can now be eliminated (*a*) by finding it first as in Expt. I, or (*b*) by reversing the magnet and taking a second reading.

If the field due to the magnet is F, and that of the earth H, the currents required will be (H + F) and (H − F), whence F can be found. The readings can be repeated with the magnet on the other side of the coils.

Results.

	Balancing current.
(1) Magnet south of coil with N. pole pointing north	0·117 amp.
(2) Magnet south of coil with S. pole pointing north	0·160 amp.
(3) Magnet north of coil with N. pole pointing north	0·117 amp.
(4) Magnet north of coil with S. pole pointing north	0·162 amp.

1st result. $\dfrac{0{\cdot}160 - 0{\cdot}117}{2} = 0{\cdot}043$

2nd result. $\dfrac{0{\cdot}162 - 0{\cdot}117}{2} = 1{\cdot}045$

Average 0·044.

A 72-825. The Microid Double Coil Magnetometer—*continued.*

Distance of centre of magnet from compass centre = 40·0 cms.
Length of magnet .. .. = 16·5 cms.
Let moment of magnet be M.

Then field $= \frac{2Md}{(d^2 - l^2)^2} = \frac{2 \times 40{\cdot}0 \times M}{[(40{\cdot}0)^2 - (16{\cdot}5)^2]^2} = 4{\cdot}50 \times 10^{-5} M.$

Whence $M = \frac{0{\cdot}044}{4{\cdot}50 \times 10^{-5}} = 980$ weber-cms.

Expt. III.—Investigation of the Variation of the Field on the Axis of a Coil.

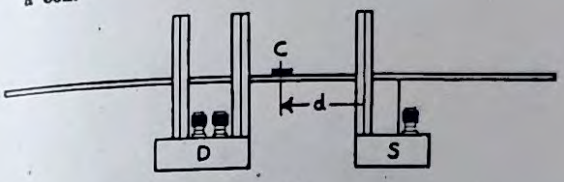


Fig. 2.

Place the single coil whose field is to be investigated over the metre rule as shown in Fig. 2. Place the plotting compass C outside the centre of the double coil as close as possible to the coil face. Set the instrument in the magnetic meridian. Connect a cell, rheostat and ammeter to the double coil. Make a similar set-up for the single coil, exercising the usual precautions with regard to length of leads. Take readings o 1(1) the current in the double coil to produce no field at C and (2) the distance d. The earth's horizontal field is measured by taking a reading on the double coil with no current flowing in the single coil. This figure, subtracted from the other readings, gives a result representing the field due to the single coil alone.

Results.

Diam. of single coil .. .. .. = 9·0 cms.
No. of turns .. .. = $n = 20$
Current in coil .. .. = 0·64 amps.
Current required to balance earth's field = 0·183 amps.

Distance d. cms.	Magnetometer Current. amps.	Field due to Coil. units.
0·0	2·14	1·96
0·5	2·12	1·94
1·0	2·02	1·84
1·5	1·87	1·69
2·0	1·69	1·51
2·5	1·49	1·31
3·0	1·29	1·11
4·0	1·00	0·82
5·0	0·777	0·594
6·0	0·598	0·415
7·0	0·480	0·297
8·0	0·416	0·233
9·0	0·352	0·169
10·0	0·320	0·137
11·0	0·293	0·110
12·0	0·276	0·083
13·0	0·259	0·076
14·0	0·250	0·067
15·0	0·243	0·060
16·0	0·239	0·056

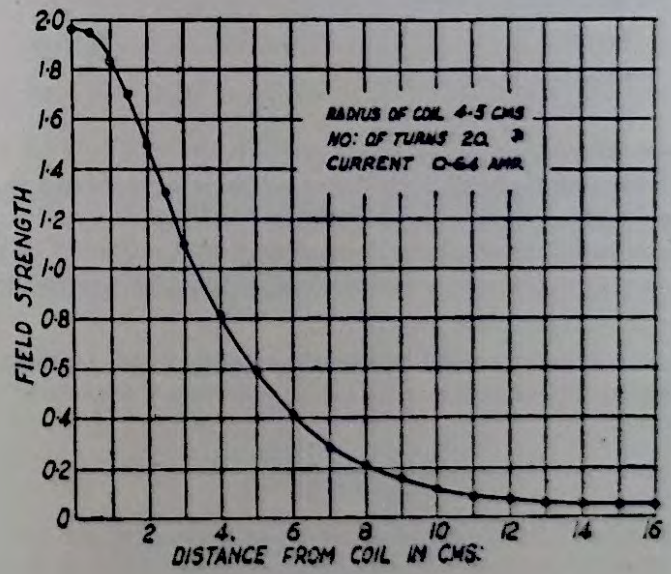
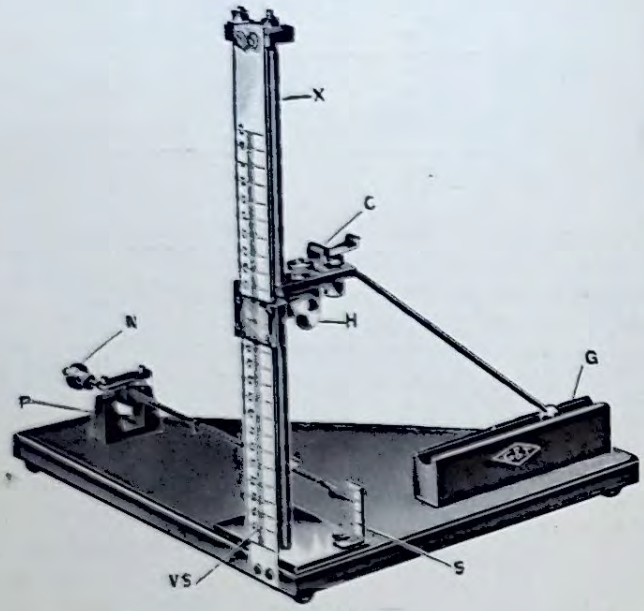


Fig. 3.

Note.—Although the field due to a coil is being investigated by opposing it by the field due to another coil, the only assumption involved in the method is that the field in any conductor is proportional to the current flowing. This assumption enables the variation of the single coil field to be determined and the point of inflexion of the curve found, without the absolute value of the field being known.

THE MICROID MAGNETIC BALANCE

A new precision model for accurate results over a wide range of magnetic field strengths



A 73-150.

Fig. 1.—Assembly for verification of the inverse square law.

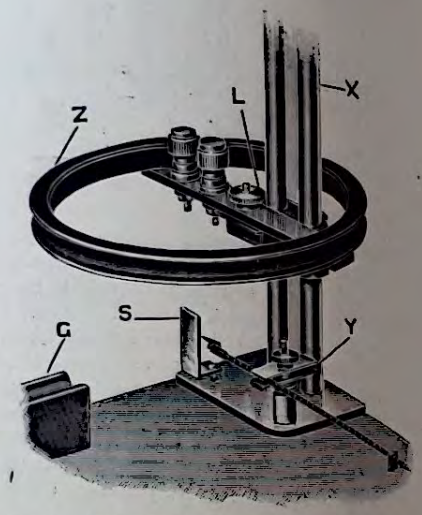


Fig. 2.—Assembly for investigating field on axis of a flat circular coil carrying a current. View on back of pillars X (Fig. 1), showing beam clamp Y and method of clamping flat coil Z, or solenoid by nut L.

The verification by direct measurement of the inverse square law of force between magnetic poles has hitherto always proved difficult. This has been due partly to the difficulty of eliminating the unwanted forces between the other poles of the magnets used, and partly to the difficulty of avoiding induced poles. In the Microid Magnetic Balance these difficulties have been overcome by the use of suitably disposed cobalt steel magnets. By arranging one magnet as a gravity balance beam, considerable sensitivity has been achieved without the disadvantages attendant upon the use of torsion wires.

In addition to the verification of the inverse square law the balance may be used for the comparison of pole strengths, the determination of the magnetic field at points on the axis of a flat coil, a solenoid, or at points on the axis of a bar magnet.

SPECIFICATION

On a polished wood baseboard about 13 in. side fitted with rubber feet, are fixed two pillars P with agate bearings of the cone and groove type on which rests a floating magnet forming one half of a balanced beam. The magnet is counterpoised by two brass weights N; one for coarse and one for fine adjustment. The magnet carries a rider which rests in any one of the grooves marked at every centimetre along its length. The force on one pole of the magnet passes through the axis of rotation and so has no effect on the deflection of the beam; the force on the other pole is the one under investigation. As this latter pole Q must have as small a dimension in the vertical direction as possible, and as induced poles are undesirable, no ball has been provided.

Two upright pillars X carry a special clamp C which is used to support either the solenoid or the flat coil, a small bar magnet, or the upper pole of a Robison magnet. The other pole of the latter slides in a horizontal groove G level with the rest position of the floating beam and so has no effect on the final equilibrium.

Vertical heights can be read on the scale VS by a celluloid cursor. The scale is divided up to 25 cm. and is adjustable for the purpose of eliminating zero error.

[continued overleaf

A 73-150. **The Microid Magnetic Balance**—*continued.*

A scale S indicates whether the beam is swinging evenly. The beam may be fixed, or may have its amplitude of swing restricted by an adjustable clamp Y.

A 73-150. **MICROID MAGNETIC BALANCE** (*School Sci. Rev.*, 1933, **15**, 185), on polished wood baseboard with vertical scale, balanced beam magnet, flat coil, solenoid, short cobalt steel magnet and cobalt steel Robison magnet .. .. £ 20 0 0

EXPERIMENTAL NOTES

Expt. 1.—To verify the Inverse Square Law of Force between Magnetic Poles.

After first eliminating scale zero error (see below) the sensitivity of the beam is adjusted by raising or lowering the needle points on which it pivots until the beam, though stable, has a reasonably slow period of swing (about 3 to 4 seconds). Then, with no other magnet near and with the rider on any of the grooves near the clamp Y, the beam is balanced by adjusting the balance weights N until it swings evenly across the scale. If the rider is now moved 1, 2, 3 cms. to the left, forces in the proportion of 1, 2, 3 acting downwards on the floating pole will be required to restore the balance of the beam. These forces are produced by inserting the ball of the Robison magnet in the clamp C and adjusting the height of this pole. This is done by unscrewing the clamping screw H, sliding the whole mechanism up or down the pillars to the desired position and re-clamping by tightening H. A series of readings is taken of d, the distance through which the rider has been moved from its initial position, and D the distance between the poles as measured on the vertical scale. Then if the inverse square law is true $d \times D^2$ should be constant or d plotted against $\frac{1}{D^2}$ should give a straight line graph.

The zero error of the scale can be eliminated by reading the distance between the poles with a cathetometer and then setting the vertical scale (which is adjustable) to read this amount. In view of the nature of the field in which the oscillating pole is swinging, a setting which gives equal swings above and below the zero line will not usually cause the pointer to come to rest exactly on the zero line. Equality of swing should not therefore be taken as the final indication of correct adjustment, and when taking readings great care should be exercised to see that the pointer comes to rest actually on the zero line. The amplitude of swing can conveniently be restricted by use of the clamp Y with its jaws slightly open. There is no need to touch the beam itself from beginning to end of the experiment.

TABLE 1.

Rider movement d cms.	Scale reading D cms.	$\frac{1000}{D^2}$	dD^2	Variation of dD^2 from mean value
2	10·9	8·40	238	1·5
3	8·98	12·40	242	5·5
4	7·76	16·60	241	4·5
5	6·95	20·70	241·5	5·0
6	6·34	24·90	241	4·5
7	5·83	29·50	240	3·5
8	5·45	33·70	238	1·5
9	5·11	38·30	235	1·5
10	4·83	42·9	233	3·5
11	4·60	47·3	233	3·5
12	4·40	51·7	233	3·5
13	4·20	56·7	230	0·5
14	4·05	61·0	230	0·5
		Average	236·5	3·0

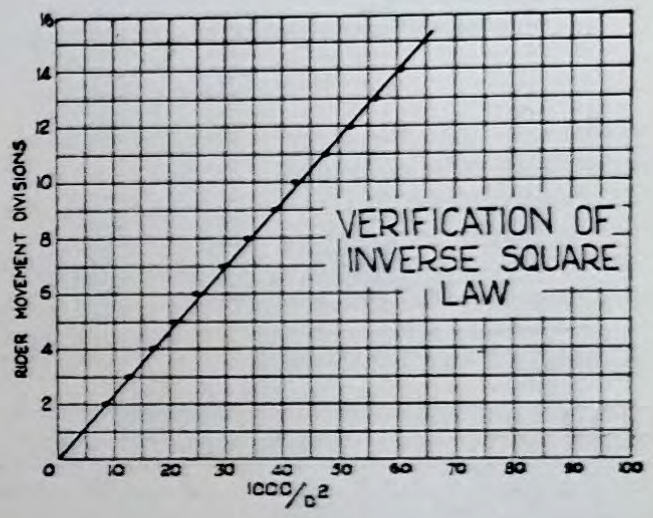


Fig. 3.

From the above table the average variation from mean value = 3·9 in 236·5 or 1·6 per cent. The variation in force measured is from 2 units to 14, *i.e.* a ratio 7 : 1. We therefore conclude that the inverse square law is verified for magnetic poles. The results are expressed on a graph by plotting $\frac{1000}{D^2}$ against d.

Expt. 2.—To investigate the Field on the Axis of a Flat Coil carrying a Current.

The flat coil is clamped on the apparatus as shown in Fig. 2 and, by adjustment of its position at different distances from the exploring pole Q, the field per ampere of current is compared at different points along its axis, by observing the current required to balance a known rider movement. The vertical scale reading may have a zero error which is first determined with callipers or cathetometer as in Expt. 1.

The field per ampere is proportional to $\frac{d}{I}$ where I is the current in ampères and $\frac{d}{I}$ the rider movement. A graph of d against D, the coil distance, is shown (Fig. 4); and it will be noted that at a distance from the coil equal to half its radius the curve has a point of inflexion—a fact made use of in the Helmholtz Galvanometer. By weighing the rider and determining the pole strength of the beam magnet the field could be determined, if required, in absolute units.

Zero error of scale .. .. Nil.

[*continued overleaf*

A 73-150. The Microid Magnetic Balance—*continued.*

TABLE 2.

Scale reading D	Rider movement d	Current I	$\frac{d}{I} = k \times$ field
cms.	cms.	amps.	
1·2	5·0	0·270	18·5
1·6	5·0	0·275	18·2
2·6	5·0	0·296	16·88
3·0	5·0	0·310	16·13
3·5	5·0	0·327	15·28
4·0	5·0	0·355	14·10
4·6	5·0	0·385	13·00
5·0	5·0	0·420	11·90
5·6	5·0	0·469	10·66
6·0	5·0	0·504	9·93
6·6	5·0	0·560	8·93
7·2	5·0	0·616	8·11
7·8	5·0	0·704	7·14
8·4	5·0	0·796	6·28
9·0	5·0	0·884	5·65
9·6	5·0	0·983	5·09
10·2	5·0	1·095	4·56
10·8	5·0	1·21	4·13
11·4	5·0	1·33	3·76
12·0	5·0	1·46	3·42
14·0	5·0	1·70	2·50
16·0	5·0	2·96	1·69
18·0	5·0	4·00	1·25
20·0	2·0*	2·23	0·898
22·0	2·0	2·89	0·692
24·0	2·0	3·76	0·532

* Rider movement was here reduced in order to avoid using unduly large currents.

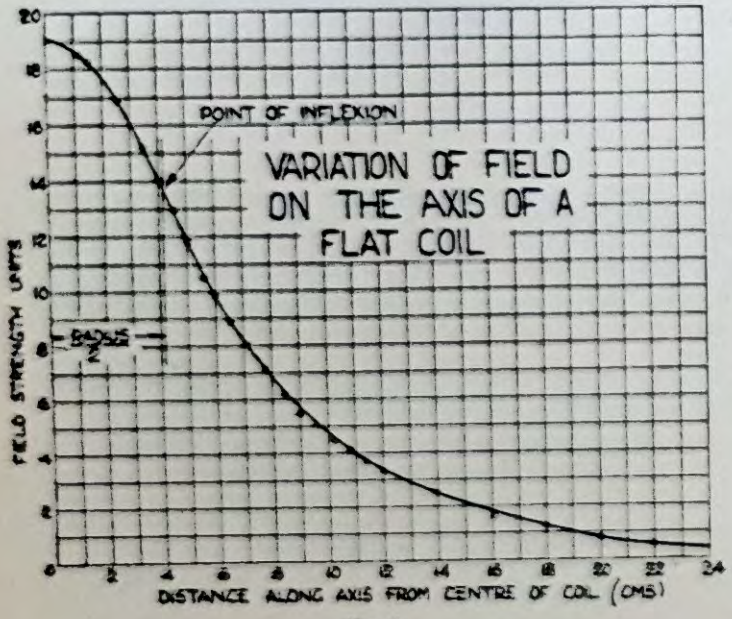


Fig. 4.

Expt. 3.—To investigate the Field on the Axis of a Solenoid carrying a Current.

The procedure is the same as for the flat coil, and the results and graph are shown in Table 3 and Fig. 5.

TABLE 3.

A = Distance from end of solenoid, cms.

B = Field/ampere.

A	2·0	2·5	3·0	3·5	4·0	5·0	6·0
B	4·25	3·48	2·97	2·58	1·93	0·977	0·510
A	7·0	8·0	10·0	12·0	14·0	16·0	
B	0·440	0·310	0·220	0·114	0·110	0·089	

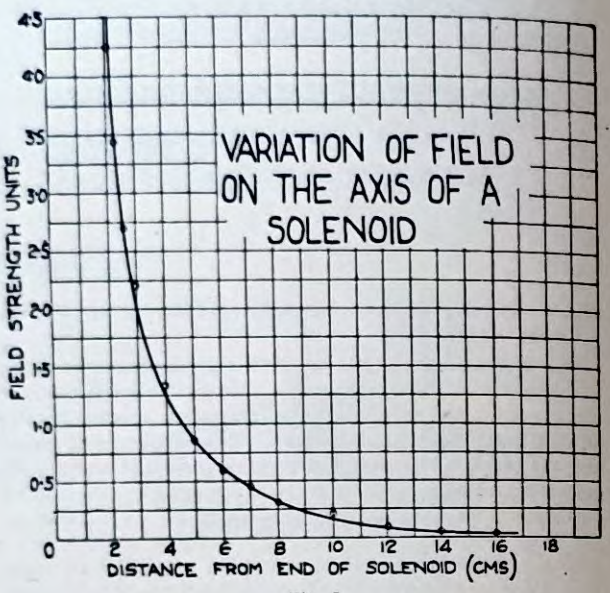


Fig. 5.

Expt. 4.—To investigate the Field on the Axis of a Bar Magnet.

The magnet is held in the clamp C with its axis vertical and so orientated as to exercise a repulsive force on the beam. A series of readings is taken in the usual way, and a graph of the field as obtained is shown Fig. 6.

Distance to be subtracted from scale readings to give distances from end of magnet = 6·0 cms.

TABLE 4.

A = Rider movement, cms.

B = Scale reading, cms.

C = Corrected scale reading, cms.

A	1	2	3	4	5	6	7
B	22·3	18·6	16·75	15·42	14·47	13·82	13·29
C	16·3	12·2	10·75	9·42	8·47	7·82	7·29
A	8	9	10	11	12	13	15
B	12·79	12·44	12·12	11·82	11·60	11·35	11·0
C	6·79	6·44	6·12	5·82	5·60	5·35	5·0

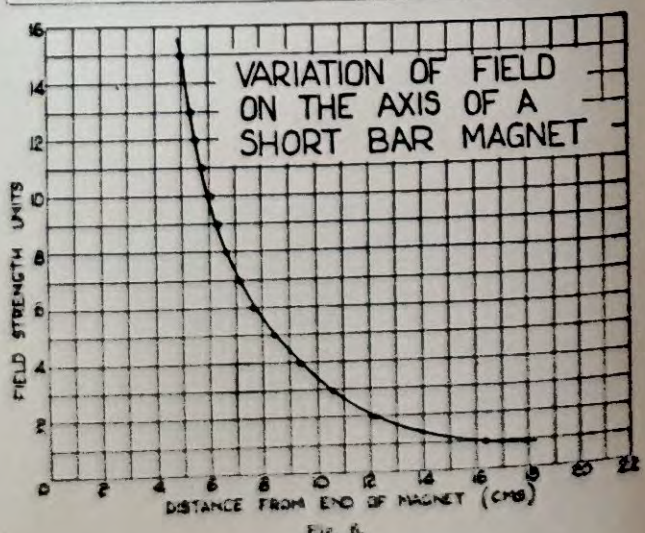
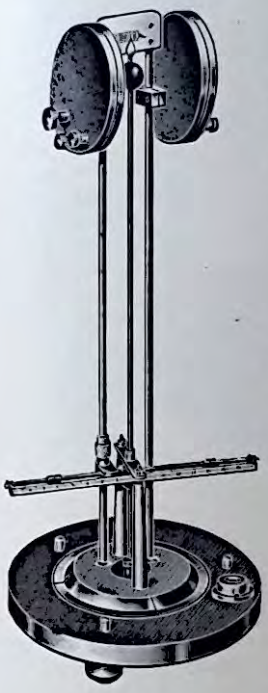


Fig. 6.

Repulsive forces are to be preferred to attractions since smaller values of D can be used without the swinging beam becoming unstable.

THE MICROID H-METER

A new sensitive magnetic balance for use in determining the pole strength of a magnet and the horizontal component of a magnetic field by direct weighing



A 73-205.

This instrument, which may be used to measure any horizontal magnetic field, and in particular that of the earth, has been designed to show how a magnetic field may be measured directly from the definition of "force per unit pole." The force on the exploring pole exerted by the field under investigation is measured by weighing on the steel yard principle. An interesting comparison with the photometer may be drawn if two bar magnets are placed horizontally in line with and on opposite sides of the upper pole. The H-meter then indicates when the intensities balance.

SPECIFICATION

A cobalt chrome magnet 25 cm. long, with a single ball end, is mounted vertically so as to be capable of rotation about a horizontal axis passing through its lower pole. The magnet is balanced by a non-magnetic counterweight, the position of which is adjustable, so that the centre of gravity of the swinging beam may be raised or lowered until the sensitivity and period of swing are suitable. A horizontal scale, graduated to 160 mm., is attached to the moving system and carries a movable wire rider. For centering the pointer on the scale two small zero adjustment collars are fitted to a horizontal screwed rod which supports the rider scale. A clamp to secure the beam during transit is provided.

The central position of the magnet is indicated by a pointer moving over a scale plate at the top of the instrument. The swinging system is balanced geometrically on needle points, one resting in an agate cone and the other in an agate groove. The agates are mounted in brass pillars fixed to a circular base, which can be rotated through exactly 90° or 180° relative to the massive cast brass baseplate 17 cm. diam., which is fitted with three levelling screws and a spirit level. A pair of lines engraved on the edge, at opposite ends of a diameter, enable the plane of swing of the beam to be set in the magnetic meridian.

On each side of the upper pole is fitted a five turn coil so that by passing a known current through the pair of coils a known and very uniform field may be created. Thus the pole strength of the upper pole may be determined and the instrument calibrated.

PRICES

	£	s.	d.
A 73-205. MICROID H-METER (*School Sci. Rev.*, 1933, **15**, 185). Brass base on levelling screws, magnet, graduated beam, 25 mgm. rider, current coils, as described above. Overall height 40 cm.	15	0	0

EXPERIMENTAL NOTES

Expt. 1.—Determination of *m* the Pole Strength.

Theory.—Balance the beam (preferably in the E-West plane). Pass a known current I amps. through the coils and observe the rider movement (y cms.) necessary to restore the equilibrium. Let the coils have *n* turns, be *d* cms. apart and of radius *r* cms. Let the rider weigh *w* gms., and the length of the magnet be *l* cms.

Then field due to the coils $= F = 2 \times \frac{2\pi n I r^2}{10\left(r^2 + \frac{d^2}{4}\right)^{3/2}}$

and $mFl = wgy$. $\therefore m = \frac{wgy}{Fl}$ webers.

Experimental.—Any measuring instruments such as ammeters which have an external magnetic field should be kept well away from the balance. For maximum accuracy it is convenient, having balanced the beam with the rider at 0·0 mms. to move the rider the whole length of the beam (160 mm.) and to determine the current necessary to rebalance.

Mass of rider	w =	0·025 gm.
Rider position, no current in coils	=	0·0 cms.
Rider position, with current in coils	=	16·0 cms.
Rider movement	y =	16·0 cms.
Current in amps.	=	0·34
No. of turns	n =	5·25 cms.
Diameter of coils	$2r$ =	6·2 cms.
Distance between coils	d =	5·4 cms.
Length of magnet	l =	25·2 cms.

$$\therefore F = \frac{2 \times 2\pi \times 5{\cdot}25 \times 0{\cdot}34 \times (3{\cdot}1)^2}{10\,(3{\cdot}1)^2 + (2{\cdot}7)^2)^{3/2}} = 0{\cdot}31 \text{ oersted.}$$

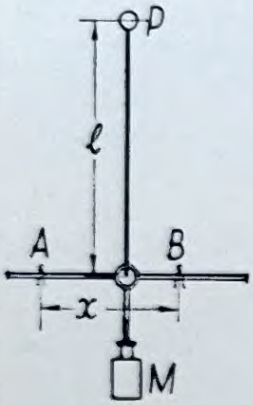
$$\therefore m = \frac{0{\cdot}025 \times 981 \times 16{\cdot}0}{0{\cdot}31 \times 25{\cdot}2} = 50{\cdot}6 \text{ webers.}$$

[*continued overleaf*

A 73-205. The Microid H-Meter—*continued.*

Expt. II.—Determination of H, the Earth's Field.

Theory.—Balance the beam when in the magnetic E-W position with the rider at A. Turn the beam through 90°. This causes a force = mH dynes to act on the pole p (in the plane of oscillation), which has a turning movement of mHl dyne-cms. If the rider has to be moved x cms. from A to B to restore the balance, we have $wgx = mHl$. $\therefore H = \frac{wgx}{ml}$ which determines H if m is known.



The accuracy can be doubled by balancing first by the zero-collars on the horizontal bar, with the line A B pointing N.-South, and then turning the instrument through 180° and rebalancing by moving the rider. The force on P caused by the rotation changes from mH to $-mH$, which is equivalent to $2mH$ and is double the previous figure. This method has been followed in the experiment described and so

$$H = \frac{wgx}{2ml} \quad . \quad . \quad (1)$$

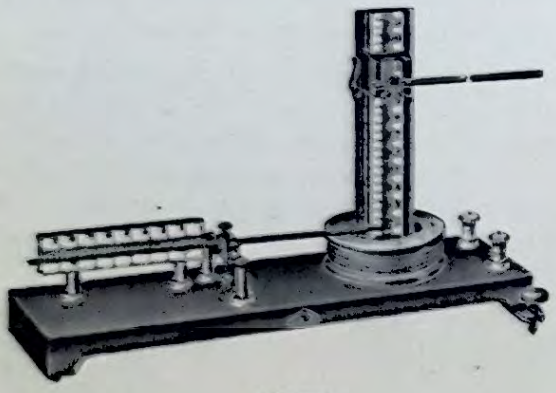
Experimental.—Since the movement of the balance weight M on its screw will almost certainly affect the horizontal equilibrium of the beam, raise M until the beam is made as sensitive as possible without instability. Next align the plane of oscillation of the beam in the meridian by means of the lines engraved on the base, and balance the beam by the horizontal counterpoises so that the pointer reads zero. This is done with the rider at one end of the scale. Now turn the upper part of the apparatus through 180° relative to the base. The beam will be found to be deflected. Restore equilibrium by moving the rider along its scale.

The pole strength of the magnet may be measured either by any of the usual methods or as in Experiment 1.

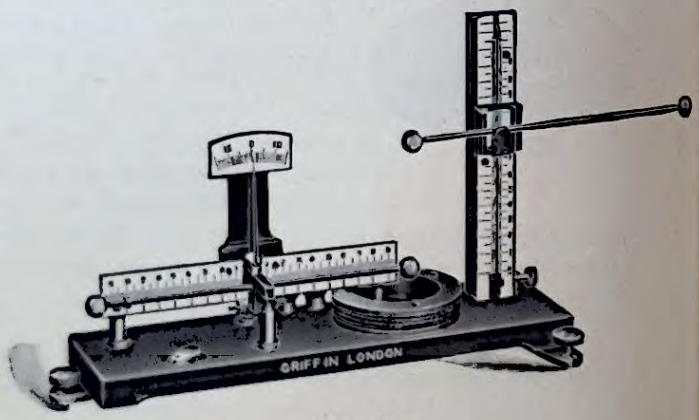
Distance of exploring pole P from the axis	l	=	25·2 cms.
Pole strength of magnet	m	=	50·6 webers.
Rider position A		=	0·0 cms.
,, ,, B		=	15·5 cms.
Rider movement	x	=	15·5 cms.
Mass of rider	w	=	0·025 gms.

Then $H = \frac{wgx}{2ml} = \frac{0{\cdot}025 \times 981 \times 15{\cdot}5}{2 \times 50{\cdot}6 \times 25{\cdot}2} = 0{\cdot}149$ oersted.

It is of course possible to measure H without knowing m, l, w, since $H = \frac{Fx}{2y}$, but the full investigation is more instructive.



A 73-230.



A 73-235.

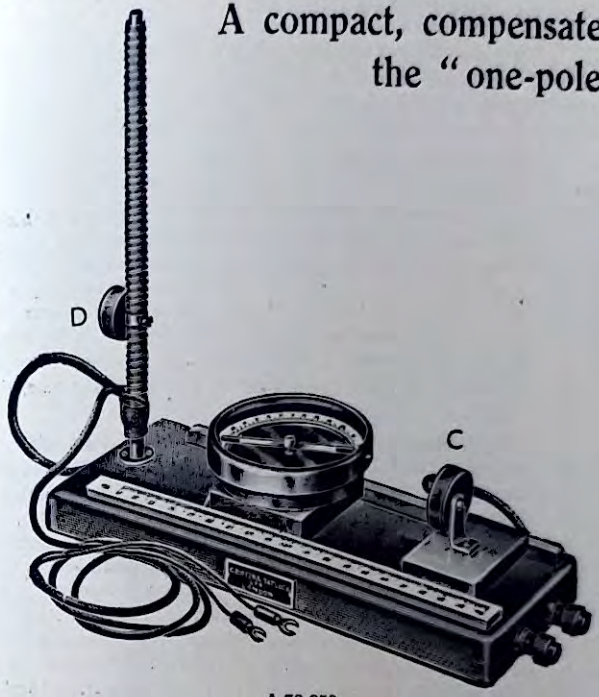
A 73-230. MAGNETIC BALANCE, Hibbert, in which the forces are balanced by means of a sliding weight, with plain magnets. One magnet is held in a clamp balanced on renewable steel points and the other is supported on a block sliding over a vertical scale. With coil to carry 5 amps. and two weights to exert forces of 20 and 50 dynes respectively £ 2 18 6

A 73-235. MAGNETIC BALANCE, Hibbert (*cf.* Smith: *Inter. Physics*, p. 659; Yarwood: *Inter. Pract. Physics*, pp. 186, 191), as **A 73-230** but with ball magnets and with pointer and graduated scale attached to the clamp which carries the balanced magnet, so that finer readings may be taken. The pointer carries an adjustable weight to alter the sensitivity of the balance system .. .. £ 3 15 0

The Microid Series is a range of distinctive designs in Scientific Apparatus principles. These special models have been developed in our own Technical Department and in collaboration with independent authorities expert in their various subjects.

THE MICROID HYSTERESIS MAGNETOMETER

A compact, compensated model employing the "one-pole" method



A 73-250.



A 73-260.

The magnetic properties of materials is a subject which properly falls within the scope of the school syllabus. It is being given increased attention in modern electrical practice and, in the radio industry, it is of paramount importance.

A lack of simple apparatus has, in the past, directed treatment rather to the theoretical than the practical side of the subject. The Microid Hysteresis Magnetometer has accordingly been designed. The apparatus is compact and particularly interesting in its being compensated both for the effect of the earth's magnetic field and for the effect of the current in the magnetising solenoid. Due to the vertical arrangement of the specimen the method is accurate and, because of the small effect that the upper pole exerts on the magnetometer, is often called the "one-pole" method.

SPECIFICATION.

A polished teak base about 13 × 8 in., fitted with rubber feet, is provided with a centimetre scale, and with guides in which a removable magnetometer and a compensating coil C can slide. The magnetometer has a cobalt steel needle and pointers which are specially ribbed for strengthening and air-damping. Terminals are fitted to one end of the base and plugs and sockets to the other end.

The magnetising solenoid, which is removable for convenience in storage and to enable the specimen to be removed, is closely wound on an ebonite tube and is connected in series with the compensating coil C, to the terminals at the end of the base. The earth compensating coil is openly wound on the magnetising coil. It is connected in series with the non-inductive coil D, the resistance of which is so adjusted that a 2 volt accumulator, correctly connected to its leads, passes such a current that the field due to this current, just balances that of the vertical component of the earth's magnetic field at places where V = 0·42 c.g.s. units.

A 73-250. MICROID HYSTERESIS MAGNETOMETER. On polished teak base, with magnetising coil, earth compensating coil, non-inductive coil D, magnetometer with specially ribbed pointers and cobalt steel needle, compensating coil C, sockets and plugs for removal of magnetising coil, terminals and leads, data of winding of H coil on under side of base, glass tube to maintain specimen concentrically in solenoid; with four specimens of widely differing magnetic properties:—soft iron (one mark on specimen); steel (two marks); Mumetal (three marks, see full description of magnetic properties on p. 248); nickel (four marks) .. .. £ 7 0 0

A 73-260. Commutator, Rotary, for demagnetising the specimen by rapid reversal of the current in the magnetising solenoid, while reducing its value to zero. 250 r.p.m. of the commutator are possible and reversal takes place 4 times per revolution. Also for use as the on-off switch in this method. On ebonite base about 4 × 4 in., fitted with rubber feet, with rotary commutator, and four terminals and contacts .. .. £ 2 5 0

A 73-265. Specimens, spare, for above.

Soft Iron	Steel	Mumetal	Nickel
4d.	4d.	6d.	6d. *each*

(continued overleaf

A 73-250—265. The Microid Hysteresis Magnetometer—*continued.*

EXPERIMENTAL NOTES

The apparatus is designed for the examination of rod specimens. The length of the specimen should be very great compared with its diameter (400–500 times is ideal) in order to reduce the self-demagnetising effect to a minimum. Specimens 33 cm. long and 1 to 1·5 mm. diam. are suitable. Four specimens are supplied with the apparatus, intended to demonstrate the widely differing behaviour of important ferro-magnetic materials.

In this apparatus a small error in locating the lower pole causes such a small different in the magnetometer reading, that a knowledge of the exact position of the pole is unnecessary. If desired, it can be placed exactly in the plane of the magnetometer needle by moving the specimen vertically until maximum deflection for a given magnetising force is obtained.

Theory.

If a long magnet PQ, Fig. 3, of pole strength m, be placed vertically, and the field, due mainly to the lower pole, at a magnetometer M, is perpendicular to the horizontal component H_e of the earth's field, then we have for the resultant :—

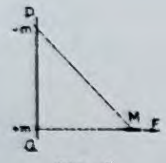


Fig. 3.

$$F = \frac{m}{QM^2} - \frac{m}{PM^2}\left(\frac{QM}{PM}\right)$$

$$= \frac{m}{QM^2}\left[1 - \left(\frac{QM}{PM}\right)^3\right].$$

If θ be the magnetometer deflection, then

$$\tan\theta = \frac{F}{H_e} = \frac{m}{H_e QM^2}\left[1 - \left(\frac{QM}{PM}\right)^3\right].$$

$$\therefore m = \frac{0{\cdot}18\ QM^2}{\left[1 - \left(\frac{QM}{PM}\right)^3\right]} \tan\theta.$$

If A = cross-sectional area of the magnet, the intensity of Magnetisation is :—

$$I = \frac{m}{A} = \left\{\frac{0{\cdot}18\ QM^2}{A\left[1 - \left(\frac{QM}{PM}\right)^3\right]}\right\} \tan\theta.$$

Since the bracketed term is constant, I may be written $= \alpha \tan\theta$.

In this experiment, the field H which magnetises the specimen, is obtained by passing a current of i amps. through a solenoid of n turns per cm. Then $H = \left(\frac{4\pi n}{10}\right) i$ which similarly may be written $= \beta i$.

The quantities α and β may readily be evaluated and I and H thus calculated. A curve can then be drawn showing the relationship between I and H. If preferred, $\tan\theta$ may be plotted against i; or B, which equals $H + 4\pi I$, may be calculated and plotted against H, the general shape of the hysteresis loop being the same in all three cases.

Adjustment of the Apparatus.

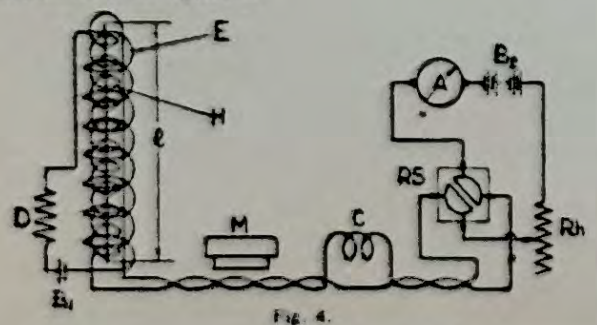


Fig. 4.

Connect up the apparatus as shown in Fig. 4, R being a reversing switch capable also of breaking the circuit (**A 73-250** is very convenient and is specially designed for the purpose). A is an ammeter covering the range 0–2 amps. B_2 is a 6 or 8 volt accumulator; Rh is a suitable rheostat (a carbon plate rheostat is convenient as it allows of *continuous* adjustment) and B_1 is a 2 volt accumulator. Use double, twisted, flexible wires and arrange that the ammeter, etc., is at some distance from the magnetometer so that its external field shall not affect magnetometer readings.

(*a*) **Compensation for the effect at the magnetometer of the horizontal component of the field due to the current flowing in the magnetising solenoid.**—Set the instrument with the pointers of the magnetometer needle at zero and directed towards the axis of the solenoid. Pass about 1 ampere through H and adjust the distance of the magnetometer from the solenoid to be 7–10 cm. A deflection will probably be observed. Slide the coil C in its guides to annul this deflection. Reversal of the plugs at the end of the base, in their sockets, may be necessary.

(*b*) **Compensation for the magnetising effect on the specimen of the vertical component of the earth's field.**—Insert the specimen into the glass tube in the magnetising coil and demagnetise by rapid reversal of the current and, at the same time, gradual reduction of it, to zero. If M be still deflected, the field due to the current in earth coil, is additive to that of the earth's vertical component, instead of being in opposition to it. Reverse, therefore, the connections to B_1 and again demagnetise. If the deflection then decrease, but be not reduced to zero, this is due to V being of value other than 0·42 c.g.s. units which field, the current in the earth coil E is designed to annul. In this event, replace B_1 by a 4 volt accumulator, and include in series with it and the coil D, an adjustable rheostat. Complete compensation can then be obtained.

It may be stated, however, that for the present purpose, too much attention need not be paid to *complete* compensation for V. It is sufficient if V be reduced to about 10 per cent. of its standard value. The coil D passes such current from a correctly connected 2 volt source as, when flowing through H in all but abnormal situations, will just neutralise the earth's vertical component.

(*c*) **Adjustment for the maximum deflection.**—Switch on B_2 again, and take the current to the maximum of 2 amperes. Should the magnetometer deflection be greater than 60°, move M to bring the maximum deflection between 45° and 60°. Above 60° the value of the tangent rapidly increases and a small error in reading the angular scale introduces a relatively large error in the tangent.

(*d*) **Final compensation.**—If the magnetometer has been moved in order to adjust the maximum deflection, remove the specimen, and slide the coil C in its guides to annul the deflection, as described in (*a*). Re-insert the specimen and demagnetise as described in (*b*). The apparatus is now adjusted and ready for use in carrying out the following experiment.

Experiment.—With the whole of the resistance Rh in circuit, switch on the current and bring its value up to 0·1 amp. Note the magnetometer deflection, reading both ends of the pointer and taking the mean, and then increase current to 0·2 amp., or other suitable value to give a convenient increase of deflection (say 5°). In making this adjustment, the current must not be reduced, *e.g.*, if its value should rise to 0·22 amp., take the magnetometer reading at this value. Do not reduce to 0·2 amp. Proceed in this manner until the deflection remains constant, indicating saturation of the specimen. A current of 2 amps. will, in most cases, be sufficient. Larger increments of current may be made as saturation is approached.

Now reduce the current in similar steps to zero, reading the magnetometer at each reduction. At zero current, reverse the switch R and proceed to − 2 amps., giving saturation in the opposite direction. Adjust the current in similar steps from − 2 to 0 amps. Reverse the switch R again and proceed to further saturation. It is important to note that in traversing the cycle, the current must not be cut off at any point except at zero.

A 73-250—265. The Microid Hysteresis Magnetometer—*continued.*

SPECIMEN RESULT

The current and magnetometer readings, and the evaluation of I and H should be recorded as shown in the table below. The figures relate to a silver steel specimen, data of the dimensions of which, and of the calculation of the constants of the apparatus, are given.

Type of specimen : Silver Steel. Dimensions, 33 × 0·101 cm. mean diam. Magnetometer distance, QM = 8 cm.

The magnetic length of the specimen is to be taken as three quarters of its actual length.

$$a = \left\{ \frac{0{\cdot}18 \times 8^2}{\frac{\pi}{4} \times 0{\cdot}101^2 \left[1 - \left(\frac{8}{\sqrt{24{\cdot}75^2 + 8^2}} \right)^2 \right]} \right\}$$

$$a = \left\{ \frac{0{\cdot}18 \times 64}{{\cdot}008\ [1 - {\cdot}0291} \right\}$$ (The correction term for the effect of the upper pole thus amounts to less than 3°/₀)

$a = 1477.$

$\therefore I = 1477 \tan \theta.$

$$\beta = \left(\frac{4\pi \times 19}{10} \right) = 23{\cdot}9.$$

$\therefore H = 23{\cdot}9i.$

i Amps.	Mean θ	Tan (Mean θ)	I lines/cm.²	H gauss	*i* Amps.	Mean θ	Tan (Mean θ)	I lines/cm.²	H gauss
0	0	0	0	0	−0·8	−32·3	−0·6322	− 934	−19·12
0·1	0·65	0·0104	15·35	2·39	−0·9	−35·5	−0·7133	−1053	−21·51
0·2	1·4	0·0244	36·04	4·78	−1·0	−38·4	−0·7926	−1170	−23·90
0·3	5·4	0·0945	139·0	7·17	−1·4	−45	−1·0	−1477	−33·46
0·4	12·6	0·2235	330	9·56	−1·8	−48	−1·1106	−1649	−43·02
0·5	19·4	0·3522	521	11·95	−2·0	−49	−1·1504	−1698	−47·80
0·6	25·1	0·4684	692	14·34	−1·8	−48·3	−1·1224	−1657	−43·02
0·7	30·5	0·5890	870	16·73	−1·6	−47·5	−1·0913	−1612	−38·24
0·8	33·2	0·6544	966	19·12	−1·4	−47·3	−1·0837	−1600	−33·46
0·9	36·3	0·7346	1083	21·51	−1·2	−47	−1·0724	−1584	−28·68
1·0	38·3	0·7898	1165	23·90	−1·0	−46·3	−1·0464	−1544	−23·9
1·2	41·1	0·8724	1288	28·68	−0·8	−45·8	−1·0283	−1518	−19·12
1·4	43·4	0·9457	1396	33·46	−0·6	−44·5	−0·9827	−1450	−14·34
1·6	44·3	0·9759	1442	38·24	−0·4	−43·0	−0·9325	−1376	− 9·56
1·8	45·7	1·0247	1513	43·02	−0·2	−40·7	−0·8601	−1270	− 4·78
2·0	46·5	1·0538	1556	47·80	0	−36·2	−0·7319	−1080	0
1·6	46·0	1·0355	1530	38·24	0·1	−33·2	−0·6544	− 966	2·39
1·4	45·8	1·0283	1518	33·46	0·2	−29·1	−0·5566	− 822	4·78
1·2	45	1·0	1477	28·68	0·3	−22·9	−0·4224	− 653	7·17
1·0	44·3	0·9759	1442	23·9	0·4	− 2·1	−0·0367	− 54·2	9·56
0·8	43·8	0·959	1415	19·12	0·5	12·8	0·2272	334	11·95
0·6	43	0·9325	1376	14·34	0·6	20·7	0·3779	558	14·34
0·37	41·8	0·8941	1318	8·85	0·7	26·6	0·5008	738	16·73
0·2	40	0·8391	1238	4·78	0·8	31	0·6009	886	19·12
0	36	0·7265	1072	0	0·9	34·5	0·6873	1014	21·51
−0·2	28·6	0·5452	805	− 4·78	1·0	37·3	0·7618	1124	23·9
−0·3	20·6	0·3759	550	− 7·17	1·2	40	0·8391	1238	28·68
−0·4	1·0	0·0175	25·8	− 9·56	1·4	42·5	0·9163	1353	33·46
−0·5	−12·3	−0·2180	−322	−11·95	1·6	44·3	0·9759	1440	38·24
−0·6	−20·4	−0·3719	−549	−14·34	1·8	45·4	1·0141	1498	43·02
−0·7	−27·6	−0·5228	−781	−16·73	2·0	46·5	1·0538	1556	47·8

Fig. 5 shows the curve obtained for a silver steel specimen, by plotting the appropriate columns from the table above. Fig. 6 shows a curve for soft iron plotted on the same scale, introduced to illustrate the wide difference in the shape of the curves for the two materials. The remanence, OB, of the two materials is not greatly different, but the coercivity of the silver steel is seen to be about 4 times that of the soft iron. The intensity of magnetisation of the latter is about 50 per cent. greater than that of the silver steel.

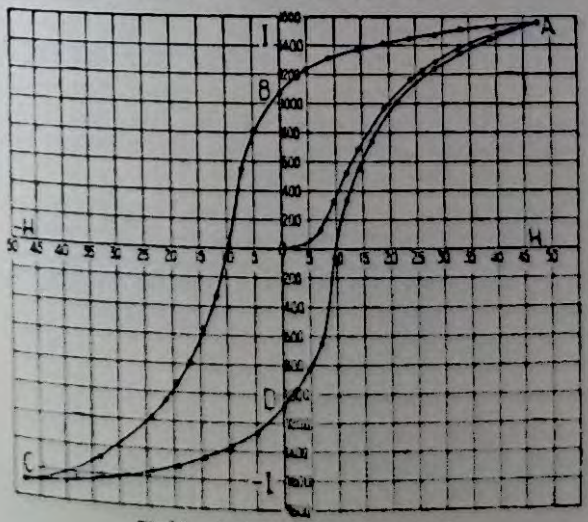


Fig. 5.—I-H Curve for Silver Steel.

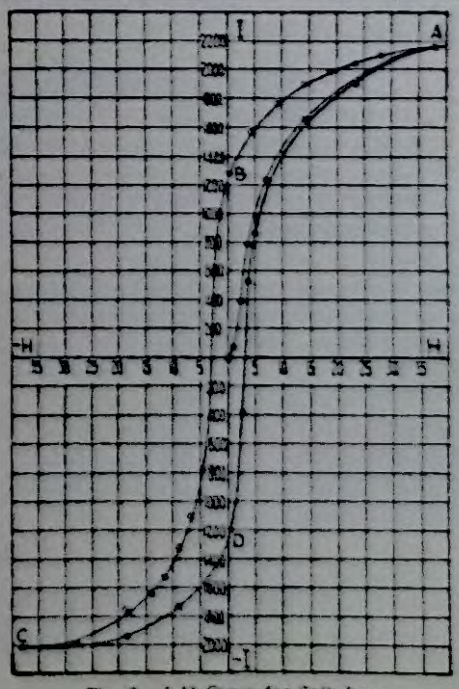
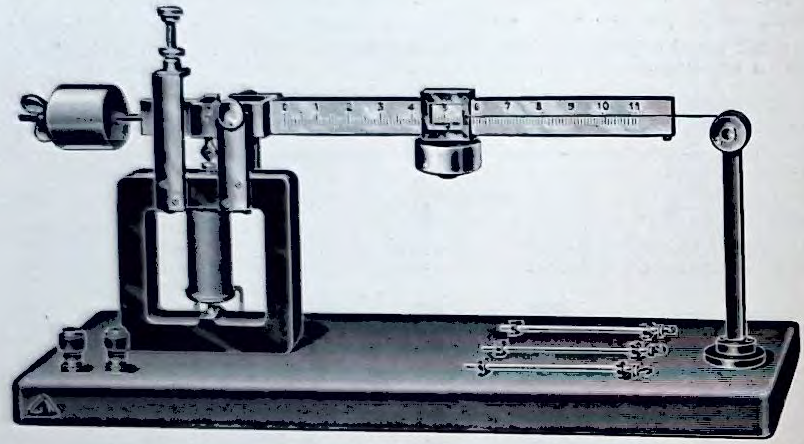


Fig. 6.—I-H Curve for Soft Iron.



A 73-320.



A 73-340.

A 73-320. ATTRACTED IRON AMMETER (Allen & Moore: *Text-Book of Practical Physics*, p. 464). Iron rod suspended from a spring so that its lower end just enters a solenoid. Mounted on wood stand with cm. scale, and terminals to solenoid **1 15 0**

When a current passes round the coil, the iron bar is magnetised and is attracted some distance into the coil. The amount of motion which takes placed depends on the force of attraction and the tension in the spring.

A 73-340. TRACTION PERMEAMETER, Woolwich. Iron yoke 6 in. square, 1 in. section, surrounding vertical solenoid with number of turns marked. Specimen with hook is suspended within solenoid from graduated beam by stirrup with steel knife-edge. Beam about 16 in. long with adjustable counterpoise weight at one end, pivoted on steel knife-edge, graduated 0–11 lb. × 0·1 lb. Sliding weight with bevelled reading edge running on small wheels to minimise friction, moved along beam by cord passing round drum having milled edges, mounted on upright. Adjustable stop for beam. Base 24 × 7½ in. with terminals, and clips for holding specimens when not in use. Four specimens 5 × ¾ in. with hook:—wrought iron, mild steel, cast iron, Staybright steel. With instructions for use **22 10 0**

The force of attraction between two magnetised bodies depends upon (*a*) the degree of magnetisation of the two bodies, (*b*) the area of the contact surfaces. Hence the force required to separate two magnetised surfaces may be used as a measure of the degree of magnetisation existing at the surfaces.

This apparatus is the result of the attempt to find a simpler approach to the teaching of the properties of magnetic materials. By omission of the strict interpretation of permeability as a numerical quantity (= B/H) it is found that graphs obtained by students themselves firmly implant in their minds the general idea of permeability, *i.e.* that some materials are more easily magnetised than others and the idea of magnetic saturation.

It is thought that the apparatus will appeal to teachers who are not satisfied with the orthodox approach to the teaching of electromagnetics. Moreover the experimental technique required is such as to stimulate the average elementary student but the difficulties are not great enough to cause him to lose heart.

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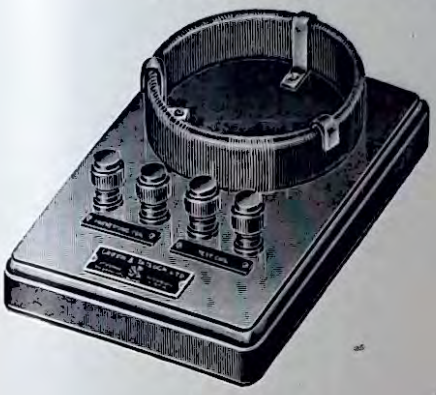
THE MICROID TOROIDAL COIL

A ring specimen for hysteresis and B – H tests by the ballistic method



A 73-450.

Two important experiments, described in detail below, may be carried out with this apparatus. They are devised to give a clear conception of the quantities which specify the properties of a magnetic material.

The method, utilising a wound specimen of ring shape, is one of the most satisfactory for determining hysteresis loss. As the material is homogeneous and the winding uniformly distributed the specimen has no free poles. No magnetic leakage, therefore, takes place and true flux changes are indicated on a ballistic galvanometer.

Calibration of the galvanometer is effected, at the time of performing the experiment, by means of a mutual inductance and is noteworthy for its simplicity.

SPECIFICATION.

The specimen is of soft iron of rectangular cross-section and about 10 cm. diam. The relative dimensions for the internal and external radii have so been selected as to minimise (to make less than 0·1 per cent.) inequalities in the magnetising field, arising from the fact that the number of turns per cm. on the inside of the ring, must necessarily differ from that on the outside of the ring. The ring is uniformly wound with a primary magnetising coil and a secondary test coil, each suitably connected to labelled, bakelite-shrouded terminals. The specimen is mounted on a wood base about 8 × 5 in. provided with rubber feet. Data of ring dimensions and winding particulars are included on the under side of the base.

	£ s. d.
A 73-450. MICROID TOROIDAL COIL, on base about 8 × 5 in., fitted with rubber feet, with soft iron ring specimen, primary and secondary coils, labelled terminals and data for calculation of the ring constants	*r* 3 5 0
A 73-455. Mutual Inductance, 10 millihenries, for use with above, for calibration of the ballistic galvanometer and for use generally. Wound on marble cylinders, in polished wood case, with 2 pairs of labelled terminals. Accuracy of adjustment, 0·01 per cent.	*t* 8 0 0

EXPERIMENTAL NOTES

Two important experiments may be carried out by means of this toroidal coil. The first is the plotting of a complete hysteresis loop by sudden alteration to another value of the magnetising field, H, due to the current in the primary coil and determining the corresponding change in the induction B by the throw of a ballistic galvanometer, which is subsequently calibrated with a mutual inductance of known value.

The second experiment concerns the plotting of a B, H curve, by reversal of the current in the primary coil, and thus changing the magnetic field from + H to – H. The induction similarly changes from + B to – B and is measured by the throw of a ballistic galvanometer which is subsequently calibrated with a mutual inductance of known value.

Experiment I.—Hysteresis Loop for a Toroidal Specimen.

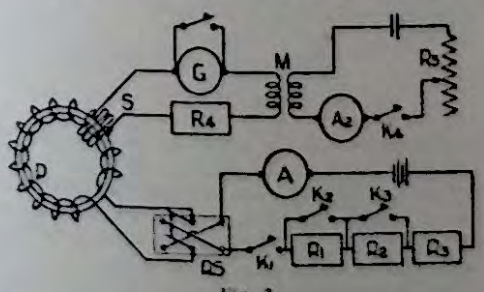


Fig. 2.

The apparatus shown in Fig. 2 should first be set up. P, S is the wound specimen; RS a reversing switch; R_1, R_2 and R_3 resistance adjustable from about 0 to 5 ohms (*e.g.* A 87-120 1·4 ohms 3·2 amps.) and connected in such a manner that by means of the plug keys K_2 and K_3, R_1 and R_2 may be included in, or cut out of, the circuit suddenly. A is a 0–2 amps. ammeter; R_4 a resistance box; G a ballistic galvanometer (*e.g.* A 84-170, 18 ohms resistance) with damping key; M a mutual inductance in the primary circuit of which is connected a 0–1 amp. ammeter A_2, a key K_4 and an adjustable rheostat.

The experimental procedure may be summarised as follows:—

(1) Include all R_3 and plug in K_2 and K_3 and remove say 500 ohms from R_4.

(2) Close RS and K_1 and adjust R_3 so that 2 amperes is passing through P.

(3) Throw over RS and adjust R_4 to give a convenient throw. This is the maximum throw ϑ_1 during the experiment. Take the mean of ϑ_1 for several reversals of RS. The value of R_4 having once been set, must not be changed during the course of the experiment.

(4) Open K_2 and adjust R_3 so that 1 amp. is passing through P. Similarly, with K_2 still open, withdraw the plug from K_3 and adjust R_1 so that 0·5 amp. is flowing in P.

It is now possible to reverse the hysteresis loop, commencing at the maximum value of B corresponding to a magnetising current of 2 amps.

(5) Insert K_2 and K_3, close K_1, and note the throw ϑ_2 of the galvanometer. Open K_2, thus reducing the current from 2 to 1 amp. and note the throw. Similarly open K_3, reducing the current from 1 to 0·5 amp. and note the throw. Finally, open K_1, reducing current from 0·5 to zero and note the throw.

(6) Reverse the switch RS and proceed in similar steps to – 2 amps.; in this case, however, closing the switches K_1, K_2 and K_3 in that order and observing throws.

(7) Traverse the third portion of the hysteresis loop by reducing the current from – 2 to zero amps., opening the switches K_3, K_2 and K_1, and observing throws.

[*continued overleaf*

A 73-450.—The Microid Toroidal Coil—*continued.*

(8) Reverse the switch RS and proceed as before to + 2 amps.

A greater number of points can be obtained on the loop by traversing it a second time, with other values of current change, e.g. 2·0 to 0·8 amps.; 0·8 to 0·3 amps.; 0·3 to zero amps.

The subsidiary experiment to calibrate the galvanometer can now be carried out. By adjustment of the rheostat R_s, pass a suitable current i_0 through the primary of M so that, on making or breaking K_s, a suitable throw φ is obtained. Take the mean of φ for several determinations.

Calculation.

If B = maximum ordinate of hysteresis curve, N = number of turns on secondary coil of the specimen, a = cross-sectional area of the specimen then reversal of the current at 2 amps., gives a change 2B in B and $2BaN \propto \theta_1$ and may be written $2aN = K\theta_1$ . . (1)

The throws subsequently obtained are due to changes ΔB in B caused by alteration of the current from some known value to some other known value. If ΔB causes a throw θ_2, then $\Delta BaN = K\theta_2$ . . . . . (2)

The resistance of the galvanometer circuit has been kept constant in both the main and the subsidiary experiments. From the subsidiary experiment (calibration of the galvanometer), if M be the value of the mutual inductance in henries we have that $Mi_0 = K\varphi$ . . . . . (3)

Hence, from (1) and (3) $B = \left(\frac{Mi_0}{2aN\varphi}\right)\theta_1$, which may be written $= \lambda\theta_1$

and from (2) and (3) $\Delta B = \left(\frac{Mi_0}{aN\varphi}\right)\theta_2$, which may be written $= 2\lambda\theta_2$.

The value of the field for a toroidal coil is, when i is in amperes, $H = \left(\frac{4\pi n}{2\pi a \cdot 10}\right) i = \left(\frac{2n}{10a}\right) i$, which may be written $= \beta i$, where n = number of turns on primary and a = mean radius of the ring.

SPECIMEN RESULT.

Type of Specimen :—Soft Iron.

Constants of the apparatus :—

$a = 2{\cdot}5 \times 0{\cdot}32$ cm. $a = 5{\cdot}1$ cm. $N = 25$ turns.

$n = 278$ turns. $M = 10$ millihenries (= 10^5 line-turns per amp.).

Mean $\varphi = 9{\cdot}75$ cm. $i_0 = 0{\cdot}35$ amp.

$$\lambda = \left(\frac{Mi_0}{2aN\varphi}\right) = \frac{10^5 \times 0{\cdot}35}{2 \times 2{\cdot}5 \times 0{\cdot}32 \times 25 \times 9{\cdot}75} = 897.$$

$$\beta = \left(\frac{2n}{10a}\right) = \frac{2 \times 278}{10 \times 5{\cdot}1} = 10{\cdot}7.$$

TABLE 1.

Current change Amps.	Mean θ_2 cm.	B (= $2\lambda\theta_2$)	Ordinate of curve B	Abscissa of Curve H
Reversal at 2 amps	9·75 (= θ_1)	..	8745	21·4
—1	0·44	— 788	7957	10·7
—0·8	0·87	— 1024	6933	5·35
—0·8	1·08	— 1954	4979	0
—0·8	2·32	— 9544	—4565	— 5·35
—0·8	1·24	— 2224	—6789	—10·7
— 1·0	0·92	— 1650	—8439	—21·4
1·0	0·45	+ 808	—7631	—10·7
0·8	0·88	1580	—6521	— 5·35
0·8	1·1	1972	—4549	0
0·8	2·3	8260	4481	5·35
0·8	1·3	2334	7285	10·7
1·0	0·82	1470	8755	21·4

The hysteresis loop plotted from these results is given in Fig. 4.

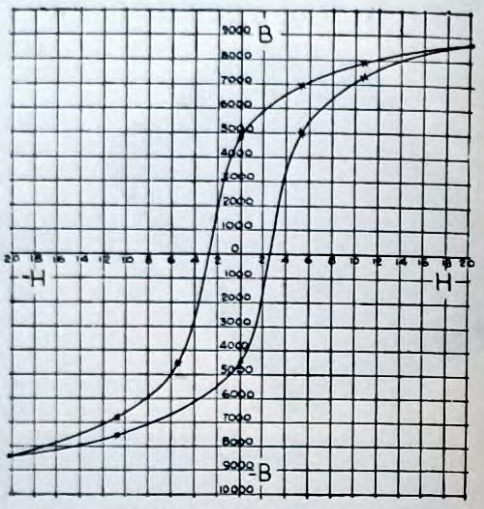


Fig. 4.—Hysteresis Loop.

Experiment II.—B, H Curve for a Ring Specimen.

To determine how B, the induction, depends upon H the magnetising field.

The Method.—In this experiment, the method is to reverse the current in the primary coil thus changing the magnetic field from + H to — H and the induction from + B to — B. The quantity of electricity which then passes through the galvanometer is proportional to (*a*) the change in 2B in B, (*b*) the area of cross-section a of the ring and (*c*) the number of turns N on the secondary coil. The resistance of the secondary circuit of the ring is maintained constant and the galvanometer calibrated by means of a standard mutual inductance.

Theory.—If a reversal of current in the primary of the ring gives a galvanometer throw θ then $2BaN \propto \theta$ and may be written $= K\theta$.

If a current i_0 be reversed through the primary of a mutual inductance M and, with the same total resistance of the galvanometer circuit as above, a throw φ is obtained, then $2Mi_0 = K\varphi$.

Hence $B = \left(\frac{Mi_0}{aN\varphi}\right)\theta$, which may be written $= \lambda\theta$.

The field H for a toroidal coil is, as in Expt. I, given by $H = \left(\frac{2n}{10a}\right) i$, which may be written $= \beta i$.

Thus B and H may readily be evaluated and the corresponding curve plotted as shown in Fig. 5. It is instructive also to plot at the same time, the μ, H curve, μ being the permeability and equal to B/H. It will be observed that the maximum ordinate of the μ, H curve, occurs at the point of inflection on the B, H curve, where dB/dH is a maximum and d^2B/dH^2 is zero.

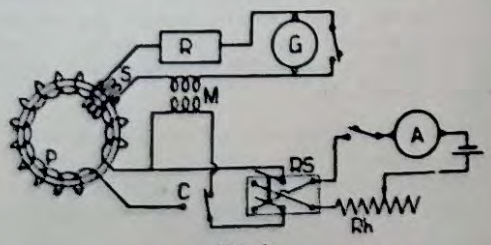


Fig. 3.

Experimental.—The apparatus shown in Fig. 3 should first be set up. PS is the wound specimen, G the galvanometer (Ballistic Galvanometers **A 54-178**, 18 ohms resistance are suitable), R a resistance box in series with the secondaries of the coil and of the mutual inductance M. KS is a reversing switch; A, a 0–2 ammeter and C a change-over switch allowing the primary of the mutual inductance to be switched into the circuit and substituted for the primary of the specimen during calibration.

The experimental steps may be summarised as follows :—

(1) Set R equal about 500 ohms, close KS, adjust value of current through A to about 1·5 amps. and reverse KS. Adjust R to give as large a throw on G as is convenient.

A 73-450. The Microid Toroidal Coil—*continued.*

(2) Adjust the rheostat to give a current through the primary of the ring specimen of 0·1, 0·2, 0·3 . . . 1·5 amps. in succession, reversing at each increment; and obtain the mean deflection θ for each reversal. The first throw of each set of readings should, owing to hysteresis, be rejected. A carbon plate rheostat is convenient as it allows of *continuous* current adjustment.

(3) To calibrate the galvanometer increase Rh to maximum resistance, change over switch C to bring primary of M into circuit and adjust current i_0 to give a suitable throw φ upon reversal of RS. Note the throw.

Arrange the observations as shown in Table 2.

SPECIMEN RESULT.

Type of Specimen :—Soft Iron.

Constants of apparatus :—

$a = 2{\cdot}5 \times 0{\cdot}32$ cm. $\quad \alpha = 5{\cdot}08$ cm. $\quad N = 25$ turns.
$n = 273$ turns. $\quad M = 10$ millihenries. $\quad i_0 = 0{\cdot}2$ amp.
$\varphi = 17{\cdot}2$ cm.

$$\therefore \lambda = \left(\frac{Mi_0}{aN\varphi}\right) = \frac{10^6 \times 0{\cdot}2}{2{\cdot}5 \times 0{\cdot}32 \times 25 \times 17{\cdot}2}.$$

$$= \mathbf{582}.$$

$$\beta = \frac{2n}{10\alpha} = \frac{2 \times 273}{10 \times 5{\cdot}08}.$$

$$= \mathbf{10{\cdot}74}.$$

TABLE 2.

i Amps.	θ cm.		Mean θ cm.	B $(=\lambda\theta)$ lines/cm.^{2}	H $(=\beta i)$ lines/cm^2	μ $(=B/H)$
0·1	0·86	0·90	0·88	512	1·074	476·5
0·15	3·2	3·08	3·14	1827	1·611	1134
0·2	5·8	5·75	5·77	3360	2·148	1563
0·3	9·6	9·35	9·48	5515	3·222	1713
0·4	12·0	12·1	12·05	7015	4·296	1632
0·5	14·05	13·9	13·98	8130	5·37	1514
0·6	14·8	15·05	14·93	8690	6·444	1349
0·7	16·4	16·1	16·25	9460	7·518	1258
0·8	17·0	17·2	17·1	9948	8·592	1157
0·9	18·1	17·89	17·99	10460	9·666	1082
1·0	18·95	18·7	18·83	10950	10·74	1019
1·1	19·6	19·45	19·53	11360	11·814	962
1·2	20·45	20·15	20·3	11810	12·888	919
1·3	21·1	20·8	20·95	12180	13·962	874
1·4	21·6	21·4	21·5	12500	15·036	832
1·5	22·2	21·8	22·0	12800	16·110	795

The B, H and μ, H curves plotted from the results in Table 2 are shown in Fig. 5 below.

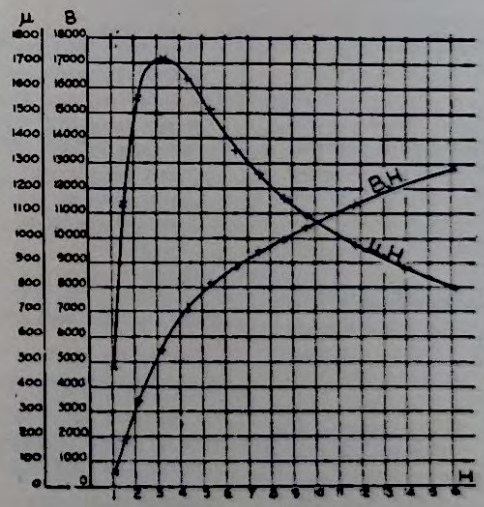


Fig. 5.—B — H, μ — H Curves.

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Electrostatics

POLYTHENE ("ALKATHENE"). The experimental teaching of electrostatics both at the lecture table and in the laboratory has in the past not received the fulness of treatment which the importance of the subject merits. The absence of an insulator which would enable experiments to be performed with the certainty that they would afford effective demonstration under varying conditions of atmospheric humidity, is partially the cause. Sulphur, paraffin wax, shellac, ebonite, amber, varnished glass and quartz have been variously employed. None of these materials embodies all the characteristics required for both economical construction and effective use of apparatus.

As a result of war-time development, there is now available a new insulator, polythene, which has every prospect of giving a new impetus to the experimental side of electrostatics; polythene is a generic name adopted to define polymers of ethylene suitable for use in plastics.

Polythene includes a series of polymers of ethylene of various average molecular weights. It is tough and flexible over a wide range of temperatures, is translucent, is normally white in colour and is similar to densely-white paraffin wax in appearance and to the touch. The characteristics of polythene place it in a category between those materials known as rigid plastics and those termed non-rigid plastics. A number of grades are manufactured, of different toughness, which varies considerably with temperature. It can be turned in a lathe, can be screwed (with care) and can be melted and cast into simple shapes. Its structure results in unusual water resistance and outstanding electrical properties, such as extremely low power factor and low dielectric constant, along with high resistivity and high dielectric strength. The unusual combination of electrical and mechanical properties make polythene very suitable for the insulation of high-frequency and high-voltage equipment.

The dielectric constant of polythene and its power factor remain constant over a wide range of frequencies, and the former changes little over the temperature range — 50° to 220° F. Since polythene has very low moisture absorption (0·01 by A.S.T.M. method D 570–42) its electrical properties are practically unaffected by changes in humidity or by immersion in water. It is readily electrified by friction. It has been reported to us that an "Alkathene" electrophorus, stored away with some residual charge at the end of a demonstration, was found to be still charged when again taken into use a year later. It would therefore appear to be the ideal material for use in the construction of electroscopes, electrophorus, electrometers and a wide range of apparatus for use in Electrostatics.

Not only is polythene resistant to water vapour, but total contact of one side of a film with liquid water has no effect on rate of transfer. It is not readily wetted by water; for example, water has a contact angle of 90° advancing, or 70° receding, measured on a clean surface.

These characteristics show that in polythene the physicist is provided with a new material superior in most respects to the materials which have hitherto been used for the insulation of high-frequency and high-voltage equipment. As far as possible the apparatus in the following pages on Electrostatics embodies "**Alkathene**" brand of polythene, where previously the traditional materials have been employed. "Alkathene" is the registered trade name for the original polythene discovered and manufactured by Imperial Chemical Industries, Limited.

PHYSICAL CHARACTERISTICS

Power factor (tan δ) at 10^3 c.p.s./20° C. ..	0·0001
" " " 10^6 c.p.s./20° C. ..	0·0002
" " " 10^8 c.p.s./20° C. ..	0·0003
" " " 10^9 c.p.s./20° C. ..	$0{\cdot}0003_5$
Permittivity, 50 c.p.s. to 2×10^9 c.p.s./20° C. ..	2·3
Dielectric strength, volts/mil.	1,000
Volume resistivity, ohm. cm. 20° C.	3×10^{17}
Surface resistivity, ohms	10^{14}
Refractive index	1·52
Crystal melting point	110–115° C.
Density, gms./ml. 20° C.	0·92
Coefft. linear expansion, cm./cm./° C., range 0° C. to 40° C.	0·00020
Thermal conductivity cal./cm.²/cm./° C. at 20° C.	0·0007

Water absorption and diffusion.

Permeability for films 0·002–0·01 in. thick = 4×10^{-9} gms./sq. cm./cm. thickness/mm. Hg of water vapour pressure at 20° C.

A polythene film 0·0025 in. thick, with 100% humidity at room temp. on one side and anhydrous calcium chloride on the other side transmits about 0·03 mgm. water vapour/sq. in./hour.

Limiting water absorption after prolonged exposure < 0·05 per cent.



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Diam.	⅜	½	½	¾ in.
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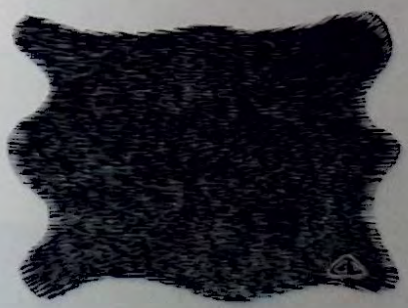
A 81-180. **Ditto**, 12 × ¾ in., one half roughened to show the difference produced by friction on the different surfaces	0	3	9
A 81-185. **ROD, half glass, half brass**, 12 in. long	0	5	6
A 81-190. **ROD, half ebonite, half brass**, 12 in. long	0	5	6



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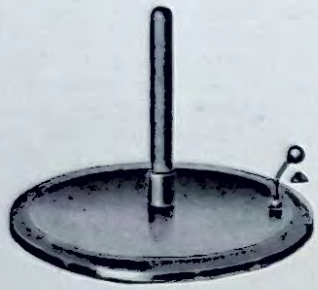
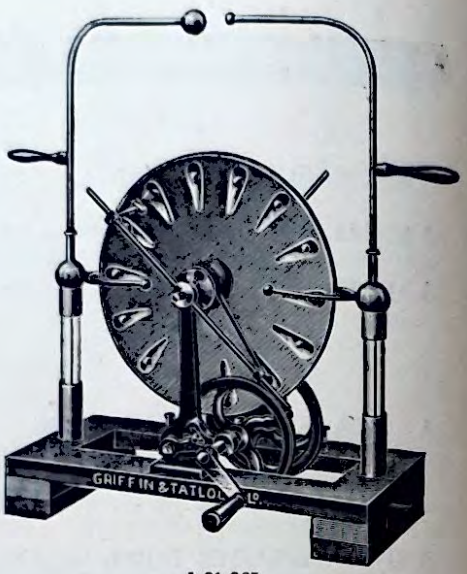


A 81-247.



A 81-260.



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A 81-245. ELECTROPHORUS, Students', "Alkathene" disc 3½ in. diam. (see p. 268), in metal sole, brass cover 3 in. diam., with "Alkathene" handle	0	10	0
A 81-247. ELECTROPHORUS, "Alkathene" disc 6 in. diam. in metal sole, brass cover 4 in. diam. with "Alkathene" handle and small brass sphere	0	17	6
A 81-250. Ditto, disc 10 in. diam., cover 6 in. diam.	1	5	0
A 81-260. WIMSHURST MACHINE, on polished wood base 12 × 6 in., with plates 8½ in. diam., brass sectors, "Alkathene" Leyden jars, (see p. 268) and dischargers mounted on "Alkathene" insulating bar	6	10	0
A 81-265. WIMSHURST MACHINE, on polished mahogany base 18 × 9½ in., with arrangement for belt adjustment. Two 12 in. plates, with brass sectors and contact studs, and two "Alkathene" Leyden jars	15	0	0

A 81-270. PLATES, Wimshurst Machine, with brass sectors, with 1⅛ in. hole in centre.

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Width	⅛	3/16	*in.*
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A 81-300. TINFOIL, commercial packing foil, in rolls .. .. .. 8 *oz.* 1/7 ; 1 *lb.*		0	3	2



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A 81-430. ELECTRIFICATION APPARATUS. Two tin cans, with "Alkathene" Handles (Starling: *Electricity and Magnetism, 6th Edn.*, p. 108), nested, diam. × height respectively 3 × 4 in. and 1¾ × 3 in., the outer can having an "Alkathene" disc (see p. 268) inside on the bottom. Can be used as described in para. 4 of note below	0	8	6
A 81-440. ICE PAILS, Faraday, nest of four, tin plate, with three "Alkathene" feet fitted to each. Largest pail about 6 in. diam. × 7 in. high	1	15	0

The ice pails are used to demonstrate that the maximum quantity of electricity induced in a body is equal to that of the inducing body. The gradual lowering of a charged sphere into the innermost pail results in a gradual divergence of the leaves of an electroscope connected to the outermost pail, until a certain divergence is reached. Thereafter, if the sphere be brought into contact with the pail, no further divergence results and on withdrawing the sphere it is found to be completely discharged.

If, while the sphere is inside the pail, the outer pail is touched or earthed, the leaves of the electroscope collapse and on withdrawing the sphere, diverge again to the same extent as before but with electricity of opposite sign.

By the use of four pails, it can be shown that the presence of the intermediate pails has no effect on the charge induced on the outer pail, for they can be connected together without affecting the amount of divergence of the electroscope.

The pails can also be used to show that equal quantities of electricity of opposite sign are produced by friction. A charged ebonite rod introduced, produces divergence of the electroscope: the rod with its rubber produces no divergence: the rubber alone produces equal divergence of opposite sign.

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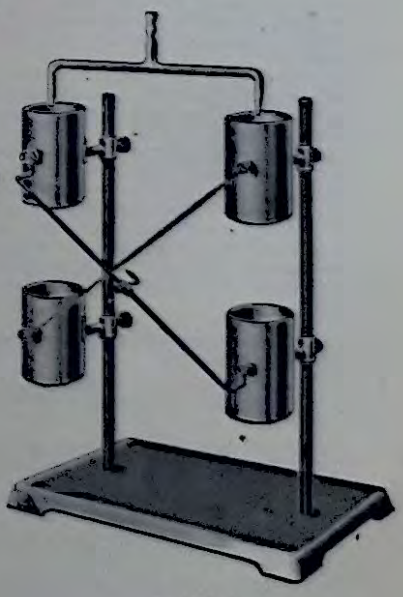
A 81-460. BUTTERFLY NET, Faraday, improved type, for showing that an electrical charge resides on the external surface of a conductor. On "Alkathene" pillar 6 in. high with "Alkathene" cord and wood base	0	17	6

Absence of charge in the interior of the net may be shown by touching with a proof plane and applying to an electroscope. On pulling the net inside-out by means of the "Alkathene" cord, the charge is found to be still on the exterior although this was previously the interior.

	£	s.	d
A 81-470. WATER DROPPER, Kelvin (Hadley: *Magnetism and Electricity for Students*, p. 213), with four metal cylinders mounted on "Alkathene"-insulated supports (see p. 268), double branch glass water tube with stopcock, spark gap, necessary clamps and stand ..	4	0	0

Two pairs of copper cylinders are connected electrically as shown. The cylinders are first charged by a Wimshurst Machine, and the flow of water adjusted by a stopcock so that it drips through the upper pair of bottomless cylinders, without touching them, into the lower cylinders, which are closed at the bottom. Connections are taken from the two cylinders on one side, to an electroscope fitted with earthing plate. Charges are built up by induction as the water drips through the cylinders, so that the electroscope leaf is deflected until it strikes the earthed plate. As dropping continues the leaf oscillates. The sign of the charge on each conductor should be tested by presenting the electroscope to each in turn.

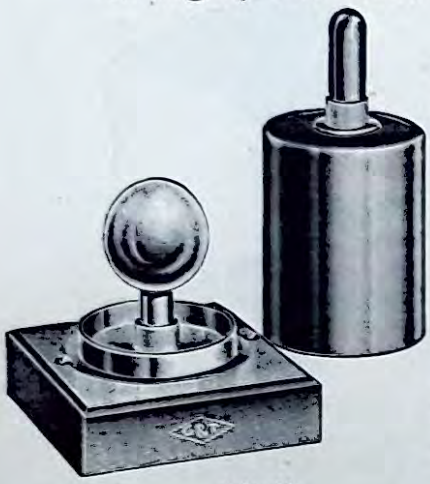
A large potential difference can be generated by this simple electrostatic machine, which can be measured by the spark length across the gap between the two crossed-over connecting wires. If the water emerges as a continuous jet the stream diverges into an inverted fountain and may fail to fall into the lower cylinders.



A 81-470.

THE MICROID ELECTROSTATIC CHARGER

A highly insulated sphere and can for induction experiments



A 81-490.

The method of charging a body with $\pm n\,q$ charges by repeated induction from an original charge of q units is of great theoretical interest in the study of electrostatics, but is also the cause of much perplexity to students. Quantitative verification is, therefore, desirable but is difficult when, as is often the case, atmospheric conditions are unfavourable. Various materials have been used as insulators to minimise the difficulty. None has been found to excel "Alkathene," which is non-hygroscopic and extremely stable towards oxidation—qualities which ebonite and sulphur do not possess. (*See descriptive notes on "Alkathene" on p.* 268.)

The Microid Electrostatic Charger employs "Alkathene" insulators so designed that the highest insulation is obtained with an economy of material which enables the apparatus to be offered at a reasonable price for the precise demonstration of a difficult experiment.

SPECIFICATION

A brass sphere 3·75 cm. diam. is rigidly mounted on a flanged brass plate recessed into a polished wood base about 3½ in. square. "Alkathene" blocks of special design are employed above and below the plate to insulate the sphere, which is anchored by means of a threaded spindle passing through the insulators. By rotating the plate through 90° it can be removed from the base.

The can is of heavy lacquered spun brass, about 2½ in. diam. by 3 in. high and is provided with a metal handle insulated by "Alkathene" blocks in a similar manner to the sphere.

A 81-490. MICROID ELECTROSTATIC CHARGER. Insulated brass sphere on metal disc and polished teak base about 3½ in. square. Insulated brass induction can. "Alkathene" insulators throughout .. .. £ 2 5 0

EXPERIMENTAL NOTES

If the insulated sphere is given a charge $+q$, Gauss's theorem shows that $4\pi q$ lines of induction must leave it and must end on a corresponding charge $-q$. When the insulated can is placed over the sphere and lowered until it is in contact with the earthed base plate most of the lines of induction leaving the sphere end on the can. It is not material that they do not *all* end on the can. The primary requirement is to be able to charge a body with a sequence of **identically equal** charges. The position of the insulated can, as it is just breaking contact with the base ring, is perfectly definite and uniform. Repetition of the experiment, therefore, results in a constant fraction of the lines of induction from the sphere ending on the can at the moment of breaking contact, and so produces always a constant charge, provided that the sphere is untouched after charging.

After charging, the can is lifted from the earthed base ring so that the induced negative charge is isolated from earth. When the can is removed from the vicinity of the sphere the charge moves to its outer surface.

In all such experiments it is assumed that the base ring of the apparatus, and therefore the can when this is seated on the base, is at earth potential. This is normally automatically achieved by leakage through the wood base of the apparatus and the table on which it rests. Under particularly dry conditions and with well waxed tables this leakage may be insufficient. It is therefore a desirable routine practice to earth the can with the finger when it is seated on the base. The finger should be removed before the can is lifted.

Expt. I.—Charges taken under identical conditions from a Charged Body are Equal.

Place a deep calorimeter of suitable size on the plate of an electroscope provided with an angular scale for measurement of the deflections. Give the insulated sphere a large charge from an electrophorus. Carry out the normal induction experiment. Lower the can over the sphere until it rests on the base ring, taking care that the two do not touch. Since the latter is earthed the "free" charge does not need to be liberated by touching the can. Lift the charged can carefully off the base ring by the insulated handle and transfer it to the calorimeter on the electroscope. The whole of its charge is transferred to the electroscope when the whole of the can is surrounded by the calorimeter and the two are brought into contact. The deflection of the electroscope is noted and the instrument is then discharged.

It will be found that repetition of this experiment will produce a deflection of exactly similar magnitude.

An interesting variation in the method of transference of the charge on the can to the calorimeter is by induction instead of by contact. In this method, the charged can is lowered into the calorimeter until its top is below the plane of the mouth of the calorimeter—but contact is not established. The can is then touched with the finger. This produces a charge on the electroscope equal, but opposite in sign, to that on the can. The charge may be measured when the can is withdrawn from the calorimeter.

Expt. II.—Characteristics of an Electroscope.

If the insulated sphere carries only a small charge, very little deflection of the electroscope will be produced on repeating Experiment I. If, however, each charge from the can is transferred entirely to the electroscope system a graph connecting deflection with number of equal charges may be drawn. It is found that the sensitivity curve so obtained rarely approximates to the straight line so often assumed when working with uncalibrated instruments.

A 81-520. ROLL OF TINFOIL, with "Alkathene" cord (see p. 268), and mounted on "Alkathene" rod, for demonstrating the relation between area and density of charge .. £ 0 8 6



A 81-520.



A 81-590.



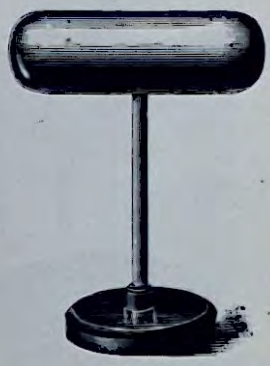
A 81-600.



A 81-610.



A 81-615.



A 81-620.

A 81-590. BRASS BALLS, Hollow, with small hole, for electrical experiments.

Diam.	½	¾	1	1½	*in.*
	2/3	5/-	12/6	£1 0 0	*dozen*

A 81-600. BRASS BALLS, 1½ in. diam., on stands, with "Alkathene" pillars. To demonstrate the separation of "free" and "bound" induced charges .. .. .. *pair* — £ s. d. 0 10 6

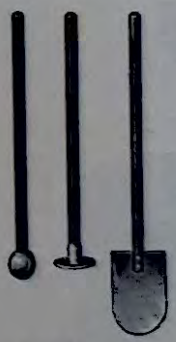
A 81-610. CONDUCTOR, Spherical, wood, 3 in. diam., coated with tinfoil, on "Alkathene" pillar 6 in. high (see p. 268) .. .. — 0 12 6

A 81-615. CONDUCTOR, Conical, wood, 6 × 3 in., coated with tinfoil, on "Alkathene" pillar 6 in. high. To show by means of a proof plane and electroscope how the surface density of a charge varies with the curvature .. .. — 0 12 6

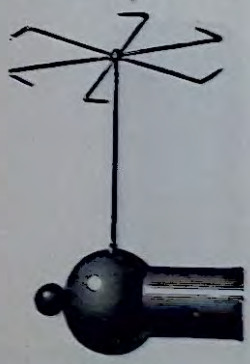
A 81-620. CONDUCTOR, Cylindrical, wood, 6 × 2 in., coated with tinfoil, on "Alkathene" pillar 6 in. high .. .. — 0 12 6



A 81-640.



A 81-660—670.



A 81-680.

A 81-640. CONDUCTORS, Tin, small, set of 3. Sphere, cone, cylinder. **Without** support. Intended for use with support **A 81-350** .. .. — £ s. d. 1 0 0

A 81-660. PROOF PLANE, brass sphere ⅝ in. diam., mounted on "Alkathene" handle (see p. 268) about 6 in. long .. .. — 0 1 9

A 81-665. Ditto, stout brass disc, 1 in. diam., with ferrule and "Alkathene" handle 5 in. long. Plane of the disc is perpendicular to axis of handle .. .. — 0 2 0

A 81-670. Ditto, sheet copper plane 2 × 1½ in., with semicircular end, mounted on "Alkathene" handle 6 in. long .. .. — 0 2 6

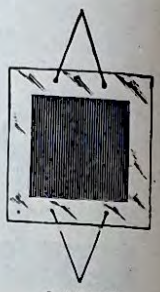
A 81-680. WHIRL on wood foot. When connected to the conductor of an electrical machine a discharge takes place from the points, ionising the surrounding air. The reaction due to the electron stream causes rapid rotation in a direction opposite to that indicated by the direction of the points .. .. — 0 17 6



A 81-720.



A 81-725.



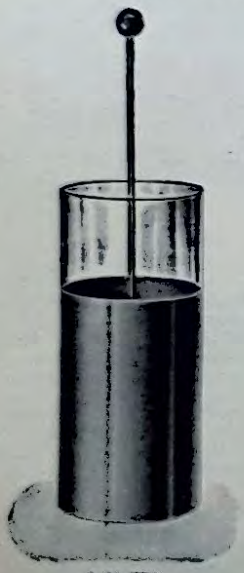
A 81-735.

A 81-720. CONDENSER, Aepinus. Two brass discs 4 in. diam., each fitted to a sliding brass rod with "Alkathene" handle, attached to "Alkathene" supports (see p. 268), on polished wood base about 12 × 7 in. The glass plate is easily removable to allow plates of other material being used (see **A 81-725**). Terminals are provided. .. .. £ 3 5 0

A 81-725. INSULATING SUBSTANCES, plates 8 × 8 × ¼ in.

Wax.	Glass.	Ebonite.	Alkathene.	
3/6	4/6	7/6	17/6	*each*

A 81-735. ELECTRICAL CONDENSER or FULMINATING PANE, "Alkathene" plate with tinfoil coatings on both sides and with silk handles .. .. £ 0 15 0



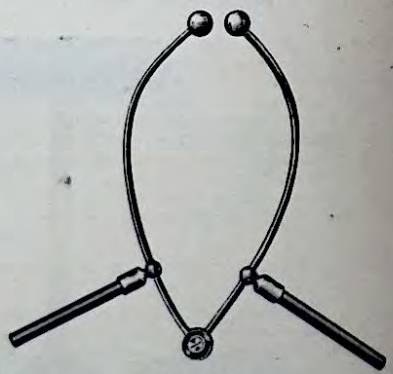
A 81-750.



A 81-755.



A 81-770.



A 81-775.

A 81-750. LEYDEN JAR, "Alkathene" jar (see p. 268) with vertical sides, no cover at top. A rod, fixed into a stout zinc casting which holds it in position, forms the insulated armature.

Nominal Capacity ..	½	1	2	4	*pints*
Diam. × height ..	2 × 4½	2½ × 6½	3½ × 8½	5 × 10	*in.*
	18/6	£1 5 0	£1 15 0	£2 15 0	*each*

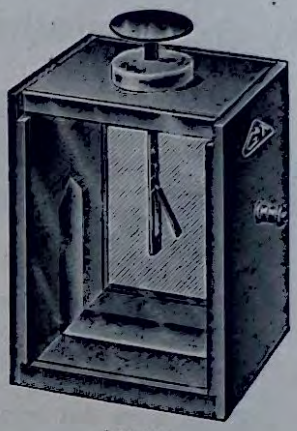
A 81-755. LEYDEN JAR, "Alkathene" jar (see p. 268), **with removable coatings** of metal (Watson: *Text Book of Physics*, p. 653). Maximum diam. 3 in., height 5 in. nominal capacity 1 pint. To demonstrate that the energy of a charged condenser lies in the state of strain imposed on the dielectric .. .. £ 1 10 0

A 81-770. DISCHARGER, jointed, with ⅛ in. diam. brass spheres mounted on arms. Radius of circle swept out by spheres, about 8 in., "Alkathene" (see p. 268) handle about 6 × ½ in. .. .. £ 1 2 6

A 81-775. Ditto, jointed, large size, spheres 1 in. diam. on brass arms ¼ in. diam. with "Alkathene" handles 6 × ¾ in. "Chord" of arms, 12 in. long. It is the most convenient form of discharger, the distance of separation of the spheres being instantly adjustable £ 1 15 0


A 81-800.


A 81-805.


A 81-820.


A 81-830.

	£	s.	d.
A 81-800. ELECTROSCOPE, Pith Ball, on "Alkathene" (see p. 268) support, with metal foot	0	5	0
A 81-805. ELECTROSCOPE, Gold Leaf, flask form, with "Alkathene"-impregnated bark cork, overall height approx. 5½ in.	0	4	6
A 81-820. ELECTROSCOPE, box about 4 in. square, with glass sides, insulated by an "Alkathene" bush, through which passes a brass rod with attached metal plate and gold leaf. A tinfoil strip is fixed to the inside of the case and is connected to an earthing terminal on the outside of the case	1	2	6
A 81-830. ELECTROMETER, Gold Leaf, Chattock. Polished base about 8 × 6 in., metal case with sliding glass sides for projection. Of small capacity and high sensitivity, with "Alkathene" insulation (see p. 268) so that it will hold its charge for a long period; transparent graduated quadrant	2	2	6


A 81-840.



A 81-860.



A 81-865.



A 81-875.

	£	s.	d.
A 81-840. CONDENSER, Electroscope. Brass plate 3 in. diam., mounted on "Alkathene" (see p. 268) handle 6 × ¼ in.	0	5	6

A 81-860. PITH BALLS.

Diam.	1/16 to ¼ in.	⅜ to ½ in.			
	1 6	2 6	*dozen*		
A 81-865. UNSPUN SILK			*reel*	0	1	0
A 81-870. DUTCH METAL LEAF			*book* †	0	2	0
A 81-875. GOLD LEAF			*book* †	0	6	0
A 81-880. ALUMINIUM LEAF			*book* †	0	2	6

THE MICROID PROJECTION ELECTROSCOPE

A new projection electroscope with low-voltage lamp for class demonstration



A 81-920.



A 81-920 c.

The projection demonstration of electrostatic phenomena usually necessitates the setting up of a science lantern and the use of a Chattock's, or other form of electroscope, having transparent sides. This arrangement is not very convenient and the Microid Projection Electroscope has accordingly been designed. It is a self-contained apparatus, requiring but little space on the lecture bench, and projects a well-defined image visible over the whole of a moderately sized lecture theatre It is constructed with an "Alkathene" insulator (see p. 268).

SPECIFICATION

The electroscope is of the normal type with a hinged gold leaf and a stationary plate, fitted with a $\frac{3}{4}$ in. diam. removable collecting plate mounted in an "Alkathene" bush. Light from a low-voltage lamp, which is housed in a well-ventilated lamphouse about $9 \times 2\frac{1}{2}$ in. diam., is collected by a condenser, and an image of the gold leaf is focussed on to the screen by a lens, mounted in the front draw-tube. The body of the electroscope is provided with a $\frac{3}{8}$ in. diam. stem which is adjustable for height in a tube mounted on a heavy tripod base.

	£ s. d.
A 81-920. MICROID PROJECTION ELECTROSCOPE. Lamphouse containing condenser, gold leaf, projection lens in draw-tube, and collecting plate with "Alkathene" insulation. Mounted on heavy tripod stand and adjustable for height. With 3 ft. flex and spade terminals	*r* 9 0 0

Component and Spare Parts for A 81-920

		£ s. d.
A 81-920 a.	**Plate,** 6 in. diam., for above, to screw on in place of small collecting plate, to convert into a condensing electroscope	*r* 0 9 6
„ „ **b.**	**Ditto,** but with "Alkathene" handle to form the other plate of the condenser. A dry battery can be connected between the two plates and the electroscope thus charged. A deflection is produced showing the rise of potential with reduction of capacity ..	*r* 0 12 6
„ „ **c.**	**Rectifier,** mounted on wood base about 8 × 3 in., with reservoir condenser and two pairs of terminals labelled respectively A.C. and D.C. For use on A.C. mains to charge the electroscope with direct current to $\sqrt{2}$ times the mains potential	*r* 2 2 6

Please state mains voltage when ordering.

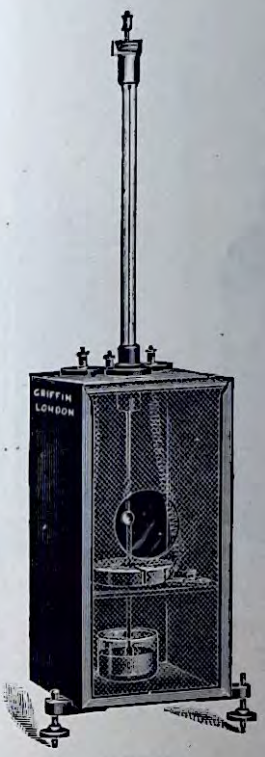
Lamps for above, Class F projector type, 24 watt, S.B.C. .. .. see **A 58-495.**

EXPERIMENTAL NOTES

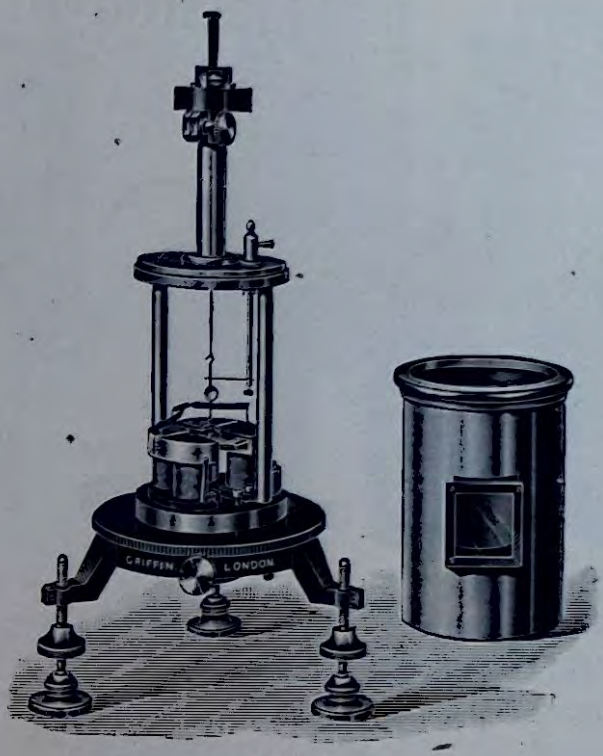
The electroscope is intended for use on the lecture bench, to throw an image on to a white screen. Since the tip of the gold leaf appears near the top of the inverted projected image, tilting the electroscope, in order to raise the image and to increase visibility, is usually unnecessary. A projection distance of 6–8 feet gives an adequately illuminated circle about 3 feet in diameter. The electroscope has a high sensitivity due to the proximity of the earth case and to the low capacity of the leaf system. An earthing terminal is provided on the lamphouse. The small collecting plate supplied with the electroscope is removable and replaceable by the large plate **A 81-920 a**, thus converting the instrument into a condensing electroscope and providing also a support for a Faraday's Ice Pail or other demonstration apparatus.

It has been found that young students often find difficulty in gaining a clear understanding of the mechanism of electrostatic charging and that their difficulties are often removed by emphasis of the fact that charging electrostatically is not fundamentally different from charging by direct application of a potential. Where D.C. mains are available, the two methods of charging may therefore be readily performed, and the electroscope calibrated as a potential measurer. A high value rheostat used as a potentiometer across the mains is convenient for the purpose. Where A.C. mains only are available, however, the special rectifier **A 81-920 c** is provided for charging readily to a known potential. The rectifier gives half wave rectification and the A.C. mains are simply connected to the A.C. terminals of the instrument, the D.C. terminals being connected respectively to the collecting plate and the earthing terminal on the lamphouse. The potential to which the electroscope is charged is then $\sqrt{2}$ times the stated mains voltage.

Demonstrations of specific inductive capacity may be carried out when the plates **A 81-920 a, b** are available. The upper disc is clamped about 2 mm. above the lower and the electroscope charged, the deflection being noted. This is repeated, using slabs of wax, glass, ebonite, "Alkathene," etc., between the plates. Precautions must be taken against charging by frictional handling. On using the same potential and removing the upper disc, a greater deflection results.



A 81-940.



A 81-950.

A 81-940. ELECTROMETER, Quadrant (Stewart and Gee: *Practical Physics*, p. 194), in mahogany case, on three levelling screws, with sliding glass front and perforated metal screen with aperture, sliding door at back. Interior of case coated with tinfoil. Paddle-shaped aluminium needle, quadrants mounted on "Alkathene" support (see p. 268) .. £ 10 0 0

A 81-950. ELECTROMETER, Quadrant, Dolezalek, with quartz fibre suspension, which can be rendered conductive by dipping in the solution of a hygroscopic salt. A small key is fitted on the top for charging the needle by direct contact. Complete with four quartz suspensions and one phosphor bronze suspension. Quadrants and terminals mounted on "Alkathene" pillars (see p. 268) .. .. £ 25 0 0

Unless we are otherwise instructed, the instrument is sent out with plane mirror, but can be supplied with a concave mirror of 1 metre focus at the same price.

A 81-955. Needle, Spare, with mirror, in box, for above .. .. £ 1 2 6

A 81-960. Suspensions, Spare, in box, four of quartz and one of phosphor bronze, for above £ 0 15 0

The highest possible insulation is effected by mounting the quadrants and terminals on "Alkathene" pillars; and the interior of the quadrant-box is made readily accessible by mounting two adjacent quadrants on a movable semi-circular base, which can be swung apart, as shown in the illustration, to admit the needle.

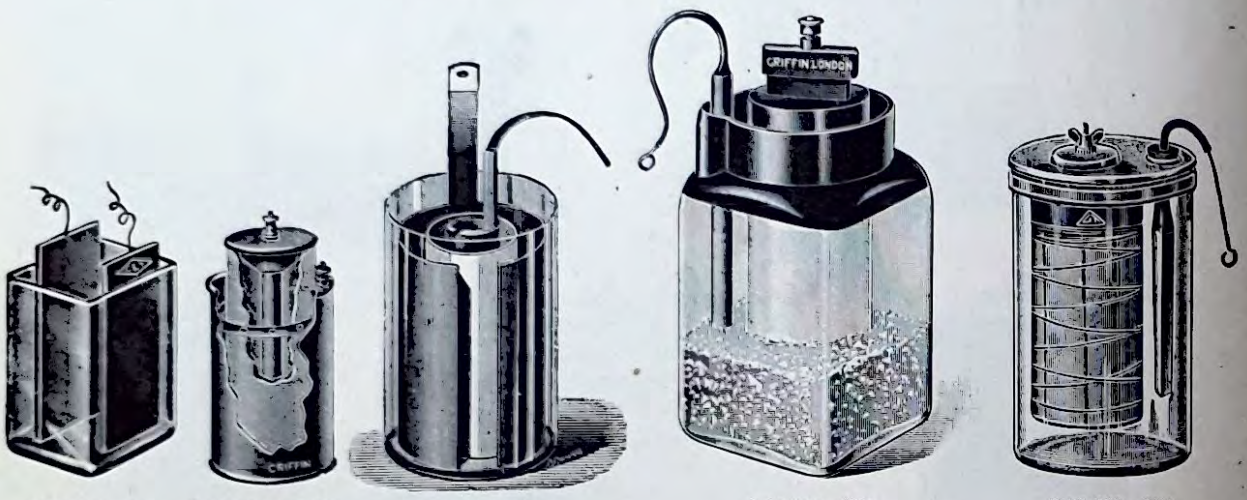
The needle is charged to a potential of 50 to 200 volts, obtained either from the mains or from a H.T. battery. It is not advisable with very fine fibres, to use a much higher potential than this, for the electrostatic effects due to any slight want of symmetry in needle, mirror or brass case, are then liable to interfere with the deflection.

The fibre is attached by means of wax to small aluminium hooks. In order to render it conductive the fibre should be hung on to the eye at the end of the suspension head, and dipped for a few minutes in a 10 % solution of caustic potash so as to remove all traces of dirt and grease. In this and the subsequent operations the top hook should be allowed to dip into the solution until the wax is covered. The fibre should then be well washed in distilled water and, finally, dipped into a 10 % to 20 % solution of calcium chloride or magnesium chloride.

For "The Use of the Quadrant Electrometer as a Ballistic Energy Meter," see *J. Sci. Instruments*, 1929, **6**, 241.

See also applications in Glazebrook: *Dict. Applied Physics*, Vol. II.

Electrodynamics



A 82-310—312. A 82-315—320. A 82-325. A 82-335—340. A 82-350—354.

CELLS, Simple.

		£	s.	d.
A 82-310. Jars, Glass, rectangular, approx. 5 × 3 × 3 in.	*each*	0	6	6

A 82-312. Plates, for above, 6 × 2 in., with terminals.

Element	Zinc.	Copper.	Carbon.
	16/-	16/-	33/- *dozen*
	1/6	1/6	3/- *each*

CELLS, Daniell, a stout copper pot with terminal and a perforated shelf near the top to carry copper sulphate, with thick zinc rod carried on a wood cover. E.M.F. 1·079 volts.

	Complete Cell.	Copper Pot with terminal.	Porous Pot.	Zinc Rod with terminal.
A 82-315. Half Pint	*p* 10/6	4½ × 3 *in.* 8/6	5 × 2 *in.* 11d.	4½ × ½ *in.* 1/6 *each*
A 82-320. One Pint	*p* 12/6	5½ × 3½ *in.* 9/6	5¾ × 2½ *in.* 1/2	5 × ½ *in.* 2/4 *each*

Solutions for Daniell Cells—a saturated solution of copper sulphate for the copper cell, and dilute sulphuric acid, containing one part of acid to ten parts of water by volume, for the zinc cell.

A 82-325. CELL, Daniell, Colonial Government pattern, with cylinders of copper and zinc, in glass jar. Capacity 3 pints. E.M.F. 1·079 volts.

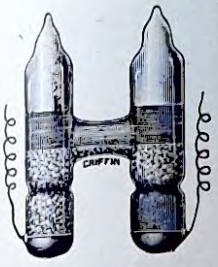
Complete Cell.	Copper.	Zinc. 4½ × 1½ × ¼ in.	Porous Pot. 5¾ × 2½ in.	Glass Jar. 7 × 5 in.
p 12/-	2/-	3/6	1/4	5/-

CELLS, Leclanché, charged porous pot and zinc in glass cell. E.M.F. 1·6 volts ; internal resistance 0·8 to 1·2 ohms. Sal-ammoniac is supplied with each complete cell:—Two Pint, 5 oz.; Three Pint, 8 oz.

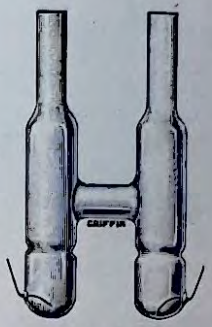
	Complete Cell.	Charged Porous Pot.	Zinc.	Glass Cell.
A 82-335. Two Pints	*p* 6 × 3½ × 3½ *in.* 5/-	5½ × 2½ *in.* 2/9	6 × ⅜ *in.* 1/-	1/6 *each*
A 82-340. Three Pints	*p* 7 × 4½ × 4½ *in.* 7/6	6½ × 3 *in.* 4/-	7 × ½ *in.* 1/3	2/6 *each*

CELLS, Leclanché, Bambairtite (*Patent No.* 256400). These cells have an approximate life of three times that of the ordinary open top Leclanché cells and once set up they require no attention as **no evaporation or creeping of the salts can occur.** Particularly suitable for use in hot climates. The cell consists of a sack element and non-encrusting zinc mounted in an air-tight glass container. E.M.F. 1·60 volts. Internal resistance 0·25 to 0·35 ohms.

	Complete Cell.	Sack Element.	Zinc.	Jar.	Lid.	Rubber.
A 82-350. One Pint	*t* 3/-	1/8	3d.	8d.	6d.	3d. *each*
A 82-352. Two Pints	*t* 3/6	2/-	3d.	1/-	6d.	3d. *each*
A 82-354. Three Pints	*t* 4/6	2/8	4d.	1/1	6d.	3d. *each*



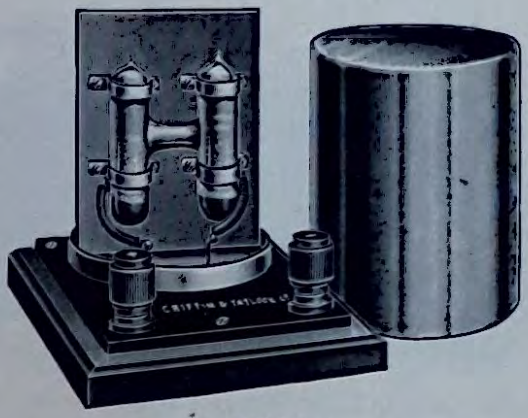
A 82-370.



A 82-372.



A 82-374—378.



A 82-385.

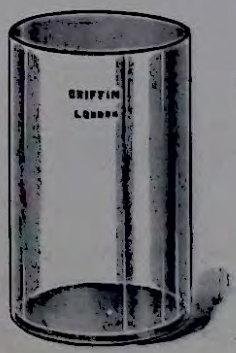
		£	s.	d.
A 82-370.	**WESTON STANDARD CELL**, unmounted, filled and sealed	r 1	7	0
A 82-372.	**H-TUBES** only, with platinum loops	t 0	6	0
A 82-374.	**Weston Standard Cell**, mounted in brass case, with ebonite top	r 3	10	0
A 82-376.	**N.P.L. Certificate** of E.M.F. at one temperature	t 1	0	0
A 82-378.	**Ditto**, of E.M.F. and temperature coefficient	t 1	16	8

CELLS, Standard, Cadmium (or Weston), National Physical Laboratory Pattern. The E.M.F. of the Weston Standard Cell is about 1·0183 International volts at 20° C. The positive electrode of the cell is mercury; the negative electrode is cadmium amalgam and the electrolyte is a saturated aqueous solution of cadmium sulphate. The temperature coefficient being only about 0·000036 volt per degree Centigrade, no thermometer is supplied with these cells unless specially ordered. With works certificate stating E.M.F. at 20° C.

A 82-385. **WESTON STANDARD CELL, in Vernon mount.** The cell is fitted on aluminium bracket fixed to ebonite and wood base with Bakelite-covered terminals. The spun aluminium cover is in one piece and totally encloses the mounted cell, fitting over the metal baseplate. It fits securely without locking device, may be removed instantaneously and allows students to see easily the form and construction of a standard cell .. r 3 0 0



A 82-420.



A 82-425.



A 82-430.

A 82-420. POROUS POTS, circular.

Length × Diam. ..	4 × 1	5 × 2	6 × 2	5¾ × 2½	6½ × 2¾	*in.*
	8d.	10d.	1/-	1/1	1/3	*each*

A 82-425. BATTERY JARS, glass, circular.

Height × Diam.	4 × 3½	5½ × 3¾	7 × 4½	8 × 4½	*in.*
	2/-	2/4	3/6	3/11	*each*

A 82-430. BATTERY JARS, glass, rectangular.

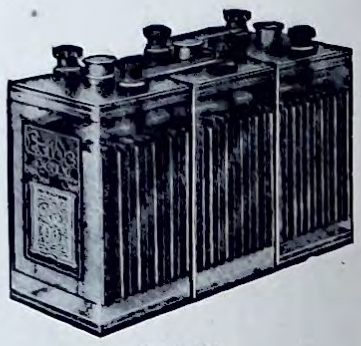
Height	3½	5	6½	6½	*in.*
Length × Width	2½ × 1¼	3¼ × 1⅝	4¼ × 2¼	4¾ × 2½	*in.*
	6/-	6/-	7/-	7/6	*each*



A 82-460.



A 82-470.



A 82-484.

A 82-460. CELLS, Storage (Accumulators), Exide, Mass Type, single cell, 2 volts, in glass containers, fitted with moulded ebonite lids and non-interchangeable terminals of different colours and shapes. For long, slow, or intermittent discharge of small currents, free from fluctuation. These cells are **not** recommended for periods between recharges of less than 15 days. Complete with metal carriers. **Uncharged.**

Capacity	20	45	70	100	*amp. hours*
(*a*) *r*	**8/8**	**16/2**	**20/6**	**27/11**	*each*

A 82-465. CELLS, Storage (Accumulators), Exide, Mass Type, 4 volts, as **A 82-460** but in two-compartment **glass containers. Uncharged.**

Capacity	20	45	*amp. hours*
(*a*) *r*	**17/4**	**32/4**	*each*

A 82-470. CELLS, Storage (Accumulators), Exide, Multi-plate Type, 2 volts, single cell, in glass containers fitted with moulded ebonite lids and non-interchangeable terminals of different colours and shapes. Suitable for **all** periods between recharges up to a maximum of two months. Complete with metal carriers. **Uncharged.**

Capacity	20	30	40	50	60	80	105	120	*amp. hours*
Maximum discharge rate	4·5	7	9	10	10	10	10	10	*amps.*
Over a period of ..	3	3	3	3·5	4·5	7	9·5	11	*hours*
(*a*) *r*	**16/2**	**19/3**	**22/4**	**24/10**	**27/11**	**39/1**	**50/3**	**55/10**	*each*

A 82-472. Ditto, 4 volts, 2 cells complete with connectors, **without** metal carriers ..

(*a*) *r*	**32/4**	**38/6**	**44/8**	**49/8**	**55/10**	**78/2**	**100/6**	**111/8**	*each*

A 82-474. Ditto, 6 volts, 3 cells complete with connectors, **without** metal carriers ..

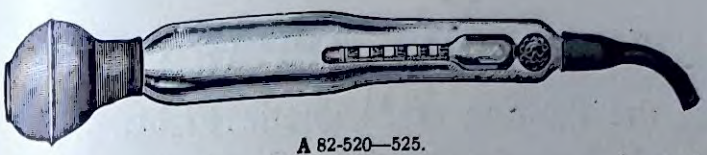
(*a*) *r*	**48/6**	**57/9**	**67/-**	**74/6**	**83/9**	**117/3**	**150/9**	**167/6**	*each*

A 82-480. CELLS, Storage (Accumulators), Exide, Multi-plate Type, 2 volts, single cell, in celluloid containers. Uncharged.

Capacity	20	30	40	50	60	*amp. hours*
Maximum discharge rate	4·5	7	9	10	10	*amps.*
Over a period of	3	3	3	3·5	4·5	*hours*
(*a*) *r*	**17/4**	**20/6**	**24/10**	**28/6**	**32/3**	*each*

A 82-482. Ditto, 4 volts, 2 cells complete with connectors .. .. (*a*) *r* **34/8** **41/-** **49/8** **57/-** **64/6** *each*

A 82-484. Ditto, 6 volts, 3 cells complete with connectors .. .. (*a*) *r* **52/-** **61/6** **74/6** **85/6** **96/9** *each*



A 82-520—525.



A 82-580.



A 82-585.



A 82-590.

£ s. d.

A 82-520. HYDROMETER, Accumulator, Pipette type, with large rubber suction ball, glass body and hydrometer float about $3\frac{1}{2}$ in. long. S.G., 1·100–1·300 .. **0 6 6**

A 82-525. Spare Parts for above.

Hydrometer float.	Glass body.	Rubber Suction ball.	
1/8	2/6	2/6	*each*

A 82-530. HYDROMETER, Accumulator, flat pattern, range 1·100 to 1·300, for testing specific gravity of accumulator acid, about 6 in. long **0 3 0**

A 82-535. Ditto, about 8 in. long **0 3 6**

A 82-580. CELLS, Dry, Dania, round. E.M.F. about 1·5 volts. Internal resistance 0·20 to 0·22 ohm.

Height × diam.	$6\frac{1}{2} \times 2\frac{1}{2}$	$7 \times 2\frac{5}{8}$ *in.*
	(*a*) *p* 4/7	5/6 *each*

A 82-585. CELLS, Dry, Siemens, round. E.M.F. about 1·5 volts. Internal resistance 0·20 to 0·25 ohm.

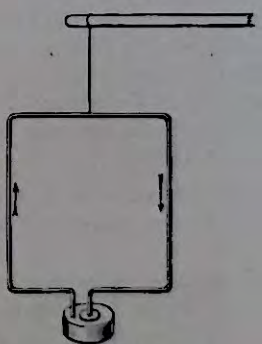
Size	C	B	A
Height × diam.	$6\frac{1}{4} \times 2\frac{1}{4}$	$7 \times 2\frac{5}{8}$	$8 \times 3\frac{5}{16}$ *in.*
	(*a*) *p* 4/-	5/6	8/3 *each*

A 82-590. Ditto, square.

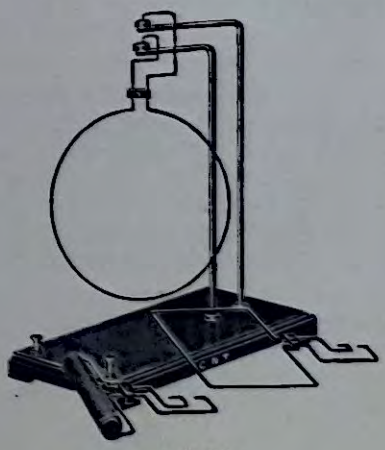
Size	S	R	P	O	N
Height × side ..	$4\frac{3}{8} \times 1\frac{7}{16}$	$5 \times 1\frac{3}{4}$	$6 \times 2\frac{1}{4}$	$6\frac{3}{8} \times 2\frac{3}{4}$	$7\frac{1}{2} \times 3\frac{5}{16}$ *in.*
	(*a*) *p* 3/5	3/8	4/7	6/2	8/11 *each*



A 82-595.



A 82-810.



A 82-815.

A 82-595. CELLS, Dry, box type, 3-cell, E.M.F. 4·5 volts, with contact strips, dimensions $4 \times 1\frac{3}{8} \times 3\frac{1}{4}$ in. .. .. *each p* **0 1 6**

A 82-597. Ditto, with terminals, dimensions $4 \times 1\frac{3}{4} \times 3\frac{3}{8}$ in. .. .. *each p* **0 1 6**

A 82-810. PARALLELOGRAM, Bent Wire (*cf.* Hadley: *Magnetism and Electricity*, p. 267), 8 × 8 in., with ebonite distance piece. Without wood mercury cup A 82-872 .. **0 4 0**

A 82-815. AMPÈRE'S TABLE, with bent wires to show the action of a magnetic field on a conductor carrying a current. On polished wood base 15 × 7 in., with brass pillars terminating in mercury cups. Three wires are provided: a solenoid 6 × 1 in., a rectangle 8 × 5 in., and a circle 8 in. diam., each fitted with distance pieces **3 5 0**

THE MICROID MAGNETIC FIELDS APPARATUS

A new Apparatus for use in the Plotting of Magnetic Fields due to the Earth and to the Current flowing in a Conductor

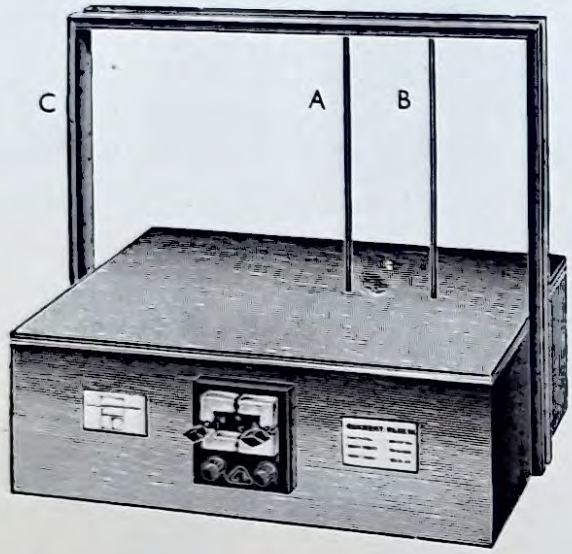


Fig. 1.

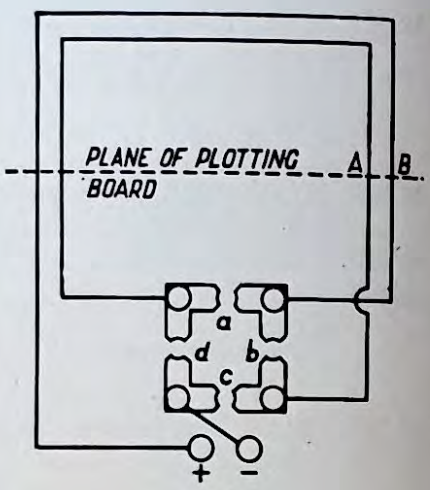


Fig. 2.

A 82-840.

This apparatus can be used for demonstration or for individual qualitative and quantitative work chiefly by Sixth Form Students. The experiments range from a simple investigation of the magnetic field surrounding a linear conductor carrying a current to a demonstration of the underlying principle of the Helmholtz Galvanometer.

The fields due to a single straight current, to two parallel currents in the same direction and in opposite directions, can be readily plotted, the apparatus being easily adapted for these experiments by a simple arrangement of plugs.

Accessory apparatus to carry out the complete range of experiments includes a good plotting compass and such other apparatus as will be found in most school laboratories.

SPECIFICATION

The apparatus consists of a horizontal board about 19 in. × 14 in. supported on a wooden framework (Fig. 1). Two coils, A and B, each of 12 turns of copper wire 30 S.W.G. are wound round the upright frame C, the parts A and B being enclosed in narrow brass tubes. A plotting board is provided midway between the horizontal portions of the coils. The free ends of coil A are connected to b and d on the plug key which is placed on the front face of the frame. The free ends of the square coil B, which enters the plotting board about 4 in. from A, are connected to a on the key and to the terminal placed on the face just below the key. The negative terminal is connected directly to c on the key.

By using various combinations of plugs as indicated below, it is possible, without any further connections or disconnections, to arrange for the current to flow in one coil only, or in both coils at the same time, either in the same or in opposite directions.

(i) By plugging in a and d, current flows down B only.
(ii) „ „ a „ c, „ „ down B and down A.
(iii) „ „ b „ d, „ „ down B and up A.

As A and B are in series under arrangements (ii) and (iii), the same current flows through each coil.

The plotting is done on a sheet of paper, squared or otherwise, placed on the horizontal board and held in position by the brass clips provided. A diagram of connections is placed on the front panel on one side of the key, and instructions for plugging in on the other side.

PRICES

	£	s.	d.
A 82-840. MICROID ELECTROMAGNETIC FIELDS APPARATUS (Yarwood: *Intermediate Practical Physics*, pp. 250–258). Drawing board 19 × 14 in. mounted on box with two coils of 12 turns d.c.c. copper wire wound on rectangular wood frame and passing vertically through drawing board to panel having brass blocks and two plug keys ..	5	10	0

A 82-840. Microid Magnetic Fields Apparatus—*continued.*

EXPERIMENTAL NOTES

The following experiments can be carried out with the apparatus, using a 6-8 volt supply. Experiments IV—VIII are described in Yarwood: *Intermediate Practical Physics.* Experiments marked with an asterisk, are described in detail on pp. 283—285.

Expt. I.—Plot lines of force due to a straight conductor carrying a current. (Use Coil **B**).

Expt. II.—Show direction of lines of force surrounding a straight conductor carrying a current using plotting compasses around the wire. (Use Coil **B**).

Expt. III.—Plot resultant fields due to earth and current through the coil when:

(i) plane of the coil is in the meridian.

(ii) " " " at right angles to the meridian.
(Use Coil **B**).

***Expt. IV.**—Plot resultant field due to earth and current in a straight wire. Find the neutral point and determine the value of H_e. (See specimen result).

Expt. V.—Plot resultant field due to two currents in the same direction. Find the neutral point and calculate the value of H_e.

Expt. VI.—Plot resultant field due to two currents in opposite directions.

***Expt. VII.**—Prove that the strength of the field due to a current in a straight wire is proportional to $1/r$:—

*(i) by plotting lines of force (See specimen result).

(ii) by using deflection galvanometer. This is virtually the same as (i) but probably more accurate.

*(iii) by method of oscillations (See specimen result).

***Expt. VIII.**—To investigate the field on the axis of a circular coil carrying a current by plotting lines of force. (See specimen result).

* * * * * *

Expt. IV.—Plot resultant field due to earth and current in a straight wire. Find the neutral point and determine the value of H_e.

Plug in as for Expt. III (i) and allow a current of about 1 ampere to flow down coil **B**. Plot the lines of force due to the combined effect of the current and the earth and find the position of the neutral point. Measure the distance from the neutral point to the coil and calculate the value of H_e, (see Fig. 3).

Theory.—At the neutral point the two fields neutralise each other, and the value of the field due to the current is given by $2\,nI/r$.

$\therefore H_e = 2nI/r$ where the current I is in c.g.s. units.

In actual practice, however, the value of H_e so calculated will probably be higher than it normally should be, since the current in the return wires along **C** exerts a measurable effect in assisting the earth's field. Hence a correction should be made.

If X (see Fig. 4) is the position of the neutral point situated at a distance d from C, then the force at X due to the current in **C** is $2\,nI/d$ acting in the direction at right angles to CX. The component of this force in the direction XH_e is the force assisting the earth's field.

Therefore the true value of the earth's field is equal to

$$2nI/r - 2nI/d \cdot \sin\alpha$$

Specimen Result.

Below is a diagram of the field that was obtained.

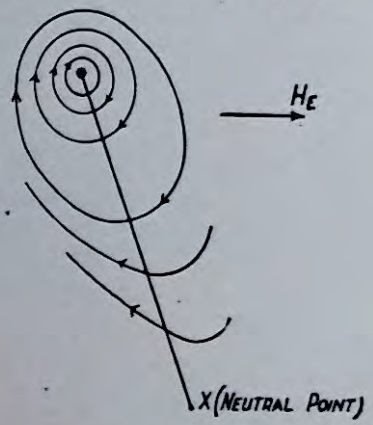


Fig. 3.

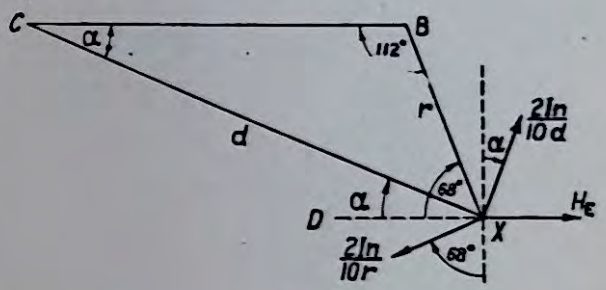


Fig. 4.

Calculation of the value of H_e.

The value of the current was taken, r and d were measured and angles $C\hat{B}X$ and $B\hat{X}D$ were found.

Readings: $I = 1{\cdot}35$ amps. $r = 16{\cdot}75$ cm. $d = 47{\cdot}0$ cm. $n = 12$.

Since the 3 forces balance at X,

$$H_e = \frac{2nI}{10r}\cos 22° - \frac{2nI}{10d}\cos(90 - \alpha).$$

and since $\cos 22° = \sin 68°$, $\cos(90 - \alpha) = \sin\alpha$

and, by the sine rule, $\sin\alpha = r \sin 112°/d$,

$$H_e = \frac{2nI}{10}\left[\frac{\sin 68°}{r} - \frac{r \sin 112°}{d^2}\right]$$

$$= \frac{2 \times 12 \times 1{\cdot}35}{10}\left(\frac{\sin 68°}{16{\cdot}75} - \frac{16{\cdot}75 \sin 112°}{(47)^2}\right)$$

$\therefore H_e = 0{\cdot}16$ oersteds.

Expt. VII (i).—Prove that the strength of the field due to a current in a straight conductor is proportional to $1/r$, by plotting lines of force.

Use Coil **B** for this experiment and pass a current of about 3/4 ampere. Arrange the apparatus so that the plane of the coil is at right angles to the magnetic meridian and draw on the paper a line passing through the coil in the direction of the meridian. At suitable distances, r, from the coil along the drawn line plot the lines of force and obtain the direction of these lines, for example, **AC** in fig. 5. This line represents the direction of the resultant field at the point O.

[*continued overleaf*

A 82-840. Microid Magnetic Fields Apparatus—*continued.*

Repeat the experiment on the other side of the coil in order to get mean values for the deflections at the various points. Measure the angles of deflections, θ, or obtain the tangents of the angles directly by measuring lines, and tabulate results (Table I). Plot log tan θ against log r (see Fig. 6). If the strength of the field, F, due to the current is proportional to $1/r$, the graph should be a straight line with a slope of -1. Also the product r tan θ should be constant, for if F is proportional to tan θ (since $F = H_e$ tan θ) and also to $1/r$, then r tan θ must be constant.

NOTE: If $F = \frac{2nI}{r}$, we have $H_e \tan\theta = \frac{2nI}{r}$, or $\cot\theta = \frac{r.H_e}{2nI}$.

Therefore if cot θ is plotted against r a straight line should result, the slope of which is $H_e/2nI$, and if H_e is known, the value of I can be calculated and compared with the ammeter reading.

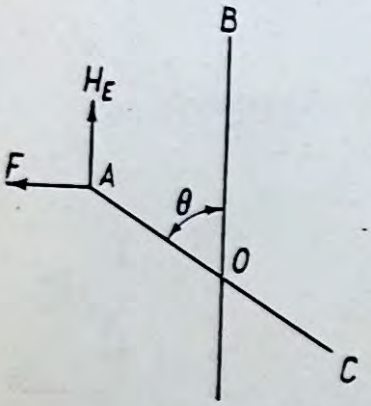


Fig. 5.

(a) Tan θ was found by direct measurement.

(b) The field was explored on both sides of the wire carrying current, so that the values in the "tan θ" column (Table I), represent the mean results for deflections at various points.

Specimen Result. **TABLE I.**

r cm.	log r	tan θ	log tan θ	r tan θ
3	0·477	1·80	0·255	5·40
4	0·602	1·37	0·137	5·48
5	0·699	1·05	0·021	5·25
6	0·778	0·89	− 0·051	5·34
7	0·845	0·77	− 0·114	5·39
8	0·903	0·67	− 0·174	5·36
9	0·954	0·60	− 0·222	5·40
10	1·000	0·53	− 0·276	5·30

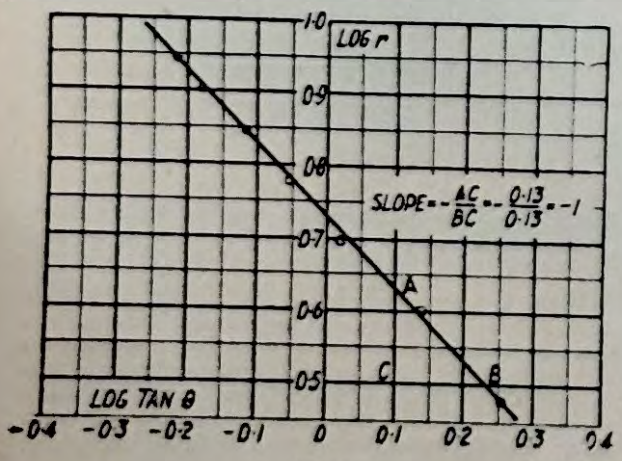


Fig. 6.

Expt. VII (iii).—Prove that the strength of the field due to a current in a straight conductor is proportional to $1/r$, by the method of oscillations.

Arrange the apparatus as in Expt. VII (i) and again use coil **B**. Draw on the paper a line passing through the coil in the magnetic E-W direction of the meridian and again mark off suitable distances along this line.

Put a Searle oscillating needle (**A 72-690**) at **any** point on the line, and by using a stop clock find the period of oscillation of the needle. This will be due to the earth's field alone and will of course be constant throughout the experiment. Let this period be T_e.

Now switch on and allow a current of about $\frac{1}{2}$ ampere to flow through the coil. In a preliminary experiment, determine on which side of the coil the two fields, due to the earth and the current, **assist** one another and the needle swings more rapidly; this is the side to use in the main experiment.

Having settled this, put the needle at each of the points marked and observe the period of oscillation in each position. Let this be T. Tabulate the results as shown in Table II, p. 285. Plot log r against $\log\left(\frac{1}{T^2} - \frac{1}{T_e^2}\right)$ (see Fig. 7). If $F \propto 1/r$, this graph should be a straight line whose slope is -1. Also the product $r\left(\frac{1}{T^2} - \frac{1}{T_e^2}\right)$ should be constant.

Theory.—If the two fields assist one another, then the resultant field $H = F + H_e$.

Now $H = k \cdot \frac{1}{T^2}$ and $H_e = k \cdot \frac{1}{T_e^2}$

$$\therefore F = H - H_e = k\left(\frac{1}{T^2} - \frac{1}{T_e^2}\right)$$

If $F \propto 1/r$, we shall have $F_1 r_1 = F_2 r_2$, etc., and if the corresponding periods of oscillation in these cases are T_1, T_2, etc., then $k\left(\frac{1}{T_1^2} - \frac{1}{T_e^2}\right) = F_1$; $k\left(\frac{1}{T_2^2} - \frac{1}{T_e^2}\right) = F_2$, etc.

By the experiment above, it is shown that

$$\left(\frac{1}{T_1^2} - \frac{1}{T_e^2}\right) r_1 = \left(\frac{1}{T_2^2} - \frac{1}{T_e^2}\right) r_2 = \ldots\ldots$$

Hence $F_1 r_1 = F_2 r_2 = \ldots\ldots\ldots\ldots$

and $F \propto 1/r$.

Method of Oscillations.

Period of needle in earth's field alone, T_e.

T'_e (= period for 30 oscillations) = 390·2 secs.

T_e (= period for 1 oscillation) = 13·007 secs.

$1/T_e^2 = 0{\cdot}005911$.

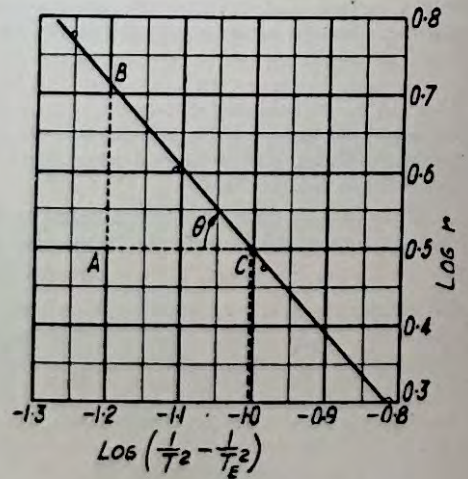


Fig. 7.

$$\tan\theta = \frac{AB}{AC} = \frac{0{\cdot}213}{0{\cdot}200} = 1{\cdot}1$$

$\therefore$ slope is $-1{\cdot}1$.

A 82-840. Microid Magnetic Fields Apparatus—*continued.*

TABLE II.

Distance from wire (r)	T^1 (period for 30 oscillations)	T (period for 1 oscillation)	$\frac{1}{T^2}$	$\frac{1}{T^2} - \frac{1}{T_0^2}$	$\log\left(\frac{1}{T^2} - \frac{1}{T_0^2}\right)$	$\log r$	$r\left(\frac{1}{T^2} - \frac{1}{T_0^2}\right)$
2 cm.	$\frac{374}{5}$ secs.	2·4933	0·1609	0·1550	−0·810	0·301	0·320
3 cm.	$\frac{454}{5}$,,	3·0267	0·1091	0·1032	−0·986	0·477	0·310
4 cm.	$\frac{519}{5}$,,	3·4600	0·0835	0·0776	−1·110	0·602	0·311
6 cm.	$\frac{603}{5}$,,	4·0200	0·0619	0·0560	−1·252	0·778	0·336

Expt. VIII.—To investigate the field on the axis of a circular coil carrying current by plotting lines of force.

This experiment is perhaps not so accurate as the method using Stewart & Gee's apparatus with a deflection magnetometer, but it is instructive and, with care, can give satisfactory results more rapidly.

Coil *B* with its return round *C* is used. It is a square coil, not circular, but the strength of the field along the axis varies in a manner similar to that of a circular coil.

Arrange the apparatus with the plane of the coil in the meridian and draw a line midway between *B* and *C* and at right angles to *BC* (see Fig. 8). This is the axis of the coil, and the field due to the current in the coil at all points on this axis will be magnetic E and W. Starting from the centre point *O* mark off on the axis suitable distances, say 2·5 cm., 5 cm., etc. on both sides (see Fig. 9). Pass a current of about 1 ampere through the coil. Place the plotting compass at *O* and by plotting the line of force, determine the direction which this line makes with the meridian as it crosses the axis. Follow the same procedure for the other points on both sides of *O* and tabulate the results as in Table III. Plot tan θ against distance (d) (see Fig. 10). The resulting curve will indicate the variation of the field strength with distance, since $F = H_0 \tan\theta$. Find the point of inflexion (P) and measure its distance from the axis of the coil. It should be approximately half the radius of the coil.

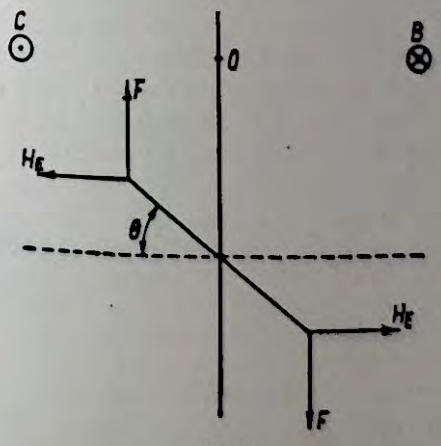


Fig. 8.

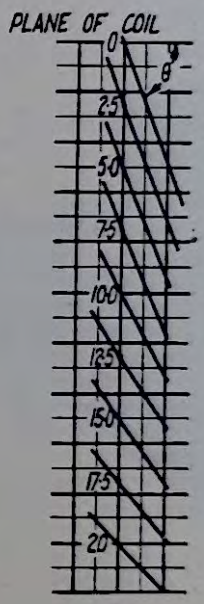


Fig. 9.

TABLE III.

Plotted lines of force for Expt. VIII (one side of coil only).

Distance d cm.	Tan θ
0	24/10 = 2·4
2·5	23·5/10 = 2·35
5·0	45/20 = 2·25
7·5	20/10 = 2·0
10·0	27/16 = 1·7
12·5	19/10 = 1·4
15·0	13/10 = 1·3
17·5	11/10 = 1·1
20·0	9·5/10 = 0·95

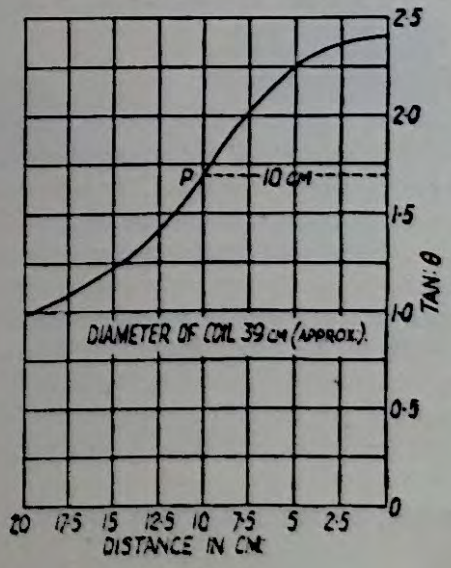
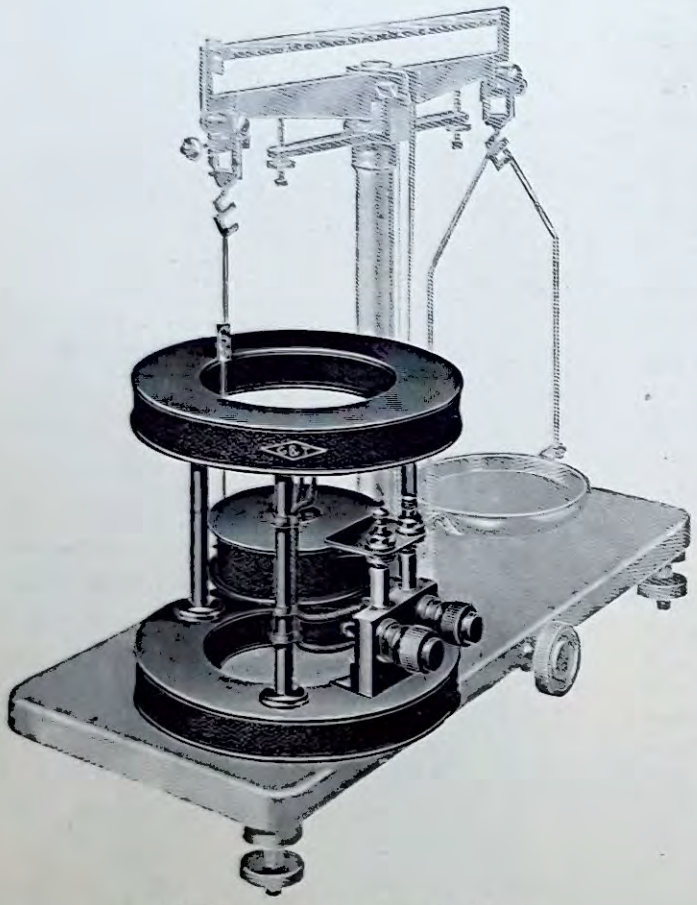


Fig. 10.

THE MICROID AMPÈRE BALANCE

A compact modification of Kelvin's Ampère Balance for the comparison of electric currents



A 82-860. Illustrated on Monorider Balance.

This new apparatus is an important development from a classical model, which has been modified to produce an apparatus specially suitable for use in educational work. It is robust, easy to set up and has been so designed as to be applicable to the majority of types of student balance.

It is essentially a complete half of the original Kelvin Balance (see Sylvanus Thompson; *Elementary Lessons in Electricity and Magnetism*, p. 420), and the mechanical force exerted on the small coil by the magnetic field due to the current flowing in the two sets of coils is weighed directly by counterpoising.

At the maximum continuous current rating of 3 amps. the magnetic force amounts to about 10 gms., while for short periods of running, pulls of over 20 gms. may be obtained with currents of about 4 amps. These mechanical forces may be measured on an ordinary balance to 20 mg. or with care to 5 mg., so that the instrument may be used for comparing currents to considerable accuracy. It is, therefore, a more accurate instrument than any ammeter ordinarily used in the laboratory.

SPECIFICATION

The two larger coils have a mean diameter of 11 cm. and are separated by the vertical pillars, 9·5 cm. in length. The smaller coil has an overall diameter of 7 cm. and is supported on two steel pins which also act as the current connections to it. The adjustable thread, which supports the small coil from one side of the beam of an ordinary balance, comes from the centre of a small rod mounted on the side of the coil. The two bearing pins are vertically adjustable to enable the sensitivity of the ampere balance to be varied. The sensitivity depends upon the distance of the centre of gravity of the small coil from a line joining the pivoting pin tips to the point of attachment of the supporting thread.

Owing to the great difficulty of determining the geometry of the coil systems to the same accuracy as the experimental measurements, it is desirable to employ the apparatus merely for the comparison of currents and not for their absolute determination.

The instrument can be used on either alternating or on direct current.

	£ s. d.
A 82-860. MICROID AMPÈRE BALANCE. Two fixed coils wound in formers, pivoted coil oscillating on adjustable pins and with cord and strainer for suspension from a balance. Two terminals	6 15 0

A 82-860. The Microid Ampere Balance—*continued.*

EXPERIMENTAL NOTES

The mechanical force on the small coil is proportional to the current flowing through that coil and to the field produced by the larger coil. The force is therefore proportional to the square of the current. This means that the apparatus can be used equally for direct or for alternating currents; the apparatus will, therefore, be found very valuable for the measurement of alternating currents and the calibration of such instruments against direct currents.

The only iron employed in the whole apparatus is the pivoting pins, and these, by their position, can exert no mechanical pull on the thread and balance. It is, however, necessary to make certain that the apparatus is set up at a sufficient distance from any external iron. When the apparatus is used on alternating current, the magnetic field of the earth, being uniform, will exert no mechanical force on the pivoted coil.

To arrange the instrument for use, the left pan and bow should be removed from the balance employed, and the large coil system placed on the base under the balance hook. The small coil is then placed in position with its pins in the cups and the supporting thread connected to the balance hook. The apparatus should then be moved until the suspending thread is quite vertical. If it is not, the balance beam may rotate slightly on its agates. The celluloid thread adjuster is then altered until, *with the balance released* (i.e. *the beam free to swing*) *and the pointer at zero*, the plane of the small coil is horizontal.

The weights necessary to obtain a balance are observed, first with zero current and then with currents at any required values, up to a maximum of 3 amps. The additional weight is the pull produced by the magnetic force due to the current.

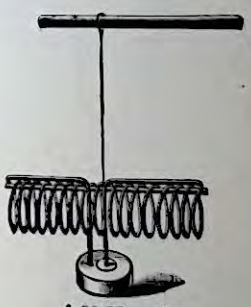
To increase the sensitivity of the apparatus, slacken the lock nuts and rotate the screwed pivoting pins in a clock-wise direction until the desired sensitivity has been attained.

If the system be unstable (as exhibited by a difficulty in obtaining an equilibrium position on the weighing balance) or if it be too sensitive, the above procedure should be reversed and the screwed pivoting pins rotated in an anti-clockwise direction to lower the centre of gravity.

The usual current measuring instruments frequently conform to B.S. No. 89, which permits a maximum inaccuracy of ± 1 per cent. of the full scale reading. It will be appreciated that for the ammeter employed in the experimental notes here quoted, this inaccuracy may amount to 0·05 amps. The uncertainty thereby introduced exceeds the error in the measurement of the magnetic pull.

By slight modification to the connections of the balance, the instrument may be used as a wattmeter. This is convenient in demonstrations of alternating current theory in connection with power factors and wattless current. Unless the A.C. is of very low voltage it will probably be necessary to insert an extra non-inductive resistance into the circuit of the potential coil.

Current C Amps.	Observed weight. Gms.	Increase W in weight. Gms.	C^2	W/C^2
0·0	83·01	0·0	0·0	—
0·48	83·34	0·33	0·23	1·43
0·89	83·97	0·96	0·792	1·21
1·28	85·05	2·04	1·64	1·24
1·68	86·71	3·60	2·82	1·28
2·08	88·49	5·48	4·33	1·27
2·48	90·68	7·67	6·15	1·25
2·70	92·27	9·26	7·29	1·27
2·88	93·64	10·63	8·29	1·28
3·47	98·43	15·42	12·04	1·28
4·12	104·58	21·57	17·0	1·27



A 82-870—872.



A 82-880.



A 82-890—895.

A 82-870. LIGHT SOLENOID, about 9 in. long × 2½ in. diam., with wood strengthening strip, for showing the action of a magnetic field upon it when carrying a current and orientation in the magnetic meridian. **Without** wood mercury cup .. .. £ 0 9 0

A 82-872. Mercury Cup, Hardwood, for above, about 2½ in. diam., with two grooves, two terminals and connecting wires from the terminals to the respective grooves .. .. .. £ 0 6 0

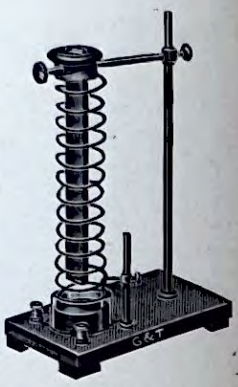
A 82-880. SOLENOID, about 6 in. long by 1 in. diam., of heavy gauge insulated copper wire with wood strengthening strips .. .. £ 0 10 6

A 82-890. ELECTRODYNAMIC CYLINDER, Ampère, to show the action of a magnetic field on a conductor carrying a current. Wood base 8 × 5 in., with pillar and adjustable arm. A solenoid 6 × 1 in. of heavy gauge insulated wire has the free ends brought out collinearly and pivots on centres in the arm and on the base. The second solenoid is connected in series with a battery and the pivoted solenoid, and the attraction and repulsion phenomena demonstrated. With one each pivoted and movable solenoids .. .. £ 1 17 6

A 82-895. Solenoid, movable, as in **A 82-890** .. .. £ 0 9 0


A 82-920.


A 82-925.

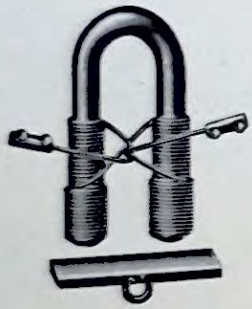

A 82-930.

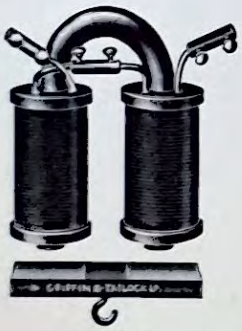
A 82-920. FLOATING BATTERY, De la Rive (Hadley: *Magnetism and Electricity for Students*), carrying a solenoid 4 × ⅝ in., in glass cell with cork float. The battery is a simple cell of copper and zinc plates to be charged with dilute sulphuric acid and floated on water. Designed to demonstrate the magnetic properties of a current-carrying coil .. .. £ s. d. 0 10 6

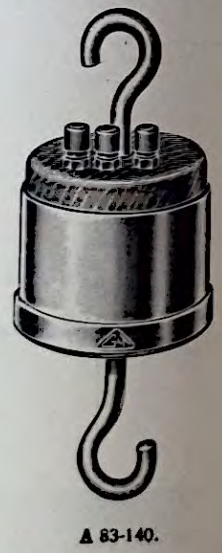
A 82-925. Ditto, with ring of coiled wire, 1½ diam., instead of solenoid 0 10 6

A 82-930. JUMPING SPIRAL, Roget (Hadley: *Magnetism and Electricity*, p. 267). Polished wood base 7½ × 4½ in. with terminals, pillar 10 in. high with adjustable arm and slotted wood holder for 8 × 1 × ¼ in. bar magnet. One end of a spiral, 1½ in. diam., is fitted round the holder and the free end inserted in a hole in the adjustable arm. With glass mercury trough 2 in. diam. and magnet. **Without** mercury .. .. *p* 1 12 6


A 83-120.


A 82-125.


A 83-130.


A 83-140.

A 83-120. U-BENDS, Soft Iron, for constructing electromagnets.

Length × diam.	4 × ½	5 × ⅝ in.
	4/6	7/6 each

A 83-125. ELECTROMAGNETS, horse-shoe form, soft iron, well annealed, with armature and carrying hook. Wound with heavy gauge insulated wire and provided with barrel connectors.

Length × diam.	2 × 5/16	4 × ½	6 × ¾ in.
	10/6	13/-	18/- each

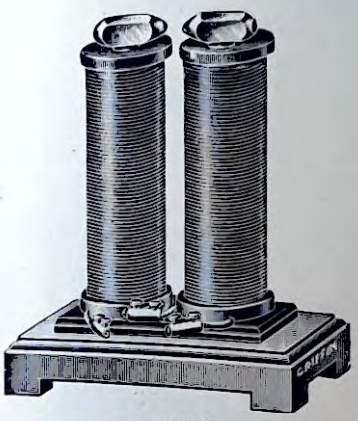
A 83-130. ELECTROMAGNETS, horse-shoe form, soft iron with armature and carrying hook. Wood bobbins wound with heavy gauge insulated wire.

Length × diam.	4 × ½	5 × ⅝	6 × ¾ in.
	£1 10 0	£1 15 0	£2 2 6 each

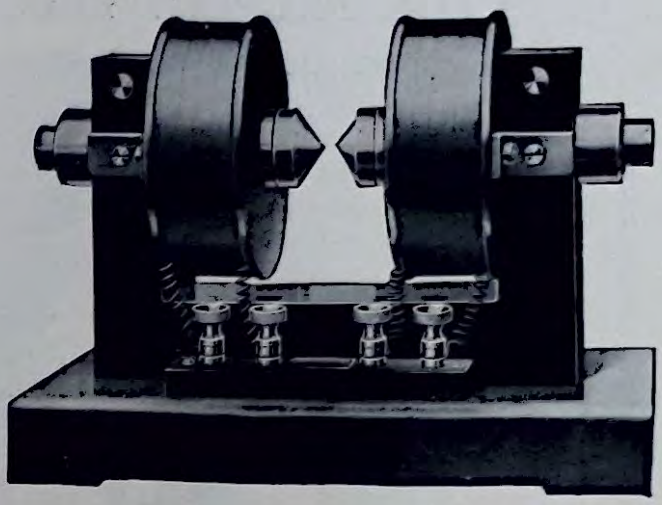
A 83-140. ELECTROMAGNET, lifting, Pot type. Heavy round iron pot, 2⅞ in. diam. × 1½ in. deep, with centre core and hook. Wound 600 turns insulated wire, with tapping at 200 and 400 turns, 3 terminals on wood discs engraved with number of turns, heavy iron armature with hook .. .. £ s. d. *p* 5 15 0

Performance of A 83-140 using 400 turns

Voltage	0·36	0·41	0·51	0·61	
Current	44	50	65	85	*mA.*
Pull	6	9·25	13	22	*lb.*

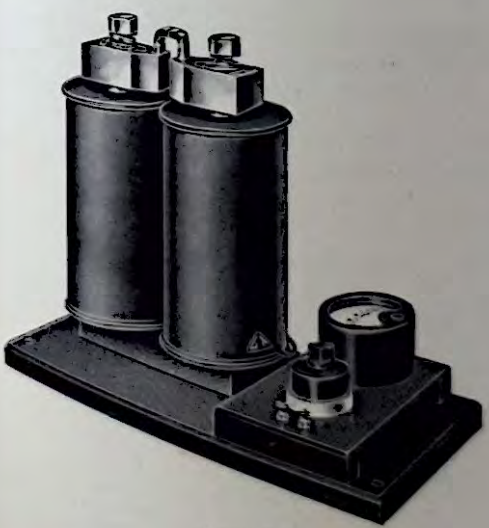


A 83-150.



A 83-160.

	£	s.	d.
A 83-150. ELECTROMAGNET, coils 8 in. long, with 1 in. cross-section soft iron cores, fitted to iron yoke and mounted on substantial wood base. The coils are removable and can be used separately or together. With two pole pieces .. .. *p*	6	5	0
A 83-160. ELECTROMAGNET. Demonstration and research type for use on 100 volts D.C. taking 6–8 amps. Arranged for operation with the limbs of the U-shaped forging in the vertical position as illustrated, or horizontal, brass supports being provided on the opposite side (not shown in illustration). U-forging of magnet iron, 10 in. long × 6 in. high × 2¾ in. wide, machined from the solid. Pole pieces of magnet iron, 1½ in. diam., are adjustable to provide gap up to 3 in. and are fitted with removable cone-shaped or square-faced end pieces. Bobbins 5 in. diam., wound with shellac-ed d.c.c. copper wire. Mounted on substantial oak base 13 × 7 in. with four terminals .. .. *t*	65	0	0

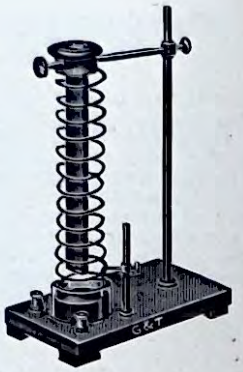


A 83-165.

A 83-165. ELECTROMAGNET, large. Designed to give a maximum magnetic pull with a loading of not more than 500 watts (*i.e.* 2·30 amps. on 220 volt D.C. circuit). Each coil is 5½ in. diam. and wound with 8,300 turns of No. 19 s.w.g. wire with interleaved and impregnated insulation, and fitted with Bakelite end-pieces. The magnetic field can be intensified and concentrated by the adjustable pole pieces opening to a maximum gap of 3 in. Mounted on substantial wood base, approx. 19½ × 9½ in. with mains terminals, rotary snap switch and ammeter, thus forming a self-contained magnetising unit suitable for experimental and demonstration work. Overall height 14¾ in. Supplied for use on any D.C. voltages up to 250 (*please state voltage when ordering*) .. .. *t* 35 0 0


A 82-920.


A 82-925.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A 82-920. FLOATING BATTERY, De la Rive (Hadley: *Magnetism and Electricity for Students*), carrying a solenoid 4 × ⅝ in., in glass cell with cork float. The battery is a simple cell of copper and zinc plates to be charged with dilute sulphuric acid and floated on water. Designed to demonstrate the magnetic properties of a current-carrying coil .. .. £ s. d. 0 10 6

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A 82-930. JUMPING SPIRAL, Roget (Hadley: *Magnetism and Electricity*, p. 267). Polished wood base 7½ × 4½ in. with terminals, pillar 10 in. high with adjustable arm and slotted wood holder for 8 × 1 × ¼ in. bar magnet. One end of a spiral, 1½ in. diam., is fitted round the holder and the free end inserted in a hole in the adjustable arm. With glass mercury trough 2 in. diam. and magnet. **Without** mercury .. .. *p* 1 12 6


A 83-120.


A 82-125.


A 83-130.


A 83-140.

A 83-120. U-BENDS, Soft Iron, for constructing electromagnets.

Length × diam.	4 × ½	5 × ⅝ in.
	4/6	7/6 *each*

A 83-125. ELECTROMAGNETS, horse-shoe form, soft iron, well annealed, with armature and carrying hook. Wound with heavy gauge insulated wire and provided with barrel connectors.

Length × diam.	2 × 5/16	4 × ½	6 × ¾ in.
	10/6	13/-	18/- *each*

A 83-130. ELECTROMAGNETS, horse-shoe form, soft iron with armature and carrying hook. Wood bobbins wound with heavy gauge insulated wire.

Length × diam.	4 × ½	5 × ⅝	6 × ¾ in.
	£1 10 0	£1 15 0	£2 2 6 *each*

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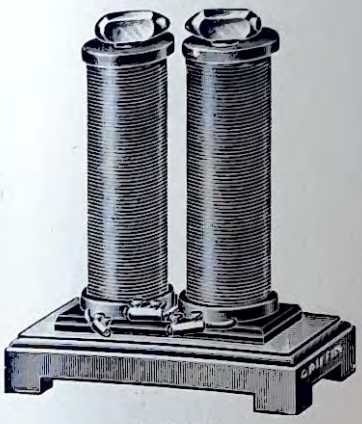
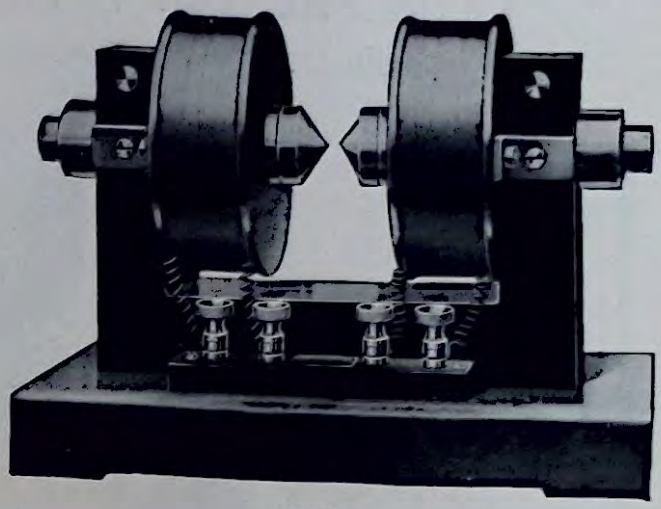


A 83-150.

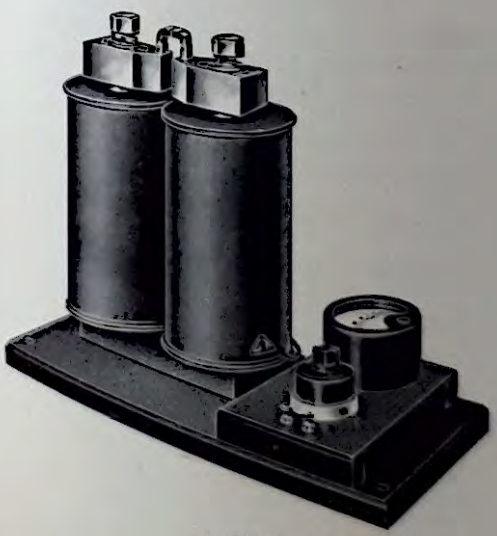


A 83-160.

£ s. d.

A 83-150. ELECTROMAGNET, coils 8 in. long, with 1 in. cross-section soft iron cores, fitted to iron yoke and mounted on substantial wood base. The coils are removable and can be used separately or together. With two pole pieces .. .. *p* 6 5 0

A 83-160. ELECTROMAGNET. Demonstration and research type for use on 100 volts D.C. taking 6–8 amps. Arranged for operation with the limbs of the U-shaped forging in the vertical position as illustrated, or horizontal, brass supports being provided on the opposite side (not shown in illustration). U-forging of magnet iron, 10 in. long × 6 in. high × 2⅜ in. wide, machined from the solid. Pole pieces of magnet iron, 1½ in. diam., are adjustable to provide gap up to 3 in. and are fitted with removable cone-shaped or square-faced end pieces. Bobbins 5 in. diam., wound with shellac-ed d.c.c. copper wire. Mounted on substantial oak base 13 × 7 in. with four terminals .. .. *t* 65 0 0

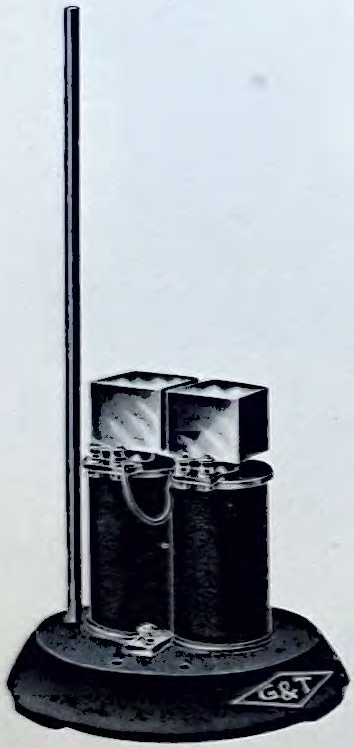


A 83-165.

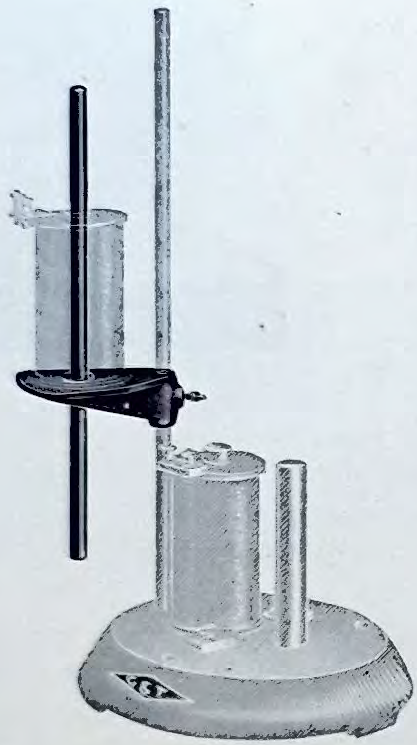
A 83-165. ELECTROMAGNET, large. Designed to give a maximum magnetic pull with a loading of not more than 500 watts (*i.e.* 2·30 amps. on 220 volt D.C. circuit). Each coil is 5½ in. diam. and wound with 8,300 turns of No. 19 s.w.g. wire with interleaved and impregnated insulation, and fitted with Bakelite end-pieces. The magnetic field can be intensified and concentrated by the adjustable pole pieces opening to a maximum gap of 3 in. Mounted on substantial wood base, approx. 19½ × 9½ in. with mains terminals, rotary snap switch and ammeter, thus forming a self-contained magnetising unit suitable for experimental and demonstration work. Overall height 14⅜ in. Supplied for use on any D.C. voltages up to 250 (*please state voltage when ordering*).. .. *t* 35 0 0

THE MICROID ELECTROMAGNET

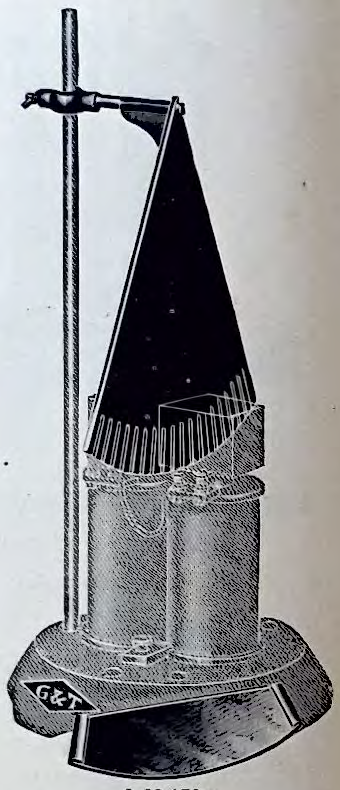
A combination to demonstrate various phenomena



A 83-170 a.



A 83-170 b.



A 83-170 c.

This powerful electromagnet will be found an invaluable addition to the equipment of the Physics Laboratory. Accessories are provided for the performance of various interesting experiments. The apparatus will also be found useful for many other purposes.

SPECIFICATION

The electromagnet consists of two substantial coils 6 in. high by about 3 in. diam. wound on insulated metal bobbins. Separate terminals are provided for each coil. The soft iron core pieces are bolted to a heavy iron base which forms the yoke. The bobbins are removable, being secured to the base by two sliding clips. The pole blocks are $2\frac{1}{2} \times 2 \times 2$ in.

A pillar supported on the base carries the various experimental attachments. The electromagnet operates on any voltage up to 12, depending on the experiment.

The accessories comprise (1) a platform and iron bar for "sucking bar" experiment, (2) a clamp, slotted plate and cover for Waldenhofen's Pendulum, (3) a rectangular coil for "dropping coil" experiment, (4) three pillars, armature and hanger for "lifting magnet" experiment, (5) plate for electromagnetic induction.

	£	s.	d.
A 83-170. MICROID ELECTROMAGNET, complete set of apparatus, with two coils, iron base, pole blocks, and attachment for five experiments, as specified below	r 17	10	0

Component and Extra Parts for A 83-170

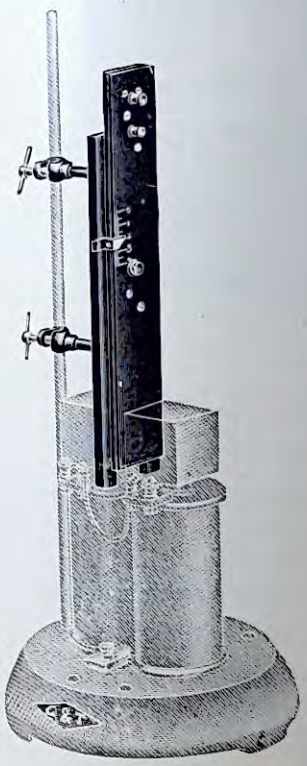
		£	s.	d.
A 83-170 a.	**Electromagnet only**, with two coils, base, pole blocks and pillar, **without** attachments ..	r 6	0	0
" " b.	**Platform** and iron bar for **sucking bar** experiment (*Expt. I*, below)	r 0	10	0
" " c.	**Clamp**, slotted plate and cover for **Waldenhofen's Pendulum** (*Expt. II*, p. 291) ..	r 2	5	0
" " d.	**Rectangular Coil** for **dropping coil** experiment (*Expt. III*, p. 291)	r 3	0	0
" " e.	**Pillars**, armature and hanger for **lifting magnet** experiment (*Expt. IV*, p 291)	r 3	0	0
" " f.	**Plate for Electromagnetic Induction**, with bosshead fixing, mounted on wood block and with terminals for connection (*Expt. V*, p. 291)	r 3	0	0

EXPERIMENTAL NOTES

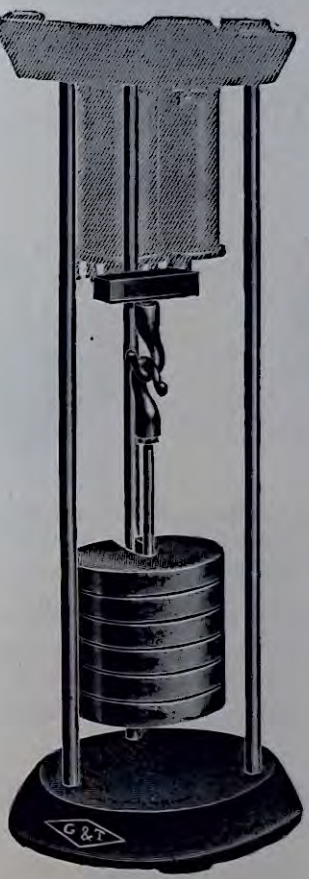
The electromagnet, wound for use up to 12 volts, D.C., and taking about 6 amperes maximum, is offered in itself as a very useful instrument for general laboratory purposes.

Expt. I.—The "sucking bar" experiment (A 83-170b) is a striking demonstration of the action of magnetic lines of force in taking the shortest path. Clamp the platform to the pillar. Remove one coil and place on platform. Insert through the coil the iron bar and adjust the height of the platform so that while the lower end of the bar rests on the bench, one or two inches remain inside the coil. When the current is switched on, the bar is sucked upward and oscillates before coming to rest in a balanced position.

A 83-170. The Microid Electromagnet—*continued.*



A 83-170 d.



A 83-170 e.



A 83-170 f.

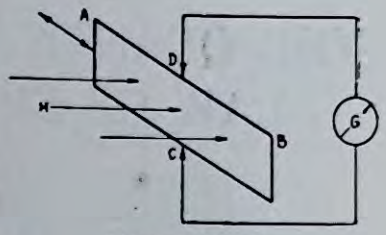


Diagram of Circuit.

Expt. II.—The Waldenhofen's Pendulum (A83-170c) affords an excellent illustration of Lenz's Law. With the components provided it is easy to show how the damping varies with the resistance, which, of course, controls the induced current. To get the most spectacular effect cover the slots with the metal cover. Then support the pendulum by means of the rod provided for that purpose. Adjust the pole blocks as close to each other as possible while leaving sufficient space for the free movement of the pendulum. Switch on the current and observe the pronounced damping, which brings the pendulum rapidly to rest. Repeat the experiment with the metal cover removed from the slots. Definite damping will still be observed but some time elapses before oscillations cease.

Finally remove the pendulum and, holding the cover in the hand, move it in the intense field between the pole pieces. The reaction between the magnetic field of the magnet and the magnetic field due to the induced currents results in marked opposition to any movement.

Expt. III.—The "dropping coil" experiment (A83-170d) shows that the quantity of electricity induced when a conductor cuts lines of magnetic force is proportional to the number of lines cut. A coil of insulated copper wire is held vertically between the pole blocks so that it may be permitted to fall through this comparatively uniform field any distance between 0 and 5 cm. measured on a scale. The coil is of a long narrow shape in order that the lines of force may be cut only by the horizontal winding on its lower edge. The winding on the upper edge being outside the magnetic field is inoperative. When the coil drops say 1 cm. it cuts a definite number of lines of force. If the lines per sq. cm. equal x and the length of the lower edge of the coil equals A, then the total lines cut equal Ax. If now the coil be dropped 2 cm., the total lines cut equal $2Ax$, that is, twice as many. The quantity of electricity is measured by a ballistic galvanometer in the coil circuit and will be found proportional to the distance dropped. To keep the spot on the scale a resistance will usually be necessary which incidentally is useful to prevent over-damping.

Expt. IV.—The "lifting magnet" experiment (A83-170e) illustrates the weight carrying capacity of the magnet relative to the expenditure of electrical energy. The pillar used in other experiments is removed from the base. The other three pillars and the extra base plate provided, are fixed in the position shown in illustration with the original base on top and the magnet turned upside down. A **dry cell** is connected across the coils and the armature and hanger for weights are fitted. The magnet will carry about **20 kilos** if 2 kilo weights are added carefully and one at a time.

Expt. V.—Plate for Electromagnetic Induction (A83-170f). The apparatus is so constructed that when fastened by means of the bosshead provided, AB (*see diagram*) comes between the polepieces. AB is a metal plate mounted so that it can slide freely in guides which are connected to terminals C and D. A galvanometer G should be connected to C and D. The plate should be arranged so that it is perpendicular to the magnetic field H. In the diagram AB is perpendicular to, and H parallel with, the plane of the paper. It will be found that when the field is on, sliding the plate in the guides results in a deflection of the galvanometer. Reversing the direction of motion reverses the deflection.

At first sight it would seem that this is an ordinary case of electromagnetic induction—a conductor moving in a magnetic field. But that this is not so is apparent when we consider that the number of linkages with the circuit DGCD is not changed by the motion of the plate. It therefore becomes necessary to account for this special case.

The free electrons in the plate AB participate in all movements of the plate. A moving charge of electricity, in this case electrons, is equivalent to an electric current. Finally, since the charges are moving in a strong magnetic field they are deflected in a direction at right angles to that of their motion and to that of the magnetic field, exactly as in the cathode ray tube. Thus, depending on the direction of motion, electron excess and electron shortage occurs at C and D and these points consequently function as positive and negative poles respectively. Hence a current, which tends to equalise the difference in potential between C and D, flows in the galvanometer circuit. (Galvanometers **A84-170** or **A84-240-242** are recommended for use in this experiment).

SPECIMEN RESULT

With pole faces 2 × 2 in., air gap 13 mm. wide and 8000 ampere turns, a deflection of 19 cm. at 1 metre scale distance was obtained with a galvanometer of resistance 700 ohms and sensitivity of 850 mm. per microcoulomb, when the full length of the plate was drawn across CD.

THE MICROID APPARATUS FOR THE QUANTITATIVE DEMONSTRATION OF THE LAW OF ELECTRO-MAGNETIC INDUCTION



A 83-280.

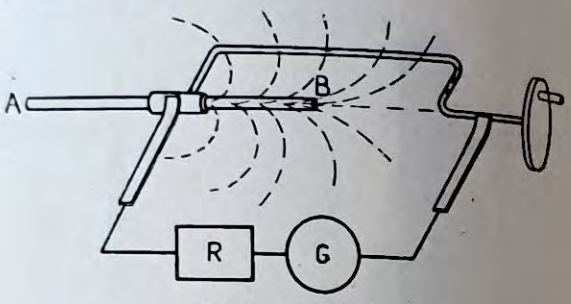


Diagram of Circuit.

A new design to exhibit the relationship between E.M.F. and Magnetic Lines of Force.

SPECIFICATION

The apparatus consists essentially of a cylindrical cobalt steel magnet $\frac{1}{2}$ in. diam. and 12 in. long, supported on a teak base, so that by means of a wooden handle, a half rectangle of copper wire can be rotated to cut the magnetic field. Copper brush contacts and terminals are provided so that the induced E.M.F. may be measured. Care has been taken by choice of suitable materials for the components, to eliminate thermo-electric and other extraneous currents.

A 83-280. MICROID ELECTRO-MAGNETIC INDUCTION APPARATUS, on teak base with magnet, copper rectangle and contacts .. .. £ 4 15 0

EXPERIMENTAL NOTES

Galvanometers suitable for use with the apparatus are **A 84-150—160** (375 ohms) and **A 84-240—242** (70 and 250 ohms). Two interesting experiments can be performed—(1) to show that the E.M.F. produced is directly proportional to the number of lines of force cut in a given time, and (2) to prove that one volt is produced when 10^8 lines of force per second are cut. The procedure in both cases is very simple.

Expt. No. 1 is carried out by connecting a galvanometer across the contact terminals. The half-rectangle is rotated so that a small steady deflection is obtained and the number of revolutions per minute is counted. Thereafter the number of revolutions per minute required to give multiples of this deflection is ascertained.

Students must appreciate that the rectangle cuts once per revolution all the lines of force emerging from the pole it embraces. It must be made clear also that the direction of the current is dependent on both the direction of rotation of the rectangle and the polarity of the magnet. The pole embraced by the rectangle may be noted and the rectangle revolved slowly in one direction and then the other. The deflections are correspondingly reversed. The theoretical side of the subject may be pursued further if the direction of deflections for currents in each direction is known. Fleming's right hand rule will be found useful in this connection.

A reflecting galvanometer with a sensitivity of about 250 mm. per microamp. will be found the most serviceable for use with this apparatus. The rheostat R shown in diagram is used to nullify variation in brush resistance and to keep the galvanometer spot on the scale.

In general a start should be made at the lowest rate of rotation for which a steady measurable deflection can be obtained, as the faster rates of rotation are more difficult to count and to maintain constant. Some practice is desirable to ensure steady rotation.

Specimen Results.

Deflections in cm.	Time for 20 revs.	Revolutions per sec.
3·0	26·0 secs.	0·77
4·0	20·3 ,,	0·99
5·5	14·9 ,,	1·34
7·0	11·3 ,,	1·77

Expt. No. 2.—The same circuit is used as in Expt. No. 1. A convenient steady deflection is maintained and the time taken for, say, 40 revolutions, is measured by means of a stop-watch. The galvanometer is used as a micro-voltmeter. Its constants must be known or determined so that the deflection may be expressed in microvolts. The deflection corresponds, of course, only to a portion of the total induced E.M.F. See Specimen Result below. If the pole strength of the magnet is unknown it must be determined by any convenient method.

Specimen Result.

Galv. Res., 100 ohms. Secs. for 40 revs. = 16·2.
Rheostat Res., 900 ohms. Revs. per sec. = 2·47.
Total Res. 1000 ohms.
Galv. Constant = 0·225 mm. per microvolt.
Deflection = 48 mm.
Lines of Force from Magnet = $8{\cdot}51 \times 10^8$.
Lines cut per sec. = $8{\cdot}51 \times 10^8 \times 2{\cdot}47 = 2{\cdot}09 \times 10^9$

Fall of potential across Galvanometer = $\frac{48}{0{\cdot}225 \times 10^6}$ volts.

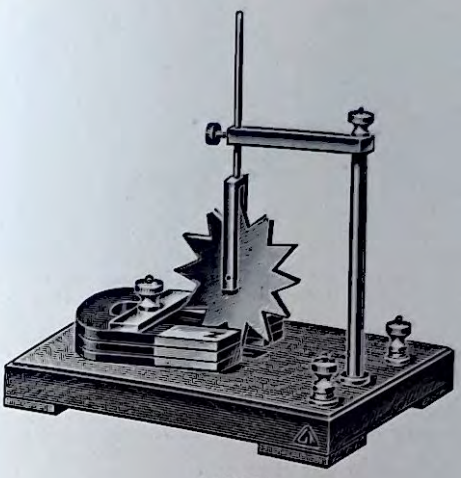
Total fall of potential across 1000 ohms (total circuit Res.)

$$= \frac{48 \times 10}{0{\cdot}225 \times 10^6} \text{ volts.}$$

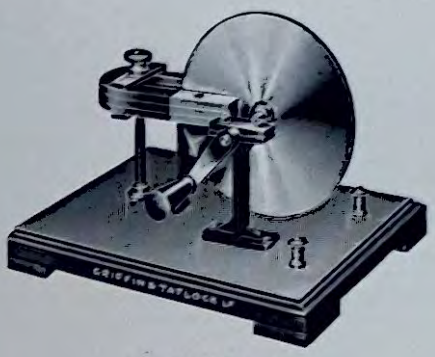
$\therefore$ $\frac{48 \times 10}{0{\cdot}225 \times 10^6}$ volts are induced from $2{\cdot}09 \times 10^9$ lines of force per sec.

$\therefore$ 1 volt will be induced by cutting

$$\frac{2{\cdot}09 \times 10^9 \times 0{\cdot}225 \times 10^6}{48 \times 10} = 0{\cdot}98 \times 10^8 \text{ lines per sec.}$$



A 83-284.

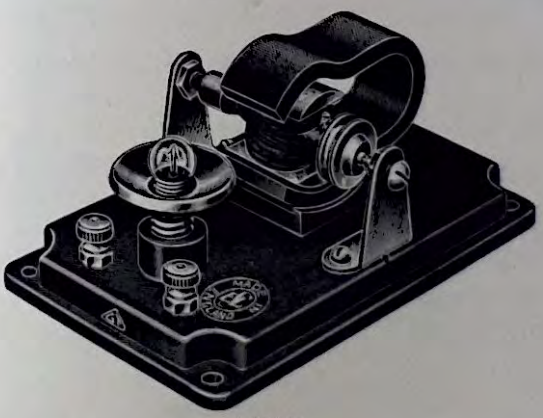


A 83-286.

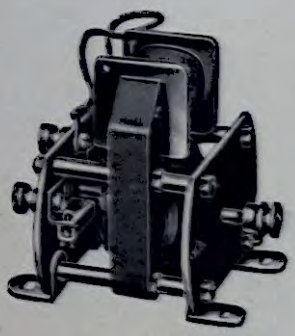
£ s. d.

A 83-284. **BARLOW'S WHEEL** (Hadley: *Magnetism and Electricity*, p. 265), a 4 in. star-shaped copper disc rotating on a pair of adjustable centres. The current passes from the axis to the radial points, which dip into a mercury trough. On polished wood base 7½ × 4 in. with terminals and triple compound horseshoe magnet 2 5 0

A 83-286. **FARADAY'S DISC** (Hadley: *Magnetism and Electricity*, p. 415), the inverse experiment to Barlow's Wheel. On rotating the 6 in. diam. copper disc a current is generated, capable of deflecting a galvanometer needle. On polished wood base 11 × 9 in. with 5 in. triple compound horse-shoe magnet and terminals .. .. *p* 6 10 0



A 83-290.



A 83-300.

£ s. d

A 83-290. **DYNAMO, Model,** to demonstrate the principle of generating electricity. On plastic base 5 × 3 in., complete with pair of terminals, lamp 2·5 volt, magnet with keeper, pulley wheel for belt drive and set of instructions .. .. *t* 1 0 0

A 83-300. **MOTOR, electric, model,** tri-polar, operates on 4 volts, skeleton construction rendering all parts visible .. .. *t* 1 1 0

The Microid Series is a range of distinctive designs in Scientific Apparatus principles. These special models have been developed in our own Technical Department and in collaboration with independent authorities expert in their various subjects.

MOTORS, LABORATORY.—These motors are designed in accordance with the requirements of B.S.S. No. 170—1926 and represent the latest practice in motor manufacture. They are specially suitable for laboratory work either for continuous or intermittent duty. The armatures are made of 50 tons tensile carbon steel accurately ground to size and all windings are vacuum impregnated with special insulating material. They are finished in black enamel and are available with a variety of windings, the salient characteristics of which are described below and should be carefully noted so that a motor may be selected suitable for any particular purpose.

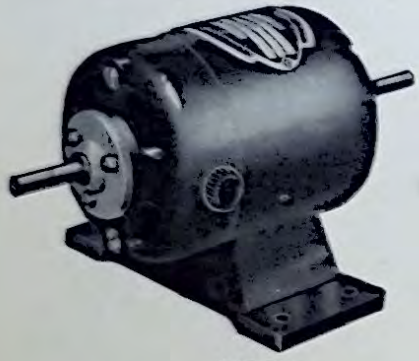
Series Windings.—These are universal motors and may be used on either D.C. or A.C. of the rated voltage, but, in general, will run a little faster on D.C. than on A.C. The speed is governed by the load and the motors therefore run considerably faster on light load than on full load. They should not be used when it is intended to maintain a steady speed but in such cases special governor-controlled motors can be supplied (*prices on application*). All series wound motors can be started with single or double pole switches and no special starters are required. Two flexible connection leads are fitted as standard but 4-lead reversing motors can be supplied without extra cost.

Shunt Windings and Compound Windings.—These types of motors may be run from D.C. mains only and the speed remains approximately constant irrespective of the load, the speed rise from full load to no load conditions not usually exceeding 20 per cent. If it is desired to maintain speeds within extremely close limits, governor-controlled motors can be supplied (*prices on application*). Shunt windings are recommended for motors up to about ¼ H.P. and, in order to avoid the cost of a special starter, compound windings are supplied for most larger sizes. All the motors listed with shunt or compound windings are suitable for direct connection with single or double pole switches to D.C. mains. Two flexible connection leads are fitted as standard but 4 or 6 leads for reversing, or 3 leads for speed control can be supplied without extra cost.

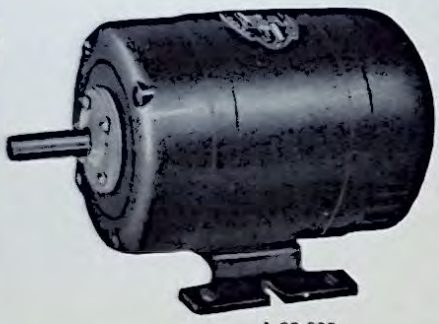
Induction Motors.—This type of motor is suitable for use on A.C. only, and is employed where a relatively constant speed, irrespective of load, is desired. The full load and no load speeds do not usually differ by more than 5 per cent. If it is desired to maintain speeds within extremely close limits, synchronous motors can be supplied (*prices on application*). Flexible leads are standard and all induction motors are reversible. No special starting switches are required; single, double or triple pole switches to meet the requirements of the electric supply can be used.

All series shunt and compound wound motors have adjustable brush rockers, except in the smallest size. When ordering any of the above types of motors, direction of rotation should be specified. Motors to run anti-clockwise facing the drive end will be supplied unless otherwise specified. All motors are fitted with ball-bearings allowing mounting with shaft in any position, except $\frac{1}{100}$ H.P. Universal size, which has journal-sleeve bearings and must be mounted with shaft horizontal.

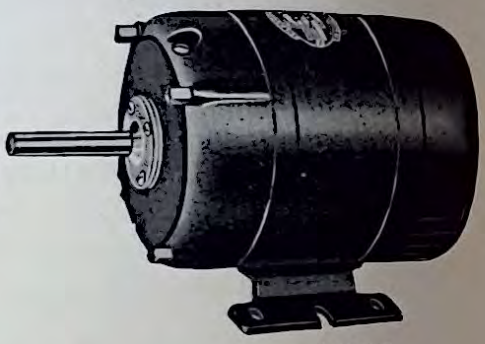
Frames.—Motors, $\frac{1}{100}$ to about $\frac{1}{10}$ H.P., enclosed, ventilated $\frac{1}{6}$ to $\frac{1}{3}$ H.P., drip-proof.



A 83-330.



A 83-335.



A 83-340.

A 83-330. MOTORS, Universal, Series Windings, for use on D.C. or single phase A.C. Available for 100–110, 200–220, 220–240 and 250 volts. As specified above.

H.P.	$\frac{1}{100}$	$\frac{1}{30}$	$\frac{1}{20}$	$\frac{1}{16}$	$\frac{1}{16}$	$\frac{1}{10}$	
Speed ..	2500	2000	3000	4000	3000	4000	*r.p.m.*
t	£1 16 0	£2 6 0	£2 6 0	£2 6 0	£2 16 0	£2 16 0	*each*
H.P.	$\frac{1}{10}$	$\frac{1}{8}$	$\frac{1}{6}$	$\frac{1}{6}$	$\frac{1}{4}$	$\frac{1}{3}$	
Speed ..	2000	2500	3500	2400	2800	3600	*r.p.m.*
t	£3 16 0	£3 16 0	£3 16 0	£4 5 0	£4 5 0	£4 5 0	*each*

A 83-335. MOTORS, Shunt or Compound Windings, for use on D.C. Available for 100–110, 200–220, 220–240 and 250 volts. As specified above.

H.P. ..	$\frac{1}{30}$	$\frac{1}{20}$	$\frac{1}{20}$	$\frac{1}{16}$	$\frac{1}{16}$	$\frac{1}{12}$	$\frac{1}{12}$	
Speed ..	1500	4000	2500	3000	1450	4000	3000	*r.p.m.*
Winding ..	Shunt	Shunt	Shunt	Shunt	Shunt	Shunt	Shunt	
t	£2 19 0	£2 9 6	£2 8 6	£2 19 0	£3 15 6	£2 8 6	£2 19 0	*each*
H.P. ..	$\frac{1}{10}$	$\frac{1}{10}$	$\frac{1}{8}$	$\frac{1}{8}$	$\frac{1}{4}$	$\frac{1}{4}$		
Speed ..	4000	2000	3000	1450	2000	2800		*r.p.m.*
Winding ..	Shunt	Shunt	Shunt	Compound	Compound	Compound		
t	£2 19 0	£4 0 0	£4 0 0	£4 9 6	£4 9 6	£4 9 6		*each*

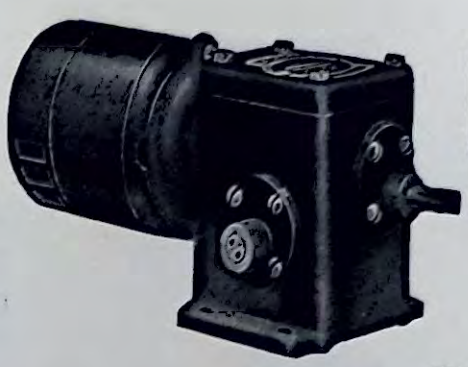
A 83-340. MOTORS, Induction Type, for use on A.C. Available for 100–110, 200–220, and 220–240 volts, 50 cycles, single phase. As specified above.

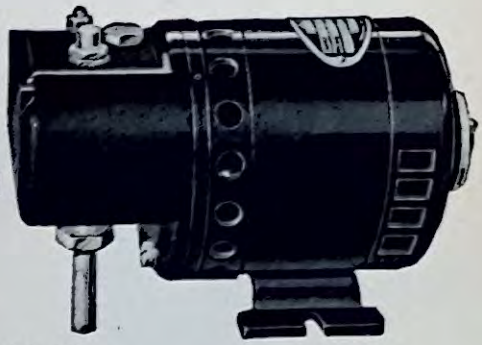
H.P.	$\frac{1}{100}$	$\frac{1}{10}$	$\frac{1}{10}$	$\frac{1}{16}$	$\frac{1}{16}$	
Speed	1375	2800	1400	2850	1400	*r.p.m*
t	£2 9 0*	£2 9 0*	£2 14 3*	£2 14 0	£3 12 0	*each*
H.P.	$\frac{1}{6}$	$\frac{1}{6}$	$\frac{1}{6}$	$\frac{1}{4}$	$\frac{1}{4}$	
Speed	2850	1420	2850	1425	2850	*r.p.m.*
t	£3 16 0	£4 2 6	£4 2 6	£4 5 0	£4 5 0	*each*

*The prices of the three smallest size motors marked * do not include starting condensers, the size of which varies with the voltage. Prices on application. Please state voltage.*



A 83-350—355.





A 83-365—375.

GEARED MOTOR UNITS.—When dealing with geared motor units, as any statement of H.P. is liable to be misleading owing to the losses in the gears, the torque required should always be specified. The torque in lbs. ins. is the force measured in lbs. exerted by a rotating shaft, multiplied by the radius in inches at which this force is measured. In the units listed below, the motors incorporated are all similar in general specification to **A 83-330—340.** Almost any intermediate speed can be supplied. *Prices on application.*

A 83-350. MOTOR UNITS, Geared, Single Worm Reduction, Universal, Series Windings, for use on D.C. or single phase A.C. Available for 100–110, 200–220, 220–240 and 250 volts.

Output speed	40	100	200	40	100	250	*r.p.m.*
Output torque	3	2	1·75	7	7	5	*lbs. in.*
Consumption	20	24	27	34	58	65	*watts*
t	£2 5 0	£2 5 0	£2 5 0	£2 19 6	£2 19 6	£2 19 6	*each*

A 83-355. Ditto, Shunt Winding, for use on D.C. only. Available for 100–110, 200–220, 220–240 and 250 volts.

Output speed	40	100	250	20	45	120	240	*r.p.m.*
Output torque	7	7	5	60	35	32	20	*lbs. in.*
Consumption	34	58	65	102	100	155	170	*watts*
t	£3 2 0	£3 2 0	£3 2 0	£7 15 0	£7 15 0	£7 15 0	£7 15 0	*each*

A 83-360. Ditto, Induction Type, for use on A.C. 50 cycles single phase only. Available for 200–220, 220–240 and 250 volts.

Output speed	27	54	110	20	60	89	240	*r.p.m.*
Output torque	7	7	4	60	30	24	10	*lbs. in.*
Consumption	25	35	35	98	85	90	98	*watts*
t	£2 19 0*	£2 19 0*	£2 19 0*	£8 1 0	£7 15 0	£7 15 0	£7 10 0	*each*

A 83-365. MOTOR UNITS, Geared, Double Worm Reduction, Universal, Series Windings, for use on D.C. or single phase A.C. Available for 100–110, 200–220, 220–240 and 250 volts.

Output speed ..	1	3	6	12	*r.p.m.*
Output torque ..	15	12	10	8	*lbs. in.*
Consumption at 230 V.	0·10	0·12	0·11	0·15	*amps.*
t	£3 8 3	£3 8 3	£3 8 3	£3 8 3	*each*
Output speed ..	2	5	10	20	*r.p.m.*
Output torque ..	15	15	12	12	*lbs. in.*
Consumption at 230 V.	0·25	0·25	0·28	0·32	*amps.*
t	£3 16 0	£3 16 0	£3 16 0	£3 16 0	*each*

A 83-370. Ditto, Shunt Windings, for use on D.C. only. Available for 100–110, 200–220, 220–240 and 250 volts.

Output speed ..	1	2	5	10	20	*r.p.m.*
Output torque ..	15	15	15	12	12	*lbs. in.*
Consumption at 230 V.	0·20	0·20	0·20	0·22	0·25	*amps.*
t	£3 18 6	£3 18 6	£3 18 6	£3 18 6	£3 18 6	*each*

A 83-375. Ditto, Induction Type, for use on A.C. 50 cycles single phase only. Available for 200–220, 220–240 and 250 volts.

Output speed ..	1	2	5	10	20	*r.p.m.*
Output torque ..	15	15	12	10	8	*lbs. in.*
Consumption at 230 V.	0·16	0·45	0·45	0·45	0·45	*amps.*
t	£3 19 0*	£3 19 0*	£3 19 0*	£3 19 0*	£3 19 0*	*each*

* *Plus starting condenser, see footnote on p. 294.*



A 83-525.



A 83-535.



A 83-540.



A 83-565.

A 83-520. ELECTRIC BELL, miniature, black plastic case, diam. of gong 1¼ in., overall height 3 in., operates on 4–6 volts D.C. .. .. *t* 0 4 [0

A 83-525. ELECTRIC BELL, Bakelite base and cover, pillar type easy-wiring terminals fitted internally, silver pointed contacts. The cover is fixed to the base by a thumb nut moulded into the Bakelite.

Diam. of gong	2¾	3	*in.*
	t 11/-	16/-	*each*

A 83-530. BUZZER, electric, miniature, Bakelite base and cover, 2 in. diam. silver contacts, high pitched tone .. .. *t* 0 3 6

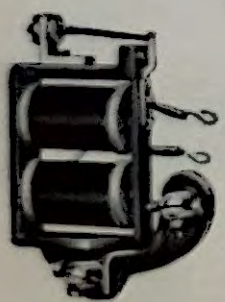
A 83-535. BUZZER, electric, Bakelite cover and base with thumbscrew for fixing cover to base. Iron frame movement, bobbins wound with enamelled copper wire, gold-silver contact points, dimensions 3¾ × 3 × 1½ in., resistance 3 ohms .. .. *t* 0 9 0

A 83-540. BELL PUSH, Bakelite base and cover, silver pointed contact springs, white Bakelite plunger, 2⅛ in. diam. .. .. *t* 0 1 0

A 83-560. BELL TRANSFORMER, Bakelite cased, giving 3, 5 or 8 volts on secondary coil. The primary is wound for 200–250 volts. Overall dimensions, 4 × 3 × 2 in. high .. *t* 0 10 6

A 83-565. Ditto, giving 4, 8 or 12 volts on secondary. The primary is wound for 100 to 110 or 200 to 250 volts, 40–60 cycles. Primary and secondary windings are arranged on separate bobbins side by side with an earth protection, the earth terminal being provided on the side of the base. A wiring diagram is affixed to the back of each transformer. In Bakelite case 3⅛ × 3 1/16 × 2 in. .. .. *t* 0 15 6

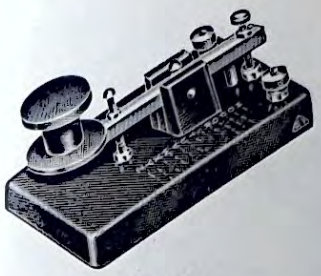
Please state voltage when ordering.



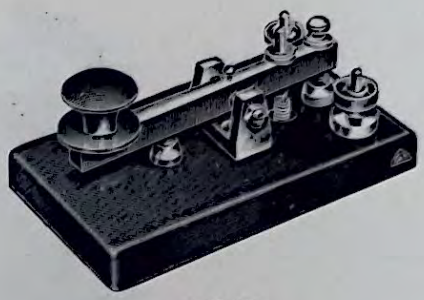
A 83-575

BELL RELAYS, for closing local circuits, battery-operated short lines.

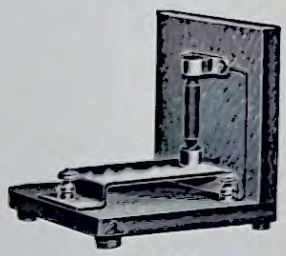
Resistance	5	10 *ohms*
A 83-575. Skeleton form	*t* 10/-	26/- *each*
A 83-580. Ditto, in teak case	*t* 26/-	45/- *each*



A 83-620.



A 83-625.



A 83-640.

£ s. d.

A 83-620. **MORSE KEY**, on moulded base $4\frac{1}{4} \times 2\frac{3}{4}$ in., with two terminals, pivoted contact arm with adjustable spring, all fittings nickelled, Morse code embossed on base .. *t* 0 6 0

A 83-625. **Ditto**, heavy pattern, on polished wood base $5\frac{3}{4} \times 3\frac{1}{4}$ in., with two W.O. type terminals, arm adjustable for gap and tension, nickel silver contacts, all fittings nickel-plated .. .. *t* 0 12 6

A 83-640. **MICROPHONE, Hughes's**, modified form, for showing the effect of sound vibrations on a contact resistance. A carbon rod with pointed ends is supported between two carbon blocks, the lower block being mounted on a metal plate fixed at one end and thus forming a vibrating platform. The ticking of a watch placed on the platform can be heard when the microphone is connected in series with a battery and telephone receiver .. .. *r* 1 10 0



A 83-660.



A 83-665.



A 83-670.



A 83-690.

£ s. d.

A 83-660. **RECEIVER, Telephone**, double pole "watch" pattern in brass case with oxidised finish. Wound to resistance of 30 ohms .. .. *Price on application.*

A 83-665. **RECEIVER, Telephone**, double pole "bell" pattern in pressed metal case coated with ebonite. Wound to resistance of 120 ohms and complete with earpiece and flexible cord .. .. *Price on application.*

A 83-670. **RECEIVER, Telephone**, extra sensitive. Perforated steel headband, receiver 60 ohms resistance, with ball and socket joint and adjustable leather pad. Receiver case of moulded Bakelite. The whole is light and comfortable. Complete with cords .. *t* 1 16 4

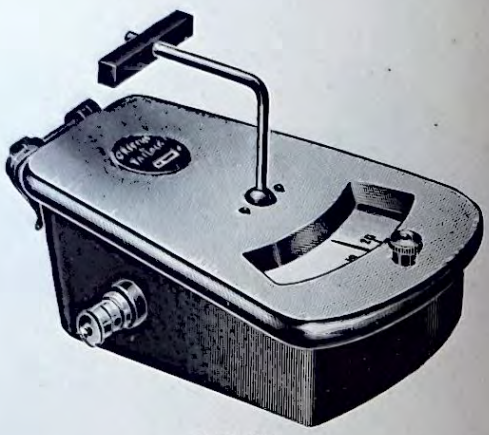
A 83-675. **Ditto**, with double earpieces, each 2000 ohms resistance, and metallic wire headband *t* 1 10 0

A 83-690. **MICROPHONE**, carbon granule type, suitable for battery call and inter-communication instruments. In brass case, oxidised finish, with brass mouthpiece and two terminals at back .. .. *Price on application.*

A 83-695. **GRANULES, Carbon**, for use in microphones .. .. *oz.* *t* 0 5 6



A 84-100.



A 84-120.

A 84-100. OERSTED'S APPARATUS, to show the action of electric currents on a magnet. Cobalt steel needle 3 in. long with agate centre, wood base about 3½ in. diam., with heavy copper rectangle and terminals .. .. £ 0 17 6

A 84-120. GALVANOMETERS, Detector, in dust-proof aluminium case with hinged inspection cover. Resistance 10, 100 or 500 ohms .. .. *each* £ 1 10 0

The moving system consists of a magnet on an aluminium vane supported by a silk fibre attached to a flexible spring. The pointer is light and rigid. A stop is fitted at each end of the scale, and the moving system is balanced. The scale covers 40 angular degrees, is about 6 cm. long, with centre zero, and is divided into 50 equal parts. It is observed through a glass window in the case. A control magnet is carried on a ball and socket joint on the cover, by means of which the sensitivity may be varied over a wide range.

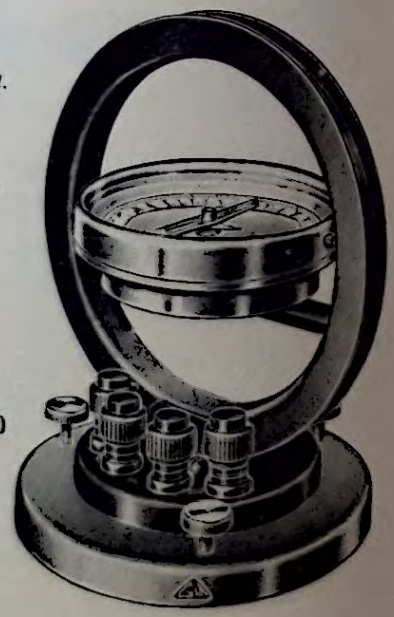
APPROXIMATE SENSITIVITY DATA FOR DETECTOR GALVANOMETER A 84-120

See Note on p. 300.

Resistance Ohms	Scale Divisions Deflection	
	Per μA	Per mV
10	0·019 to 0·0037	0·35 to 1·17
100	0·069 to 0·009	0·08 to 0·64
500	0·113 to 0·02	0·04 to 0·2

A 84-140. GALVANOMETER, Tangent, all metal. Brass ring, wound with three coils as below, removable brass compass box, 4 in. diam., with agate centre cobalt steel needle having aluminium pointers specially ribbed for strengthening and air damping (*Regd. No.* 769144), engraved silvered metal scale and anti-parallax glass mirror. Compass box and ring mounted on rotatable brass plate carrying four terminals and engraved with number of turns. Brass base 14·5 cm. diam. with three levelling screws .. £ 7 10 0

Coil turns	2	50	500
S.W.G.	18	28	36
Mean diam.	13·5	13·6	14·8 *cm.*
Resistance (approx.) ..	0·02	3·6	150 *ohms*



A 84-140.

THE MICROID ADAPTABLE GALVANOMETERS

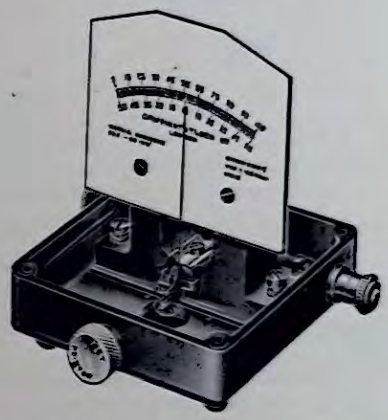
General purpose pointer-mirror instruments in Bakelite case

The chief advantage of the Microid Adaptable Galvanometer is in its combination of sensitivity with adaptability. It is a robust instrument which does not require special care in handling. It is made on high-grade lines, and its low price arises only from the simplicity of its design and the methods used in its manufacture. On removing the cover all its parts are accessible.

Two models are available; **The Universal Model** with taut suspension top and bottom fitted with pointer and mirror, for use with the scale in either a horizontal or vertical position, and **The Sensitive Model** with strip suspension at top and silver spiral at bottom also fitted with pointer and mirror, for use with the scale in horizontal position only.



Fig. 1.—The Universal Model in vertical position.



A 84-150.

Fig. 2.—The Universal Model with cover removed.

Universal Model

The Moving System is of the taut suspended D'Arsonval type and is supplied with ballistic system, or if so ordered, dead-beat. The system may be securely clamped by the vertical movement of a knob beneath the window at the back of the case (Fig. 4, p. 300). The standard resistance is about 50 ohms, but systems of about 10 or 375 ohms. may, if so ordered, be supplied at the same prices.

The Scale (Figs. 1 and 2) is about 5 cm. long and has 100 equal divisions with a centre zero and also a side zero. The pointer is adjustable by a knurled head on the top of the case (Fig. 3, p. 300) and is provided with a stop.

The Case, measuring $3\frac{1}{2} \times 3\frac{1}{2} \times 4\frac{1}{2}$ in., is of moulded Bakelite with nickelled fittings. It consists of a back plate (Fig. 2), on which all the working parts are carried, and a cover, which is secured by four easily removable screws. On removing the cover, every part of the system is immediately accessible.

The Mirror is carried on the back of the coil, opposite a window in the back plate (Fig. 4). It is supplied for one metre scale distance unless specially ordered otherwise.

Typical Sensitivities are shown in the Table overleaf. The constants of each instrument—terminal resistance and microamps. per half scale pointer deflection—are indicated at the base of the scale (Figs. 1 and 2).

The Universal Model is very robust and has a sensitivity amply sufficient for general purposes, for which it is recommended on account also of its great adaptability.

£ s. d.

A 84-150. MICROID ADAPTABLE GALVANOMETER, Universal Model, in Bakelite case, for use vertically or horizontally, with mirror for one metre scale distance. Approximate resistance 10, 50 or 375 ohms, ballistic or dead-beat 1 4 0 0

50 ohms resistance ballistic system supplied unless otherwise ordered.

[*continued overleaf*

GALVANOMETERS

A 84-160. The Microid Adaptable Galvanometers—*continued.*



Fig. 3.—The Sensitive Model.

A 84-160.

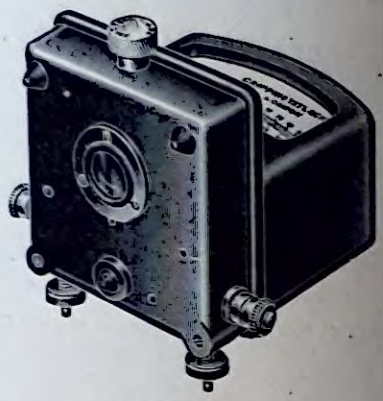


Fig. 4.—The Sensitive Model showing mirror window.

Sensitive Model

This Model is intended for those requiring an instrument of higher sensitivity. It differs in construction from the Universal Model only in having a single suspension, with silver lead-in spiral to the bottom of the coil in place of a taut suspension. It is for use with the scale in a horizontal position. It should be levelled carefully and is, for that purpose, provided with a circular spirit level (Fig. 3) and levelling screws (Fig. 4). The spirit level is now mounted on the scale plate inside the case.

The Sensitive Model is supplied of about 50 ohms resistance with ballistic system, except ordered to be 10 or 375 ohms, or with a critically damped (dead-beat) system.

Typical Sensitivities are shown in the Table below.

	£ s. d.
A 84-160. MICROID ADAPTABLE GALVANOMETER, Sensitive Model, in Bakelite case, for use in **horizontal position** only, with mirror for one metre scale distance. Approximate resistance 10, 50 or 375 ohms, ballistic or dead beat	7 4 5 0
50 *ohms resistance ballistic system supplied unless otherwise ordered.*	

TYPICAL SENSITIVITY DATA FOR THE MICROID ADAPTABLE GALVANOMETERS A 84-150—160.

U M = Universal Model **S M = Sensitive Model**

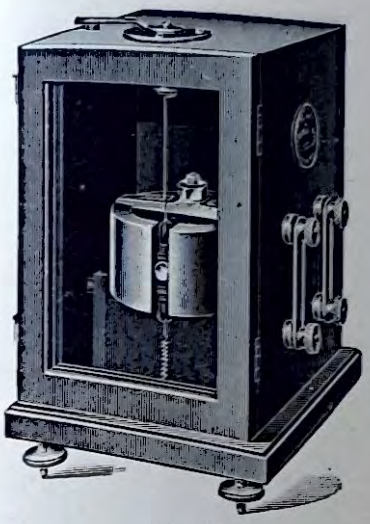
Nominal Resistance Ohms	Actual Coil Resistance Ohms		Period Seconds		1 Scale Division Deflection on Pointer for				Deflection at 100 cm. Scale Distance per μ A.		Deflection at 100 cm. Scale Distance per μ coulomb	
					μA.		μ Coulombs		Millimetres		Millimetres	
	U M	S M	U M	S M	U M	S M	U M	S M	U M	S M	U M	S M
10	10	10	1·1	3·8	4·2	1·1	0·7	0·54	5	25	28	41
50	49	47	1·2	3·8	2·0	0·5	0·4	0·27	11	50	57	82
375	372	374	1·2	3·8	1·0	0·31	0·2	0·14	25	100	131	165

GALVANOMETERS. Attention is drawn to those instruments on pages 298-303 in respect of which **Tables of Sensitivity Data** are published, and especially to their **efficiency** as compared with their **prices.** They are produced with care and each is provided with a Works Certificate giving its Sensitivity Data.

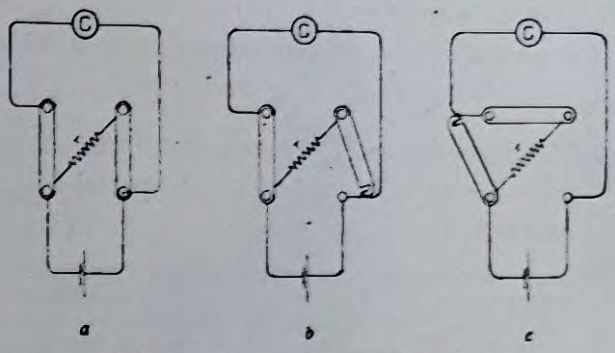
Instruments of characteristics other than those specified may be supplied and customers are invited to state their requirements.

The figures given in the following tables have been obtained in recent laboratory tests. Individual instruments may vary 15 or 20 per cent. from these, owing to differences in the resistance of coils and strength of magnets. The period in seconds to which reference is made in the tables is the time taken for one complete cycle or oscillation—not for one-half cycle, as is sometimes taken by Continental and other authorities. The Factor of Merit, where specified, is derived from the formula $\frac{100\ D}{T \sqrt{(R_y)}}$, where D = deflection in mms. per microamp. at one metre. T = the period as above defined. R_y = the coil resistance.

See *Dictionary of Applied Physics*, Vol. II., page 375.



A 84-180.



Connections for Galvanometers A 84-170—180.

A 84-170. GALVANOMETERS, D'Arsonval, Combined Dead-beat and Ballistic. Construction generally as illustrated for **A 84-180.** *(See sensitivity table below.)*

Resistance	18	150	300	750	*ohms*
	£9 5 0	£9 10 0	£9 15 0	£10 0 0	*each*

The instrument is fitted with two pairs of terminals, so that the same coil may be used either ballistically or dead-beat. By means of connecting pieces a resistance equal to the critical damping resistance of the galvanometer may be

(*a*) connected across the moving system as shown in Fig. *a*, for use in damping when the external circuit resistance is greater than the critical resistance.

(*b*) cut out for use ballistically or where the maximum sensitivity is required, as shown in Fig. *b*.

(*c*) connected in series with the moving system, as shown in Fig. *c*, for use in damping when the external circuit resistance is less than the critical damping resistance.

The magnet is of large cross-section, and made from the best magnet steel. The gap is ground out cylindrically, and a cylindrical core is so fitted as to ensure a uniform field.

The coil is cylindrical in section, and thus may be wound with a large number of turns, while the clearance is reduced to a minimum. Both the ballistic and dead-beat coils are wound without a frame, so providing for a greater number of turns and increased efficiency. The wire used is specially drawn non-magnetic. The phosphor-bronze suspension is of unusual length, and the lead-in spiral is of silver.

The case is of teak 9½ × 6½ × 7½ in., with hinged glass front and levelling screws.

The mirror is 1 cm. diam., and suitable for scale distance of 1 metre. The zero is adjusted by a lever on the top of the case.

A 84-180. GALVANOMETERS, Ayrton-Mather, Combined Dead-beat and Ballistic. Specification generally as for **A 84-170.**

Resistance ..	10	70	250	750	6000	*ohms*
	£5 5 0	£5 15 0	£6 0 0	£6 10 0	£7 10 0	*each*

The coil is of specially drawn non-magnetic wire, and is wound on a light but rigid frame of the cross-section which has been proved most efficient. After winding, it is chemically treated, to remove any trace of magnetic material in the frame or silk insulation. The phosphor-bronze suspension is of unusual length, with silver lead-in spiral.

SENSITIVITY DATA FOR GALVANOMETERS A 84-170—180

See Note on p. 300

Cat. No.	Nominal Coil Resistance Ohms	Actual Coil Resistance Ohms	Period Seconds	Mm. Deflection at 100 Cm. Scale Distance per μA.	μV.	μ Coulomb	Critical Damping Resistance Ohms	Factor of Merit
A 84-170	18 150 300 750	17·5 163	14·4 12	136 348	11 2	105 300	320 2000	28 31
A 84-180	10 70 250 750 6000	11·5 68 241 693 6000	4·8 4·6 4·6 4·2 3·6	98 273 414 910 1485	8·5 3·3 1·7 0·9 0·24	90 300 600 840 1666	92 600 1900 5000 12000	160 196 218 256 354

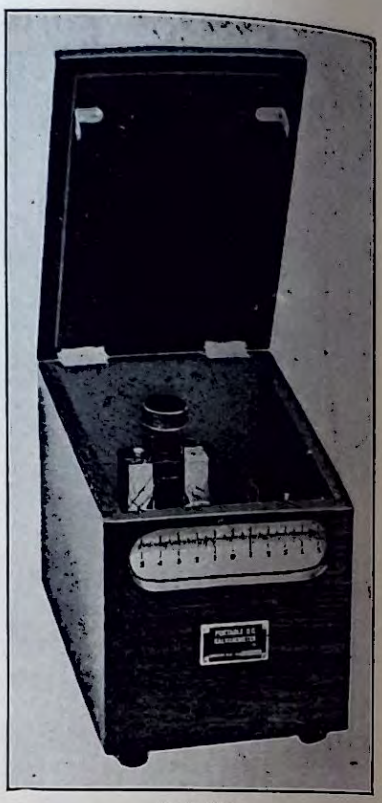
A 84-200. GALVANOMETER, Portable, Moving Coil, Reflecting, with built-in optical system and scale in wood box. *(When ordering please state Suspension number required, and if Dead-Beat or Ballistic Coil)* .. .. *tx* £ 11 2 9

A 84-205. Suspensions, spare, for **A 84-200.** *(When ordering please give Suspension number and state if Dead-Beat or Ballistic)* .. .. *tx* £ 5 2 5

This sensitive galvanometer is always ready for use, no special levelling is required, and the illumination of the spot is sufficiently bright for it to be seen in a normally lighted room. The source of illumination is a 4-volt lamp in adjustable holder for focussing and operated from A.C. mains by a transformer in the case. The cross-wire of the spot is sharply focussed and can be read to about 0·1 mm. Paper on glass scale graduated 50–0–50 mm.

The galvanometer has a short suspension, which can be supplied with any one of the interchangeable coils shown in table below. The suspension is robust, unaffected by normal vibration, gives consistent scale readings, and a stable zero. The coils are fitted with zero adjustment on the suspension head and clamp for transit. Spare suspensions are interchangeable in a few minutes.

The wood case, $8\frac{1}{2} \times 5\frac{1}{2} \times 5\frac{1}{2}$ in., on four rubber feet, is fitted with two pairs of terminals for connection to galvanometer and lamp circuits.



A 84-200.

Suspension No. ..	1*b*	2*b*	3*b*	4*b*	5*b*	6*b*	7*b*	
Resistance	6	50	320	500	850	1200	2000	*ohms*
Sensitivity	1	2·5	5·5	7·5	9	10	11·5	*mm./μA.*
Period	1	1	1	1	1	1	1	*sec.*
Suspension No. ..	1*a*	2*a*	3*a*	4*a*	5*a*	6*a*	7*a*	
Resistance	6	50	320	500	850	1200	2000	*ohms*
Sensitivity	3	10·5	22·5	29·5	36·5	41	45·5	*mm./μA.*
Period	2	2	2	2	2	2	2	*secs.*



A 84-220.

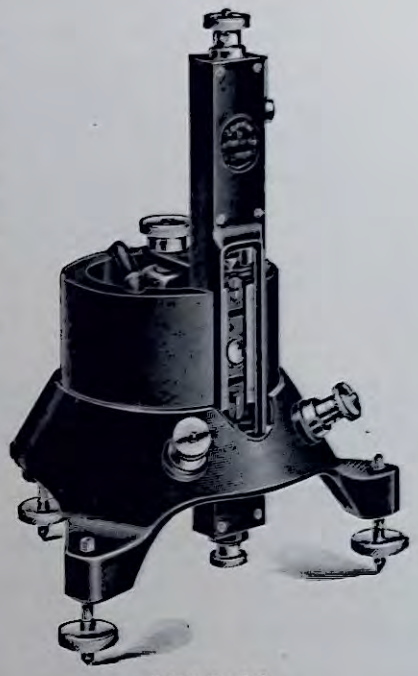
GALVANOMETERS, Spot, Cambridge. Provide in one self-contained insulated case $8 \times 8\frac{1}{4} \times 4\frac{3}{4}$ in., a complete galvanometer outfit, comprising a reflecting galvanometer of the d'Arsonval type, a lamp and a 160 mm. scale, conveniently arranged at an angle of 45°. Readings can be taken to 0·2 mm. The lamp is run from 240 v. A.C. by means of a built-in transformer. A 4-volt battery operated model is also available.

Approx. Resistance of Coils	Period Undamped	Deflection in mm. on Scale		External Damping Resistance	A 84-220. Mains Price	A 84-225. Battery Price
Ohms	Seconds	μ A.	μ V.		£ s. d.	£ s. d.
					tx	*tx*
20	2	19	0·95	150	14 13 3	14 1 9
50	2	30	0·6	500	14 13 3	14 1 9
400	2	170	0·42	14000	14 13 3	14 1 9

The instruments **A 84-240** are intended for those who require one galvanometer to cover a wide range. The suspension system is of interchangeable construction. Galvanometers **A 82-240** ordered as ballistic may be made dead-beat by the fitting of the appropriate critical damping resistance **A 84-248**, which is included in **A 82-242**. Galvanometers ordered as dead-beat are made so by the incorporation of a shorted turn, which gives somewhat higher sensitivity. Similarly with the spare suspensions. The magnet is of large cross-section and of best quality magnet steel. The gap in the magnet, and the pole-pieces of the suspension case are each ground cylindrically and are an exact fit, thus reducing the air gap to a minimum and ensuring the accurate location of the moving system. The system is held in position by a single knurled nut. The base of the instrument is an aluminium casting and has three levelling screws.

The moving system is enclosed in aluminium case with a dustproof cover, readily removable for re-suspension. The window enables the whole of the coil to be seen for accurate levelling and adjustment. Half a turn of a stud, not only firmly clamps the coil between two spring-clips, but removes the tension from the upper suspension. The upper suspension is phosphor-bronze and the lead-in spiral silver. The coil is of specially drawn non-magnetic wire, and is wound on a light but rigid frame of the cross-section which has been proved most efficient. After winding, it is chemically treated to remove any trace of magnetic material in the frame or silk insulation. The mirror is 1 cm. diam. and optically worked, for a scale distance of one metre. The zero is adjusted by a knurled head on the top of the case.

Attention is drawn to the simplicity of construction and to the ease with which suspension systems may be interchanged.



A 84-240—242.



A 84-244—246.

GALVANOMETERS, Ayrton-Mather, with Interchangeable Suspension Systems. Coils **A 84-240** may be either ballistic or dead-beat. (*Please state when ordering.*) Coils **A 84-242** are combined ballistic and dead-beat and include a critical damping resistance. The suspension systems are supplied complete as illustrated. The cases are dustproof.

Resistance ..	10	70	250	750	6000	*ohms*
A 84-240. Ballistic or D.B. *r*	£11 5 0	£11 10 0	£11 15 0	£12 0 0	£12 15 0	*each*
A 84-242. Ballistic and D.B. *r*	£12 15 0	£13 0 0	£13 10 0	£14 0 0	£14 15 0	*each*
SUSPENSIONS, Spare.						
A 84-244. Ballistic .. .. *r*	£5 15 0	£5 15 0	£6 0 0	£6 5 0	£6 15 0	*each*
A 84-246. Dead-Beat .. *r*	£5 15 0	£5 15 0	£6 0 0	£6 5 0	£6 15 0	*each*
A 84-248. Crit. Damping Resistance for **A 84-242** *r*	£1 10 0	£1 10 0	£1 15 0	£1 15 0	£2 0 0	*each*

The instrument **A 84-242** is similar to **A 84-240** but is fitted with two terminals at the back, by means of which there may be inserted in the circuit a resistance equal to the critical damping resistance of the suspension system in use. The arrangement is similar to that in **A 84-180**. The critical damping coil is not in this case, however, integral with the instrument, but is a small bobbin with a screwed extension. By screwing this into one of the terminals, the resistance is connected between that terminal and the frame. The other terminal is fitted with a screwed plug by means of which it also may be connected to the frame as required. This arrangement permits the critical damping resistance to be connected in any of the positions shown under **A 84-180**.

Any number of these detachable bobbins may be kept for use with suspension systems of various resistances. Instructions for use are supplied with each instrument.

SENSITIVITY DATA FOR AYRTON-MATHER GALVANOMETERS A 84-240—242

See Note on p. 300

Nominal Coil Resistance	Actual Coil Resistance	Period	Mm. Deflection at 100 Cm. Scale Distance per			Critical Damping Resistance	Factor of Merit
Ohms	Ohms	Seconds	μ A.	μ V.	μ coulomb	Ohms	
10	10·5	5·0	79	7·8	90	80	125
70	72	5·0	241	3·4	317	610	200
250	245	4·6	419	1·7	595	2000	220
750	710	4·4	622	0·9	832	5000	250
6000	5910	4·4	1500	0·25	1800	12000	250

SENSITIVITY DATA FOR UNIPIVOT GALVANOMETERS
A 84-320

Period	Approx. Coil Resistance	Total Internal Resistance	Standard Ranges for Full Scale Deflection	
Secs.	Ohms	Ohms	μ A.	μ V.
4 secs. to rest	5	5	360	1·8
"	10	10	240	2·4
	50	50	120	6·0
	10	10 + 40	240	12
	10	10 + 90	240	24
	10	10 + 490	240	120
	1000	1000	24	24

The moving coils of these galvanometers usually have a resistance of 10 ohms the balance being "swamping resistance."



A 84-320 + 325—330.

A 84-320. GALVANOMETER, Unipivot, Cambridge. A simple form of moving coil galvanometer which can be adapted to cover a wide range of measurements of current or pressure, in both D.C. and A.C. circuits. Scale length approx. 120 mm., and divided into 120 equal divisions. By the use of range multipliers or shunts it can be used up to a maximum of 24 amps., or 600 volts. A range multiplier is shown attached to the instrument above but is not included in the price. When provided with a second, thermal scale, the instrument range 2·4 millivolts can also be used in connection with suitable thermal accessories for the measurement of alternating currents and pressures. Complete in moulded case engraved with any single standard range. (*See table of sensitivity above*) *tx* 9 13 3 £ s. d.

Please state range and resistance required when ordering.

A 84-322. Range Box (D.C.), for **A 84-320,** self-contained, covering 10 current and 9 voltage ranges to 12 amps. and 1200 volts respectively .. ..*tx* 16 2 0 £ s. d.

Range Multipliers (D.C.) for Unipivot Galvanometer, for use with **A 84-320.** Made in a number of interchangeable units for measuring in either volts or amps. Each unit is arranged for direct connection to the instrument terminals by means of tongues, but tapered holes in the tongues enable connections to be made at a distance by utilising plug-ended leads.

A 84-325 D.C. Ampere Range Multipliers			Price
Range (amps.)	Scale Factor (amps. per division)	Combined Resistance (ohms)	£ s. d.
0·012	0·0001	10	*tx*
0·06	0·0005	2	
0·12	0·001	1	
0·24	0·002	0·5	
0·6	0·005	0·2	1 14 6
1·2	0·01	0·1	
2·4	0·02	0·05	
6	0·05	0·02	
12	0·1	0·01	
24	0·1	0·005	

A 84-330 D.C. Volt Range Multipliers			Price
Range (volts)	Scale Factor (volts per division)	Combined Resistance (ohms)	£ s. d.
0·24	0·002	1,000	*tx*
0·6	0·005	2,500	
1·2	0·01	5,000	
2·4	0·02	5,000	1 14 6
6	0·05	5,000	
12	0·1	5,000	
24	0·2	5,000	
60	0·5	5,000	
120	1	10,000	2 0 3
240	2	10,000	2 0 3
480	4	20,000	3 12 6
600	5	30,000	3 12 6

Thermal Converters and Range Multipliers (A.C.), for use with **A 84-320**. Thermal converters with self-contained vacuo-junctions give ranges of 0·36 volt and 0·18 amp. for full-scale deflection. Range multipliers, used with the converters, extend the A.C. limits up to 24 amps. or 600 volts.

A 84-340 A.C. Ampere Range Multipliers			Price
Amps. for Full Scale Deflection	Scale Factor (amps. per division)	Circuit Resistance (ohms)	£ s. d.
0·18	0·0015	1	tx 4 6 6
0·6	0·005	0·3	
1·2	0·01	0·15	
6	0·05	0·03	1 14 6
12	0·1	0·015	
24	0·2	0·0075	

A 84-345 A.C. Volt Range Multipliers			Price
Volts for Full Scale Deflection	Scale Factor (volts per division)	Circuit Resistance (ohms)	£ s. d.
0·36	0·003	10	tx 4 0 6
0·6	0·005	16·67	
1·2	0·01	33·33	
6	0·05	166·7	1 14 6
12	0·1	333·3	
60	0·5	1,667	
120	1	3,333	
240	2	6,667	4 8 7
480	4	13,333	8 17 2
600	5	16,667	9 17 10

A 84-350. Range Box (A.C.), for **A 84-320** covering 9 current ranges and 7 voltage ranges up to 12 amps. and 1200 volts .. .. £ s. d. tx 13 5 8

A 84-355. Vacuo-Junctions, for **A 84-320** to adapt the Unipivot galvanometer to the measurement of high frequency A.C. Range and price *see table below.*

The current to be detected or measured passes through a heater near to which a small thermo-junction is placed. The E.M.F. set up in the thermo-couple circuit produces a deflection which is practically proportional to the square of the heater current. The heater consists of a short fine wire, or strip, of resistance material having negligible capacitance and inductance. The thermo-junction and heater are enclosed in a highly exhausted glass bulb, which eliminates the effects of air currents and enables high sensitivity to be obtained.

The glass bulb is mounted in a compact case, provided with a 4-pin cap for insertion in a standard valve holder.



A 84-355—370.

Heater Resistance (Ohms)	Couple Resistance (Ohms)	Current corresponding to an open circuit e.m.f. of 6 mV. mA.	Safe Current mA.	A 84-355 Price £ s. d.
1600	13	1·25	2·5	tx
400	8	2·5	5	
90	8	5	10	
30	8	10	20	
12	4	25	50	
4	4	50	100	1 14 6
1	4	150	300	
0·4	4	500	1000	
0·32	4	700	1100	
0·2	4	1000	1500	

A 84-360. Vacuo-Junctions, calibrated, with specific sensitivities, for use directly with the thermal scale on the Unipivot galvanometer **A 84-320**. Mounted in standard holder, coloured red. A disc indicates the scale factor. Ranges and price *see table below.*

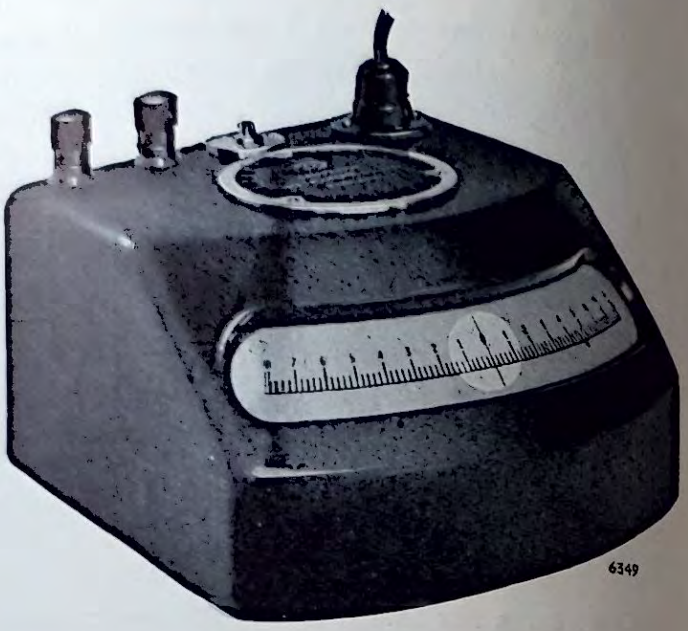
Heater Resistance (ohms)	Current for 100 div. on 10 Ω Unipivot m A.	Max. Heater Current mA.	A 84-360 Price £ s. d.
30	10	20	tx
12	20	50	
8	50	100	
4	100	200	2 12 4
0·8	200	500	
0·4	500	1,000	
0·2	1,000	1,500	

Approximate figures

A 84-370. Holder, Vacuo-Junction, for **A 84-320** engraved and provided with terminals for connection to the galvanometer and A.C. circuit respectively .. £ s. d. tx 0 9 3



A 84-380.



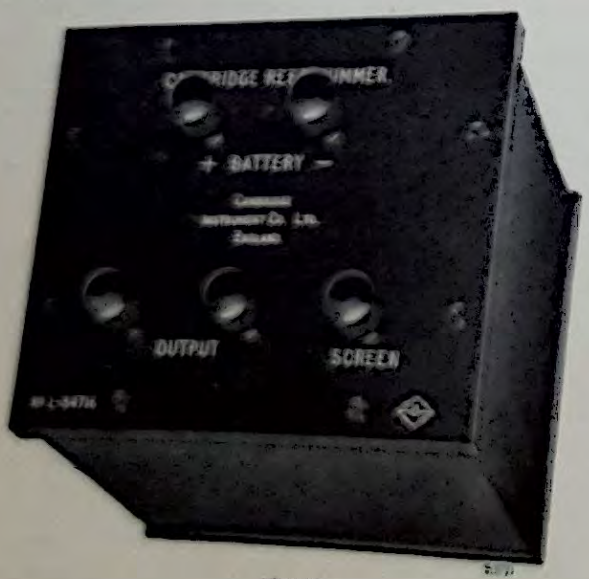
A 84-385.

A 84-380. GALVANOMETER, Vibration, Cambridge, for use in A.C. bridge networks for any one of the frequencies 50, 100, 800 or 1000 cycles/sec. (to be specified when ordering), fitted with plane mirror and lens for one metre scale distance, zero adjuster and levelling screws .. ..*tx* £ s. d 17 5 0

When ordering please, state frequency required.

This instrument is a simple and compact form of vibration galvanometer, for use in A.C. bridge networks. It can be supplied for frequencies of 50, 100, 800 or 1000 cycles/sec., but any individual galvanometer can be employed only on the one frequency for which it is supplied. A tuning control is fitted, which covers a small margin above and below the nominal frequency; this is operated by rotating the knurled head at the top of the instrument, until the luminous "band" on the scale is at its maximum width.

Nominal Frequency cycles/sec.	Margin of Control cycles/sec.	Sensitivity mm./Microamp. at 1 metre	Impedance ohms
50	± 5	90	385
100	± 15	60	326
800	± 15	1·5	143
1000	± 15	0·88	117



A 84-390.

A 84-385. GALVANOMETER, Vibration, Spot, Cambridge, comprising vibration galvanometer movement above for use at 50 cycles/sec., mounted in case with light source and translucent scale, length 160 mms. The 4-volt lamp is lit by a low voltage mains transformer provided inside the case. A tuning control provides an adjustment of ± 5 cycles/sec. Sensitivity 15 mm./microamp, impedance 385 ohms *tx* £ s. d 28 15 0

A 84-390. REED HUMMER, Cambridge. A portable source for A.C. bridge networks operating on any voltage from 4 to 10, and supplying a good wave form at 800 to 1000 cycles/sec. Screened output winding having an impedance of about 1000 ohms. With certificate giving the frequency at three input voltages .. .. .. *tx* 5 3 6



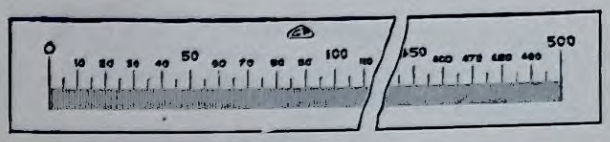
A 84-490.



A 84-550.



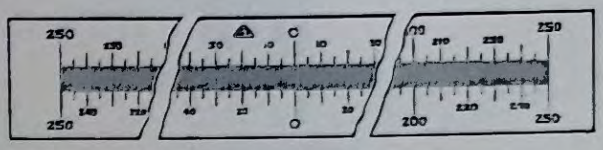
A 84-560



A 84-640—642.



A 84-580.



A 84-644—648.

A 84-490. SHUNT, Ayrton-Mather, Dial Pattern (Starling: *Electricity and Magnetism*, 6th Edn., p. 80), in brass case with ebonite top. The switch is of simple and efficient design. The wire is manganin and wound on metal bobbins.

The total resistance is 10,000 ohms, and the following values may be obtained:— 0, 1, $\frac{1}{3}$, $\frac{1}{10}$, $\frac{1}{30}$, $\frac{1}{100}$, $\frac{1}{300}$, $\frac{1}{1000}$. An extra point is also provided, at which the battery circuit is broken, which will be found very convenient .. .. £ 9 5 0

A 84-550. MIRRORS, Galvanometer, Concave, optically worked, silvered, 1 cm. diam.

Scale distance	50	100	200 *cm.*
Focal length	25	50	100 *cm.*
	5/-	5/-	5/- *each*

A 84-552. Ditto, 8 mm. diam. scale distance 100 cm., focal length 50 cm. .. .. *each* 0 5 0

A 84-560. MIRRORS, Galvanometer, Plane, optically worked, silvered.

Diam.	1	2 *cm.*
	4/6	6/6 *each.*

A 84-565. Ditto, Rectangular, 6 × 4 mm. .. .. *each* 0 5 6

A 84-580. PHOSPHOR BRONZE STRIP, for suspending galvanometer coils. 0·011 in. wide × 0·00075 in. thick .. .. *2 yard reel* 0 2 6

A 84-585. Ditto, 0·0035 in. wide × 0·0004 in. thick .. .. *2 yard reel* 0 2 6

A 84-590. PHOSPHOR BRONZE WIRE.

Diam.	0·001	0·002 *in.*
	1/9	1/9 *yard*

A 84-595. SILVER STRIP, 0·005 in. wide × 0·0003 in. thick .. .. .. *2 yard reel* 0 8 0

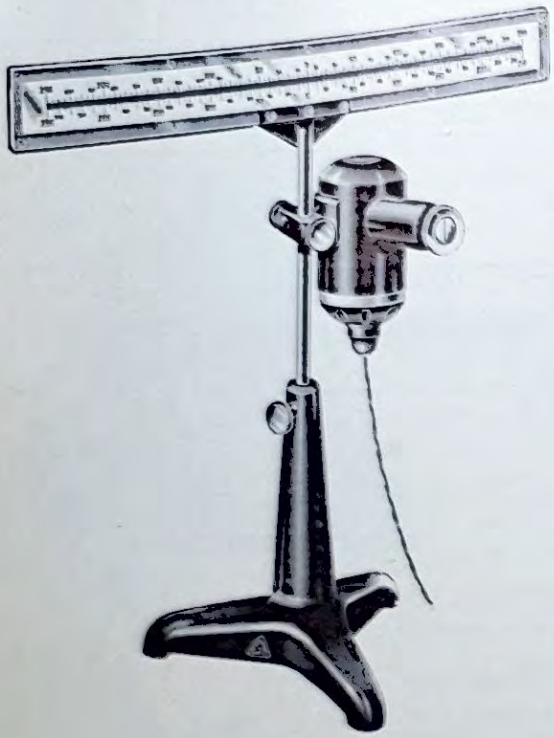
GALVANOMETER SCALES, Unmounted, graduated in mm., figured every cm.

A 84-640. Paper, opaque, graduated 0-500 mm. .. .. *each* £ 0 1 0
A 84-642. Paper, translucent, graduated 0-500 mm. .. .. *each* £ 0 1 0
A 84-644. Paper, opaque, graduated 250-0-250 mm. .. .. *each* £ 0 1 0
A 84-646. Paper, translucent, graduated 250-0-250 mm. .. .. *each* £ 0 1 0
A 84-648. Celluloid, graduated 250-0-250 mm. .. .. *each* £ 0 6 0



A 84-720.

A 84-720. GALVANOMETER SCALE, Mounted.
Translucent paper scale **A 84-646** mounted between Perspex sheets 1 7 6

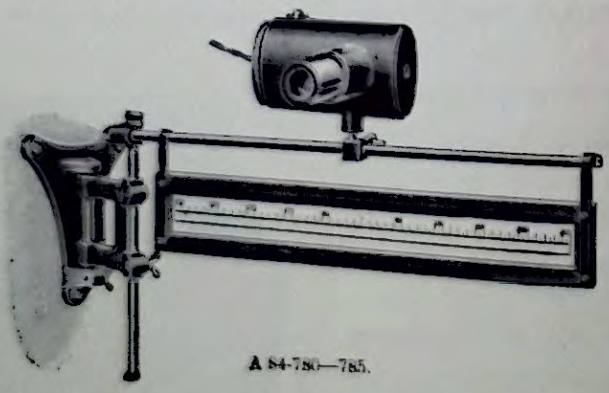


A 84-740—745.



A 84-760—765.

	£	s.	d.
A 84-740. LAMP AND SCALE, for electric lamp, brass lamphouse on new pattern tripod stand, adjustable focussing lens, translucent scale 250–0–250 mm. in Perspex frame, with 3 yards flexible wire and adapter. **Without** lamp	5	10	0
A 84-745. Lamphouse only for above	3	10	0
Lamp, for above, clear, 60 watt, gas filled, ... see **A 58-355.**			
A 84-760. LAMP AND SCALE, with small lamphouse for 6 or 12 volt, 24 watt, s.b.c. lamp, on new pattern tripod stand, with focussing lens, translucent scale in Perspex frame, 3 yards flexible wire. **Without** lamp	5	10	0
A 84-765. Lamphouse only for above	3	10	0
Lamp, for above, s.b.c., 6 or 12 volt, 24 watt, ... see **A 58-495.**			



A 84-780—785.

A 84-780. LAMP AND SCALE, wall mounting. Lamphouse and scale may be set independently of each other. Provision is made for varying the distance between the scale and the galvanometer. Lamphouse is a stout aluminium casting, fitted with universal joint, and sufficiently ventilated to allow a 60 or 100 watt gas-filled lamp to be used. A large and brilliant spot is obtained, and readings can be taken in daylight. The image has a black V-shaped pointer enabling precise readings to be made. Translucent scale, 50 cm. long, with centre zero, in Perspex frame. Fine zero setting device. Hinged metal wall bracket. **Without** lamp £10 0 0

A 84-785. Lamphouse only for above £6 0 0

Lamps, for above, 60 or 100 watt, ... see **A 58-355**

THE MICROID LONG RANGE GALVANOMETER LAMP

A simple lamp giving a bright spot up to 20 metres for virtual increase of galvanometer sensitivity



A 84-790. Long Range Galvanometer Lamp with clamp for mounting on stand.



A 84-795. Long Range Galvanometer Lamp mounted on tripod, with translucent scale.

SPECIFICATION

The lamp body is of stout metal tube about 9 × 2 in. The lamp is a 12 volt, straight filament, gas-filled, projection lamp and is carried in a holder which slides into the body. Three set screws fitted to the holder enable the lamp to be centred accurately.

Inside the body a condenser is fitted which focuses light from the lamp on to a diaphragm containing a small circular aperture diametrically across which is stretched a very fine wire soldered in position. The beam emerging from this aperture is focused on to the scale by an achromatic lens mounted in a draw tube sliding inside the lamp body and produces a bright spot at scale distances of from 1 to 20 metres.

The body is held in a ring to which is attached a brass stem of ⅜ inch diam. A rectangular brass block, drilled with two holes at right angles and fitted with set screws, enables the position of the lamp to be adjusted as desired.

The lamp house is also available mounted on a heavy tripod base of a new type fitted with a stainless steel rod and a translucent scale. In this convenient form it can be used at 1 metre distance as well as for long distance projection, the only adjustment necessary being the focusing of the spot by sliding the drawtube.

	£ s. d.
A 84-790. MICROID LONG RANGE GALVANOMETER LAMP, with metal body, adjustable lamp holder with centring screws, condenser, diaphragm, achromatic focussing lens in drawtube, and clamp and stem support. **Without** lamp	6 15 0
A 84-795. Ditto, mounted on heavy metal tripod base with stainless steel rod and translucent scale. **Without** lamp	8 10 0
Lamps, 6 or 12 volt, 24 watt s.b.c. straight filament, ...	see A 58-495

PIVOTED ELECTRICAL INDICATING INSTRUMENTS

The variety of designs of electrical indicating instruments available to-day makes it necessary to exercise careful consideration before any particular type is chosen. In educational work important factors are, the requirement of the syllabus to be covered, the nature of the practical work to be carried out, the number of students to be provided for and the funds available. In the following pages an endeavour has been made to assist users in the selection of suitable instruments, by setting out clearly the salient characteristics of, and the differences between, each type of instrument listed. Scale length, sensitivity, damping and resistance are specified and users are recommended to study this data before ordering. First grade accuracy instruments made to conform to British Standard Specification 89—1937, bear a "hall-mark" of performance. This specification covers such points as damping, scale marking, limits of error due to self-heating, external magnetic fields, etc., but it does not ensure the selection of the correct instrument for any given measurement. The notes below are intended as additional guidance for those to whom they may be of value.

Resistance.—It should be noted that the resistance of an instrument remains constant and the expression "ohms/volt" applies only to the upper limit of the scale reading. The actual resistance per applied volt increases as the deflection of the pointer decreases.

For direct current bench work the moving coil permanent magnet system is to be preferred. Modern magnet steels permit mechanically strong movements to be made, with ample clearances, with high torque/weight ratio, unlikely to suffer from stiction, and with a maximum error not exceeding 1 per cent. of the maximum scale reading. Some instruments may, without damage, withstand a momentary overload of 1000 per cent.

Where it is possible to allocate an instrument to be retained for use in only one experiment, a single range, self-contained, ammeter or voltmeter is often chosen. Where funds are more limited, one instrument may be required to serve for a number of different experiments, and a multi-range instrument, or an instrument whose range can be extended by the use of external shunts and multipliers, may show advantage, but inexperienced students must use them with care. It is preferable that such instruments should have a round figure resistance, that they should be scaled to allow readings of both voltage and current, that the external multipliers should be clearly marked with range and resistance, and that these should be so designed that the correct sequence in coupling or uncoupling must be maintained, so preventing electrical damage to the movements. These instruments have a further advantage that their accuracy can be checked, one against another. They will be found listed in the following pages.

Certain moving coil voltmeters are listed with a resistance of 66·6 ohms/volt, which is high enough for most purposes. Generally, however, where higher values are available a resistance of 200 ohms/volt may be specified. While resistances as high as 500 or 1000 ohms/volt can be supplied, such instruments, having windings of fine gauge wire, are not so robust as those of a lower unit value.

A scale length of 2½ in. has been in common use in schools with moving coil instruments for many years. When provided with suitable scale markings and knife edge or finely lipped pointers these instruments give an order of accuracy adequate for the majority of school or college laboratories. They occupy little bench space and if mounted on a desk type stand readings are not fatiguing to take and parallax error is reduced. The moulded rubber bases listed are specially noteworthy as they also cushion the movements against damage from mechanical shock. For more advanced work a longer scale length up to 5 in. is preferable. Knife edge pointers and antiparallax mirror contribute to the accuracy of reading of this larger instrument.

For students' galvanometer work in bridge and similar null-point methods, attention may be directed to the centre-zero instrument 40 ohms resistance and calibrated 2–0–2 mA and 80–0–80 mV for full scale deflection. These modern instruments, progressively developed during the past twenty years have largely eliminated troubles with the student's galvanometer. If they are provided with additional self-contained ranges of 2–0–2a and 4–0–4v, they would appear to meet final requirements in the elementary laboratory of the smaller school.

For Alternating Circuit work in the measurement of current the moving iron instrument may satisfactorily be used where the current exceeds 100 mA. Moving iron current indicators for lower ranges than 0–500 mA (with scale calibrations down to 100 mA) increase steeply in resistance, making them unsuitable for general laboratory work. Well-designed instruments, with Mumetal elements, give accurate readings from 100 mA up to 5 amps. on both D.C. and on A.C. at frequencies from 25 to 500 cycles/sec.

The hot wire and the induction types of ammeter are but little used, the latter as it operates on A.C. only and at one frequency and its self-contained range is limited. Thermo-couple milliammeters and ammeters are included as these are practically the only type of instrument which can be used for measuring currents at radio frequencies; the same instrument can be used on A.C. power frequency supplies or on D.C.

In the measurement of A.C. pressures with the moving iron voltmeter great care should be taken in the selection of the instrument. Generally the M.I. instrument has a low resistance per volt, which makes it inherently unsuitable for use as a voltmeter when low range readings are required in a high resistance circuit. A voltmeter scaled 0–120 volts should not be read below 12 volts. A 0–10 volt M.I. voltmeter may have a resistance of only 2 ohms/volt, thus requiring 0·5 amp. for full-scale deflection. Such an instrument would be useless for measurements in a high resistance circuit and would give misleading values in most low resistance circuits. Thus care is essential in choosing and using a moving iron voltmeter. Moving iron type voltmeters with nickel-iron elements and ranges from 0/120 volts upwards may be used on either D.C. or A.C. circuits and if the frequency of the latter does not exceed 100 cycles/sec. the accuracy will be substantially the same on either type of circuit. If they are for use on a circuit of frequency exceeding 100 cycles/sec. they should be calibrated for such frequency and marked accordingly.

For lower readings than 25 volts A.C. moving coil instruments incorporating full wave rectifiers are to be preferred. Since these instruments cannot be low priced their utility is often economically extended by making them into multi-range instruments. The rectifier characteristics usually limit the lowest voltage range to 0–3 and the mA range extends up to rectifier capacity. Typical values would be 5 mA for voltmeters with 200 ohms/volt and 1 mA with 1000 ohms/volt. A rectifier M.C. voltmeter for a range lower than 0–3 generally embodies a step-up transformer; the resistance/volt is then lower and the errors of transformer, rectifier and instrument movement may be significant. For measurements below 0·5 volt A.C. the potentiometer method is recommended.

Dynamometer type voltmeters are now seldom used: they have a comparatively low resistance, especially on the low ranges. Improvements in the moving iron type have been a factor in limiting the use of the dynamometer type.

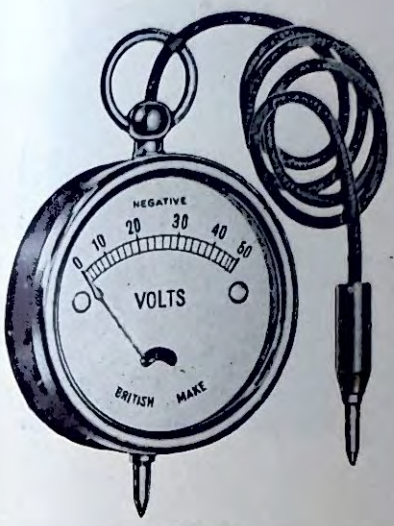
The induction type of voltmeter (for A.C. circuits only at a stated frequency) is not in common usage for educational purposes.

Hot wire and thermo-couple voltmeters are used chiefly on radio frequency circuits. They are less robust than the moving coil and moving iron types and unsuitable for junior physics laboratory use.

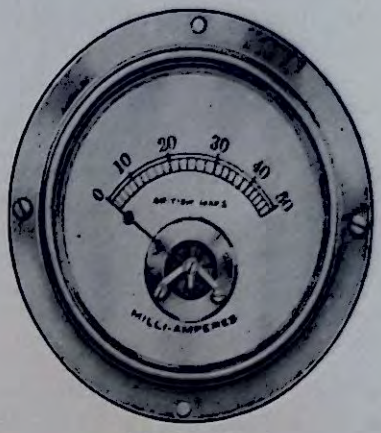
Electrostatic voltmeters may be required for circuits on which it is not expedient to impose even the small load required to operate a high resistance moving coil type instrument. The type cannot be used for low voltage measurements and lacks the robustness desirable in instruments for educational institution use.

For lecture work it is advantageous to use instruments larger than, but otherwise similar in scale and design to, the laboratory instruments used in practical work. Though the values of the pointer deflection cannot be read from a distance with exactitude, the order of values can be observed. A smaller instrument on the lecturer's side of the table can conveniently be used to repeat the demonstration instrument's indications. The large instrument may have a scale length up to 18 in. and if the zero is off-set and the scale as figured 3–0–15 it can be used as a demonstration galvanometer.

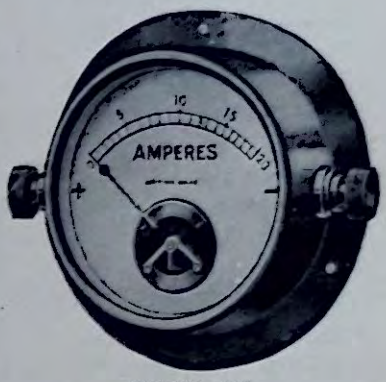
The General Index at the end of this Catalogue is a complete guide to its contents. Please consult it.



A 85-105—115.



A 85-120—130.



A 85-140—145.

A 85-105. AMMETERS, Pocket Type, Moving Iron for D.C. and A.C., spring controlled, 2¼ in. diam., polished Bakelite case, nickel plated fittings.

Range 0 to	3	6	12	*amps.*
	r 9/-	9/-	9/-	*each*

A 85-110. VOLTMETERS, specification as **A 85-105.**

Range 0 to	3	6	12	25	50	100	150	200	*volts*
Resistance (*approx.*)	4	11·5	20	330	1250	4000	6000	8000	*ohms*
	r 9/-	9/-	9/-	9/-	10/-	10 6	12/-	13 6	*each*

A 85-115. Ditto, double range, 0–9 volts (resist. 300 ohms) and 0–180 volts (resist. 6000 ohms) .. r £ 0 10 6

A 85-120. MILLIAMMETERS, Switchboard Type, Flush Pattern, Moving Iron for D.C. and A.C., spring controlled, 2¼ in. diam., nickel plated case, with back connections.

Range 0 to	100	250	500	750	1000	*m.A.*
Resistance (*approx.*)	150	26	9	3·6	1·4	*ohms*
	r 10/6	10 6	10 6	10 6	10 6	*each*

A 85-125. AMMETERS, specification as **A 85-120.**

Range 0 to	3	6	10	25	*amps.*
	r 10 6	10 6	10 6	10 6	*each*

A 85-130. VOLTMETERS, specification as **A 85-120.**

Range 0 to	3	6	12	20	60	100	130	*volts*
Resistance (*approx.*) ..	4·3	23	60	133	1500	4000	5100	*ohms*
	r 10 6	10 6	10 6	10 6	12 6	14/-	14/-	*each*

A 85-140. AMMETERS, Switchboard Type, Projecting Pattern, Moving Iron for D.C. and A.C., spring controlled, 2¼ in. diam., nickel plated case with side terminals.

Range 0 to	3	6	10	25	30	*amps.*
	r 13 6	13 6	13 6	13 6	14/-	*each*

A 85-145. VOLTMETERS, specification as **A 85-140.**

Range 0 to	3	6	12	20	120	200	*volts*
Resistance (*approx.*)	4·3	23	60	130	4800	12000	*ohms*
	r 13 6	13 6	13 6	13 6	17 6	21/-	*each*

METERS

METERS, Switchboard pattern, in black moulded flush or projecting type cases. *(We supply flush type unless otherwise ordered.)* With zero adjuster, and terminals at back. The $2\frac{1}{2}$ in. diam. instruments can be supplied mounted on black enamel ripple finish angle metal stands **A 85-198** for bench work, as illustrated, at extra cost.



A 85-190—196 + A 85-198
A 85-210—216.

	Moving Iron.	Moving Coil.
Movements		
For use on	D.C. and A.C.	D.C. only.
Accuracy	2%.	First Grade, B.S. 89-1937.
Resistance (Voltmeters)	See below.	200 ohms/volt.
Case, diam.	$2\frac{5}{8}$ in. and $3\frac{1}{2}$ in.	$2\frac{5}{8}$ in. and $3\frac{1}{2}$ in.
Scale length	$2\frac{1}{8}$ in. and 3 in.	$2\frac{1}{8}$ in. and 3 in.
Scale divisions	Practically linear, down to one-fifth of full scale.	Linear.
Damping	Pneumatic.	Inductive.
Period	2 secs.	1 sec.
Shielding	Nil.	Nil.
Momentary Overload Capacity	40%.	40%.

A 85-190. Ammeters, Moving Iron, $2\frac{1}{2}$ in. diam.

Range o to	1	2	3	5	10	*amps.*
t	£2 5 0	£2 5 0	£2 5 0	£2 5 0	£2 5 0	*each*

Range o to	20	30	40	50	*amps.*
t	£2 5 0	£2 5 0	£2 8 6	£2 8 6	*each*

A 85-192. Voltmeters, Moving Iron, $2\frac{1}{2}$ in. diam.

Range o to	5	10	15	20	*volts*
Resistance	5	5	10	10	*ohms/volt*
t	£2 5 0	£2 5 0	£2 5 0	£2 5 0	*each*

Range o to	30	50	120	250	*volts*
Resistance	20	20	70	70	*ohms/volt*
t	£2 5 0	£2 5 0	£2 5 0	£3 0 0	*each*

A 85-194. Ammeters, Moving Coil, $2\frac{1}{2}$ in. diam.

Range o to	1	2	5	10	15	*amps.*
t	£2 12 6	£2 12 6	£2 12 6	£2 12 6	£2 12 6	*each*

Range o to	20	30	50	75	100	*amps.*
t	£2 12 6	£2 12 6	£2 17 6	£3 10 0	£3 13 6	*each*

A 85-196. Voltmeters, Moving Coil, $2\frac{1}{2}$ in. diam., resistance 200 ohms/volt.

Range o to	3	6	10	20	*volts*
t	£2 12 6	£2 12 6	£2 12 6	£2 12 6	*each*

Range o to	30	60	120	250	*volts*
t	£2 12 6	£2 12 6	£2 12 6	£3 8 6	*each*

	£ s. d.
A 85-198. Stand, black enamel ripple finish, for **A 85-190—196** .. .. *each*	0 11 6

A 85-210. Ammeters, Moving Iron, $3\frac{1}{2}$ in. diam.

Range o to	10	20	30	40	50	*amps.*
t	£3 6 0	£3 6 0	£3 6 0	£3 10 6	£3 10 6	*each*

A 85-212. Voltmeters, Moving Iron, $3\frac{1}{2}$ in. diam.

Range o to	50	100	160	250	*volts*
Resistance	20	30	70	70	*ohms/volt*
t	£3 6 0	£3 6 0	£3 6 0	£4 1 0	*each*

A 85-214. Ammeters, Moving Coil, $3\frac{1}{2}$ in. diam.

Range o to	1	2	5	10	15	*amps.*
t	£3 15 0	£3 15 0	£3 15 0	£3 15 0	£3 15 0	*each*

Range o to	20	30	50	75	100	*amps.*
t	£3 15 0	£3 15 0	£3 19 0	£4 12 0	£4 16 0	*each*

A 85-216. Voltmeters, Moving Coil, $3\frac{1}{2}$ in. diam., resistance 200 ohms/volt.

Range o to	3	6	10	20	*volts*
t	£3 15 0	£3 15 0	£3 15 0	£3 15 0	*each*

Range o to	30	60	120	250	*volts*
t	£3 15 0	£3 15 0	£3 15 0	£4 10 6	*each*

Internal shunts are fitted to **A 85-194** *and* **A 85-214** *ranges up to* 50 *amps., above* 50 *amps. external shunts are supplied.*



A 85-240—246+250.

METERS, Switchboard Pattern, in projecting type, transparent, moulded cases, visible movement, balanced for use in any position, external zero adjuster, white enamel dial, knife-edge pointer and front terminals. Moulded rubber desk pattern base available at extra cost.

Movement	Moving Coil.
For use on	D.C. only.
Accuracy	First Grade, B.S. 89-1937.
Resistance (Voltmeters)	see below. (200 *ohms/volt supplied unless otherwise stated.*)
Case, diam.	3½ in.
Scale length	2⅝ in.
Scale divisions	Linear.
Damping	Inductive.
Period	Less than 1 sec.
Shielding	Nil, complies with B.S. Specn. unshielded.
Momentary Overload Capacity ..	1000%.

A 85-240. Milliammeters.

Range	0 to 1	0 to 2	0 to 5	0 to 10 *mA.*
tx	£3 16 8	£3 16 8	£3 16 8	£3 16 8 *each*
Range	0 to 15	0 to 50	0 to 100	0 to 500 *mA.*
tx	£3 16 8	£3 16 8	£3 16 8	£3 16 8 *each*

A 85-242. Ammeters.

Range	0 to 1	0 to 1·5	0 to 2	0 to 5 *amps.*
tx	£3 16 8	£3 16 8	£3 16 8	£3 16 8 *each*
Range	0 to 7·5	0 to 10	0 to 15	0 to 20 *amps.*
tx	£3 16 8	£3 16 8	£3 16 8	£3 16 8 *each*

Millivoltmeters, Voltmeters, see table below.

Cat. No.	Range	Resistance Per Volt				
		66·6 ohms	100 ohms	200 ohms	500 ohms	1000 ohms
		£ s. d. *tx*	£ s. d. *tx*	£ s. d. *tx*	£ s. d. *tx*	£ s. d. *tx*
	Millivoltmeters					
A 85-244	0 to 75	3 16 8	—	—	—	—
	0 to 250	3 16 8	3 16 8	—	—	—
	0 to 500	3 16 8	3 16 8	3 16 8	—	—
	0 to 750	3 16 8	3 16 8	3 16 8	3 16 8	—
	0 to 1000	3 16 8	3 16 8	3 16 8	3 16 8	3 16 8
	Voltmeters					
	0 to 3	3 16 8	3 16 8	3 16 8	3 16 8	3 16 8
	0 to 5	3 16 8	3 16 8	3 16 8	3 16 8	3 16 8
	0 to 10	3 16 8	3 16 8	3 16 8	3 16 8	3 16 8
	0 to 15	3 16 8	3 16 8	3 16 8	3 16 8	3 16 8
	0 to 30	3 16 8	3 16 8	3 16 8	3 16 8	4 9 3
A 85-246	0 to 50	3 16 8	3 16 8	3 16 8	3 16 8	4 9 3
	0 to 80	3 16 8	3 16 8	3 16 8	3 16 8	4 9 3
	0 to 100	3 16 8	3 16 8	3 16 8	3 16 8	4 9 3
	0 to 150	—	3 16 8	3 16 8	4 9 3	—
	0 to 200	—	—	4 4 11	4 9 3	—
	0 to 250	—	—	4 4 11	4 9 3	—
	0 to 300	—	—			

£ s. d.

A 85-248. Voltmeter, as **A 85-246.** but three ranges resistance 200 ohms/volt: 0–3, 0–15, 0–150 with four terminals .. .. *tx* 4 4 11

A 85-250. Base, desk pattern, moulded resilient rubber, for above instruments, provides a convenient angle for reading, avoids errors due to parallax and reduces risk of mechanical damage to instruments .. .. *tx* 0 6 2

METERS, Rectifier, Switchboard Pattern. Specification as for **A 85-240—246**, fitted with internal rectifiers for use on A.C. The instruments are of high sensitivity, low consumption, and indications are unaffected by change of frequency within wide limits.

Movement	Moving Coil, Rectifier.
For use on	A.C. only.
Accuracy	First Grade, B.S. 89—1937.
Resistance (Voltmeters)	Normally 200 ohms/volt at top figure on scale.
Case, diam.	3¼ in.
Scale Length	2⅝ in.
Scale Divisions	Linear.
Damping	Inductive.
Period	Less than 1 sec.
Shielding	Unshielded.
Momentary Overload Capacity	100% (Rectifiers may be damaged by overloads exceeding 100%).

	£ s. d.
A 85-254. Milliammeters, ranges 0–1, 0–5, or 0–10 mA.	*each tx* 5 1 1
A 85-256. Voltmeters, any range from 0–3 v. to 0–150 v.	*each tx* 5 1 1

A 85-258. Meters, Three Range, having two potential ranges and one current range, as follows, the current being read on the higher voltage scale:—

Volt ranges	Resistance Ohms/volt	Current Range Milliamps.	Price £ s. d.
			tx
0-3 and 0-15	200	0-5	
0-3 and 0-15	1000	0-1	
0-3 and 0-30	200	0-5	5 9 5
0-3 and 0-30	1000	0-1	
0-30 and 0-150	200	0-5	

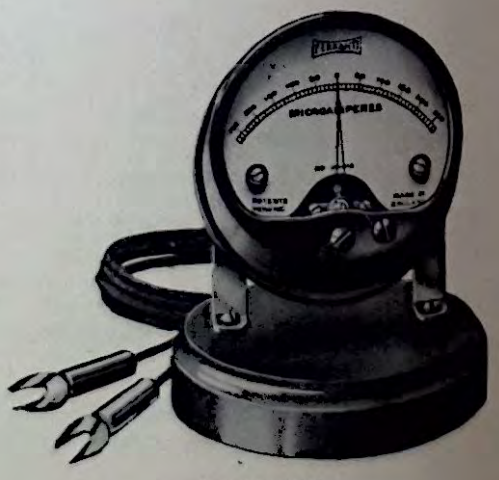
There has hitherto been difficulty in supplying at a reasonable price instruments suitable for indicating low voltages and low currents. The resistance of moving iron voltmeters for the pressures used for bench work varies from only about 0-5-10 ohms according to size and type of instrument. On the other hand moving iron milli-ammeters have such high resistance that they are often useless where supply voltages are low. The above 3-range instruments are suggested to fill most requirements. The drop for full-scale deflection for the current range is only about 1 volt. Separate scales are provided for each voltage range.

A 85-270. MICROAMMETER, projecting pattern, Bakelite case, with external zero adjuster, back connections. **Without** stand or leads. £ s. d. *t* 4 6 9

Movement	Moving Coil.
For use on	D.C. only.
Range	250-0-250 μA.
Each scale division	10 μA.
Accuracy	First Grade B.S. 89-1937.
Resistance	75 ohms (approx.)
Scale length	2½ in.
Scale Divisions	linear.
Diam. of case	3⅛ in.
Damping	exceptionally good.

A 85-272. Wood Stand for above with leads and spade-ended tags as illustrated

Price on application.



A 85-270+272.



A 85-310—315 + A 85-250.

MILLIAMMETERS (Galvanometers). Robust construction, balanced for use in any position. In transparent dust-, damp- and acid-proof moulded cases, with front terminals and external zero adjuster. Calibrated as micro-ammeters and millivoltmeters, with linear or non-linear (double logarithmic) divided scales, the latter having, near the zero, double the sensitivity of the former for null work. Will withstand temporary connection directly across terminals of a fully-charged accumulator.



A 85-326.

Movement	Moving Coil.
For use on	D.C. only.
Accuracy	First Grade, B.S. 89-1937 as current indicator.
Case	$4\frac{3}{8} \times 3\frac{1}{4}$ in. approx.
Scale Length	$2\frac{5}{8}$ in.
Scale Divisions	Linear or Double Logarithmic Type.
Damping	Inductive.
Period	Less than 1 sec.
Shielding	Complies with B.S. 89-1937 unshielded.
Momentary Overload Capacity	3000%.
Special Features	The 2–0–2 mA. 50 ohm linear scale instrument **A 85-325**, with a self-contained range of 2–0–2 amps. and a self-contained range of either 2–0–2, 4–0–4, 8–0–8 or 20–0–20 volts is recommended for the less advanced bench work on D.C.

MILLIAMMETERS (Galvanometers), as described above, with two terminals.

Range	2–0–2	1–0–1	0·5–0–0·5	*mA.*
	80–0–80	80–0–80	200–0–200	*mV.*
Resistance	40	80	400	*ohms*
A 85-310. Linear scale	*tx* **£3 16 2**	**£3 16 2**	**£3 16 2**	*each*
A 85-315. Non-linear scale	*tx* **£3 16 2**	**£3 16 2**	**£3 16 2**	*each*

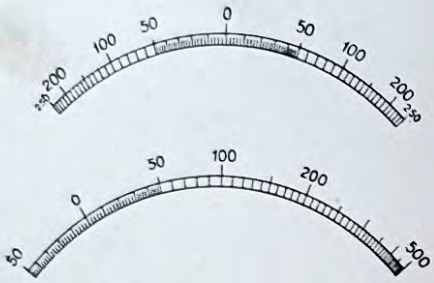
MILLIAMMETERS (Galvanometers) with self-contained current and voltage ranges, with 4 terminals:—

Cat. No.	Ranges				Price
	Current	Scale	Volts		£ s. d.
A 85-320	2–0–2 mA. (40 ohms)	Linear	4–0–4 (2000 ohms)	20–0–20 (10,000 ohms)	*tx* 4 4 5
A 85-322	2–0–2 mA. (40 ohms)	Non-linear	4–0–4 (2000 ohms)	20–0–20 (10,000 ohms)	4 4 5
A 85-324	1–0–3 mA. (40 ohms)	Linear Displaced Zero	2–0–6 (2000 ohms)	5–0–15 (5000 ohms)	4 4 5
A 85-326	2–0–2 mA. (50 ohms) 2–0–2 a. (0·2 ohms)	Linear	4–0–4* (2000 ohms) * Can be supplied with alternative voltage range of :—2–0–2, 8–0–8, or 20–0–20 to special order. *No extra charge.*		4 7 1

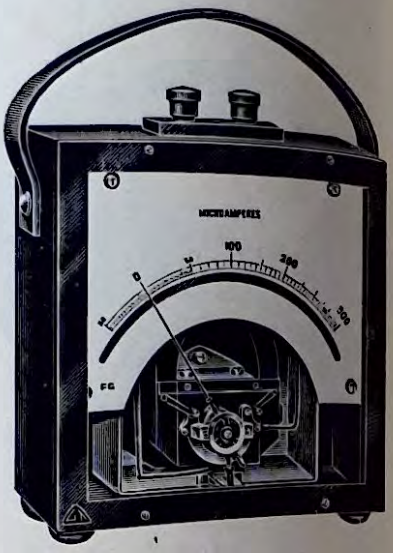
Base, desk pattern, moulded resilient rubber, for above instruments. Provides a convenient angle for reading, avoids errors due to parallax and reduces risk of mechanical damage to instruments .. .. *see* **A 85-250.**



A 85-350—352.



Typical scales.



A 85-355—357.

MICROAMMETERS (Galvanometers), calibrated for direct readings in microamps. and milliamps., balanced for use in any position, external zero adjuster. Fitted with knife-edge pointers but can be fitted with spade-ended pointers for demonstration purposes, if so ordered, at the same prices. Instruments having a resistance greater than 40 ohms are not damaged by temporary connection across the terminals of a 2-volt cell. Full details of ranges and resistances are marked on the dial.

The standard instrument is arranged, as illustrated, with a centre zero, but **side or displaced zero** (see illustration and reproduced scales above) can be incorporated, if specified, at the time of ordering, **without extra charge.** In this case the range must be equal to the sum of the positive and negative maximum readings of the central zero instrument having the same resistance, *i.e.* a 2–0–2 mA. 40 ohm instrument can be calibrated for use as a 0–4 or a 1–0–3 mA. instrument.

Movement	Moving Coil.
For use on	D.C. only.
Accuracy	First Grade, B.S. 89—1937 as Current Indicators.
Case	Projecting Type, 8 in. and 9½ in. diam. approx. Portable Type, 8½ × 8½ in. approx.
Range	See Table below.
Scale Divisions	Linear or Double Logarithmic Type.
Damping	Inductive.
Period	Less than 2 secs.
Shielding	Projecting Type :—cast-iron case. Portable Type :—internal soft-iron box.
Momentary Overload Capacity	Varies from 1000–3000 %.

MICROAMMETERS (Galvanometers), projecting type case, for wall or batten mounting, with front terminals. (*State range required. See table below.*)

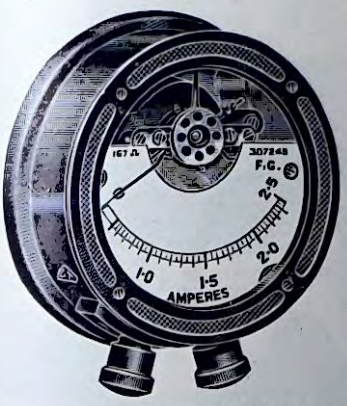
Scale length	6	8	*in.*
A 85-350. Resistance, 2, 5, 20 or 40 ohms ..	*tx* £6 14 9	£7 10 6	*each*
A 85-352. Ditto, 200 or 2000 ohms ..	*tx* £6 16 6	£7 12 3	*each*

MICROAMMETERS (Galvanometers), portable type, in built-up insulating material cases, with carrying strap, scale length 8 in., knife-edge pointer, anti-parallax mirror, terminals on top of case, rubber feet for vertical and horizontal positions. (*State range required. See table below.*)

	£	s.	d
A 85-355. Resistance, 2, 5, 20 or 40 ohms	*each tx* 10	12	8
A 85-357. Ditto, 200 or 2000 ohms	*each tx* 10	14	5

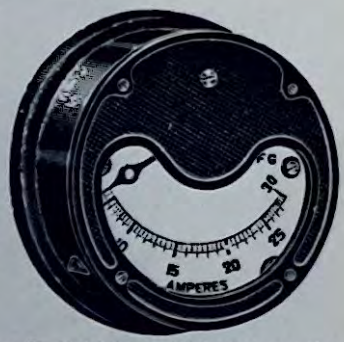
SENSITIVITY DATA FOR A 85-350—355

Figured	Scale Divisions	Resistance of Movement Ohms	Milliamps	Approx. Millivolts	1 Scale Division Deflection per	
					Microamps	Microvolts
15–0–15	75–0–75	2	15–0–15	30–0–30	200	400
10–0–10	50–0–50	5	10–0–10	50–0–50	200	1000
5–0–5	50–0–50	20	5–0–5	100–0–100	100	2000
2–0–2	40–0–40 or 80–0–80	40	2–0–2	80–0–80	50	2000
1000–0–1000	50–0–50	40	2–0–2	80–0–80	25	1000
250–0–250	50–0–50	200	1–0–1	200–0–200	20	4000
		2000	0·25–0–0·25	500–0–500	5	10000



Type A—Glass front with front terminals.
A 85-370.

AMMETERS AND VOLTMETERS, in projecting cast-iron cases, for switchboard or batten mounting, semi-matt black finish; in two types. **Type A,** all glass front (to display movement to students), with front terminals. **Type B,** metal front with back connections. Spring controlled for use in any position, fitted with Mumetal irons and jewelled bearings. Figures of ranges are given as zero to maximum, but the first scale marking is at one-fifth of full scale value. Intermediate ranges supplied at the price of next higher range. Please state actual range required when ordering.



Type B—Metal front with back connections.
A 85-380.

	Moving Iron.	Moving Coil.
Movements	**Moving Iron.**	**Moving Coil.**
For use on	D.C. and A.C.	D.C. only.
Accuracy	First Grade, B.S. 89-1937.	First Grade, B.S. 89-1937.
Resistance	80 volts—1000 ohms. 160 volts—3500 ohms. 260 volts—8500 ohms.	200 ohms/volt at full scale marking, *i.e.* 5 milliamps max. load imposed on circuit.
Case diam.	$4\frac{5}{8}$ in.	$4\frac{5}{8}$ in.
Scale length	$3\frac{1}{2}$ in.	$3\frac{1}{2}$ in.
Scale divisions	Non-linear.	Linear.
Damping	Pneumatic.	Inductive.
Period	2 sec. approx.	Less than 2 sec.
Shielding	Cast-iron case.	Cast-iron case.
Momentary Overload Capacity	1000%.	1000%.

Ammeters, Moving Iron.

Range o to ..	0·5	1	3	5	*amps.*
A 85-370. Type A *tx*	£2 5 6	£2 5 6	£2 5 6	£2 5 6	*each*
A 85-372. Type B *tx*	£2 0 8	£2 0 8	£2 0 8	£2 0 8	*each*

Range o to	10	20	50	100	*amps.*
A 85-370. Type A *tx*	£2 5 6	£2 5 6	—	—	*each*
A 85-372. Type B *tx*	£2 0 8	£2 0 8	£2 0 8	£2 0 8	*each*

Voltmeters, Moving Iron.

Range o to	80	160	260	*volts*
A 85-374. Type A .. .. .. *tx*	£3 3 0	£3 3 0	£3 3 10	*each*
A 85-376. Type B .. .. .. *tx*	£2 15 2	£2 18 3	£2 19 0	*each*

Ammeters, Moving Coil.

Range o to	1	3	5	10	20	30	*amps.*
A 85-378. Type A *tx*	£4 1 5	£4 1 5	£4 1 5	£4 1 5	£4 1 5	£4 5 0	*each*
A 85-380. Type B *tx*	£3 16 7	£3 16 7	£3 16 7	£3 16 7	£3 16 7	£4 0 2	*each*

Voltmeters, Moving Coil.

Range o to	75 *mV.*	1	3	5	10	20	*volts*
A 85-382. Type A *tx*	£3 17 11	£4 3 2	£4 3 2	£4 3 2	£4 3 2	£4 3 2	*each*
A 85-384. Type B *tx*	£3 13 2	£3 18 5	£3 18 5	£3 18 5	£3 18 5	£3 18 5	*each*

Range o to	50	120	150	200	260	300	*volts*
A 85-382. Type A *tx*	£4 3 2	£4 4 11	£4 4 11	£4 6 7	£4 6 7	£4 6 7	*each*
A 85-384. Type B *tx*	£3 18 5	£4 0 2	£4 0 2	£4 1 10	£4 1 10	£4 1 10	*each*



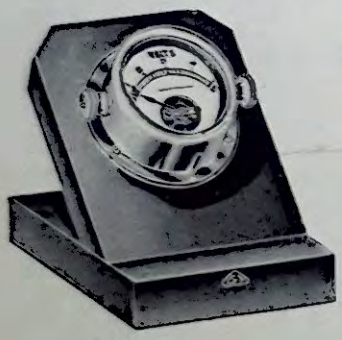
A 85-450.



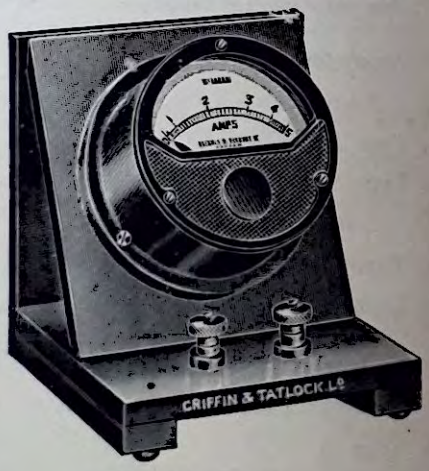
A 85-460.

A 85-450. VOLTMETER, Electrostatic, Low Range, 0-150 volts, for D.C. and A.C. 3½ in. diam., on base 5 in. diam. The scale reads in 5 volt divisions from 20 volts to its maximum at 150 volts. Magnetically damped. Capacitance at 150 volts, 100 $\mu\mu$F. The instrument is spring mounted on the base, to protect it from shock, and should be mounted horizontally *tx* 14 17 6

A 85-460. VOLTMETER, Electrostatic, for D.C. and A.C. In moulded case 2½ in. diam., projecting pattern, range 50 to 300 volts, capacitance at full scale 55 $\mu\mu$F . . . . . *tx* 8 13 3



A 85-500.



A 85-510—514.

A 85-500. STANDS, Bench, suitable for mounting 2½ in. diam., switchboard type ammeters and voltmeters. Polished wood base 4 × 6 in., with inclined panel 4¾ × 4 in. wide.
each 5/- ; *dozen* 2 14 0

STANDS, Bench, for ammeters, voltmeters, etc. Oiled wood panel with base, extra heavy terminals and rubber feet.

For laboratory bench use of ammeters, voltmeters and similar measuring instruments, this type of mounting is the most convenient. Parallactic errors can be eliminated without fatigue, the instrument is stable and the rubber feet prevent slipping.

A 85-510. Stand, with panel 5 in square, suitable for instruments up to 4½ in. flange diam. 0 10 6

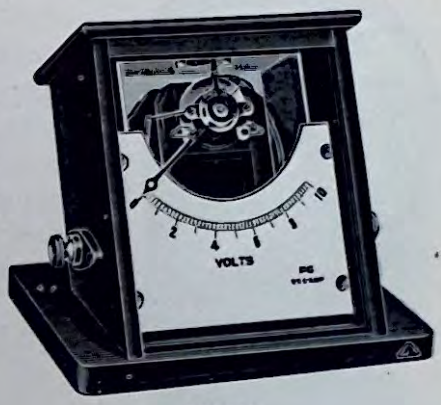
A 85-512. Ditto, with panel 7 in. square, suitable for instruments up to 6½ in. flange diam. 0 12 6

A 85-514. Ditto, with panel 10 in. square, suitable for instruments up to 9½ in. flange diam. 0 15 0



A 85-550.

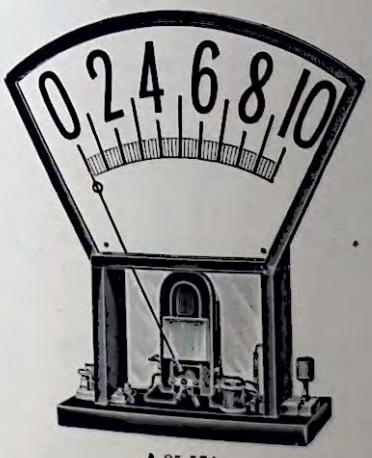
METERS, Inclined, Bench Type. Designed specially for educational laboratory use, mounted in 60° inclined oak cases, facilitating the taking of readings and reducing parallax error. Spring controlled movements, balanced for use in any position, provided with external zero adjuster. The movements are fully in view for demonstration.



A 85-554.

	Moving Iron.	Moving Coil.
Movements	Moving Iron.	Moving Coil.
For use on	D.C. and A.C.	D.C. only.
Accuracy	First Grade, B.S. 89-1937.	First Grade, B.S. 89-1937.
Resistance	—	66·6 ohms/volt.
Case, dimensions	Height 6 in., base 7½ × 5½ in.	Ditto.
Scale length	4 in.	4 in.
Scale divisions	Linear from one-fifth upwards to max. reading.	Linear.
Damping	Pneumatic.	Inductive.
Period	2 secs. approx.	2 secs. approx.
Shielding	Int. soft-iron box.	Int. soft-iron box.
Momentary Overload Capacity	1000%.	1000%.

Range	0–1	0–3	0–5	0–10	0–20
A 85-550. **Ammeters**, moving-iron *tx*	£3 16 2	£3 16 2	£3 16 2	£3 16 2	£4 4 0 *each*
A 85-552. **Ammeters**, moving coil *tx*	£5 15 6	£5 15 6	£5 15 6	£5 15 6	£5 19 11 *each*
A 85-554. **Voltmeters**, moving coil *tx*	£5 15 6	£5 15 6	£5 15 6	£5 15 6	£5 19 11 *each*

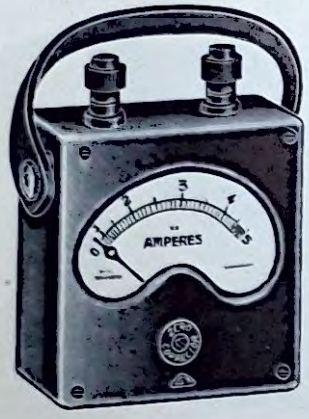


A 85-574.

AMMETERS AND VOLTMETERS, Lecture Pattern, movement enclosed in glass case and fully exposed, with jewelled bearings, hardened steel pivots, girder type spade-ended pointer. Scale boldly divided and figured, can be read at a distance of 40 ft.

Movements	Moving Iron for use on D.C. and A.C. Moving Coil for use on D.C. only.
Accuracy	± 1 per cent.
Case	17 in. high overall.
Scale length	11 in.
Damping	Moving Iron, pneumatic. Moving Coil, inductive.
Resistance (Moving Iron Voltmeters)	20 ohms/volt.

	Moving Iron £ s. d.	Moving Coil £ s. d.
A 85-570. **Ammeter**, two-range, 3 amps. and 30 amps.	7 17 6	9 0 0
A 85-572. **Voltmeter**, two-range, 3 volts and 30 volts	7 17 6	9 0 0
A 85-574. **Ammeter and Voltmeter combined**, range 10 volts and 10 amps.	—	11 5 0
A 85-576. Ditto, range 20 volts and 20 amps.	—	11 9 0



A 85-610—612.

AMMETERS AND VOLTMETERS, Portable, in black Bakelite case with terminals, leather strap handle, rubber feet, external zero adjuster. Robust construction. In two sizes: 3 and 6 in. scales, with moving iron or moving coil movements.



A 85-628—630.

	Moving Iron.		Moving Coil.	
Movement	D.C. and A.C.		D.C. only.	
For use on	First Grade B.S. 89—1937.		First Grade B.S. 89—1937.	
Accuracy	3 in.	6 in.	3 in.	6 in.
Scale length	$4\frac{1}{4} \times 4\frac{1}{4} \times 2$ in.	$7\frac{1}{2} \times 7 \times 2\frac{3}{4}$ in.	$4\frac{1}{4} \times 4\frac{1}{4} \times 2$ in.	$7\frac{1}{2} \times 7 \times 2\frac{3}{4}$ in.
Case				
Resistance (Voltmeters)	See below.		200 ohms/volt.	
Scale Divisions	Non-linear.		Linear.	
Damping	Pneumatic.		Magnetic.	
Period	3 secs.		1 sec.	
Shielding	Nil.		Nil.	
Momentary Overload Capacity	100%.		100%.	

Ammeters, Moving Iron.

Range 0 to ..	5	10	15	20	25	30	*amps.*
A 85-610. Scale 3 in.	£2 8 0	£2 8 0	£2 8 0	£2 8 0	£2 8 0	£2 8 0	*each*
A 85-612. Scale 6 in.	£5 5 0	£5 5 0	£5 5 0	£5 5 0	£5 5 0	£5 5 0	*each*

Voltmeters, Moving Iron. (*State frequency when ordering if for A.C.*)

Range 0 to ..	5	10	15	20	*volts.*
Resistance approx.	16	82	125	220	*ohms*
A 85-616. Scale 3 in.	£2 9 0	£2 9 0	£2 9 0	£2 9 0	*each*
A 85-618. Scale 6 in.	£5 5 0	£5 5 0	£5 5 0	£5 5 0	*each*

Range 0 to ..	50	120	200	250	*volts*
Resistance approx.	1000	4800	8000	10000	*ohms*
A 85-616. Scale 3 in.	£2 9 0	£2 10 0	£2 12 6	£2 12 6	*each*
A 85-618. Scale 6 in.	£5 5 0	£5 15 0	£6 0 0	£6 5 0	*each*

Ammeters, Moving Coil.

Range 0 to ..	5	10	15	20	25	30	*amps.*
A 85-622. Scale 3 in.	£3 17 6	£3 17 6	£3 17 6	£3 17 6	£3 17 6	£3 17 6	*each*
A 85-624. Scale 6 in.	£8 10 0	£8 10 0	£8 10 0	£8 15 0	£8 15 0	£8 15 0	*each*

Voltmeters, Moving Coil.

Range 0 to ..	5	10	15	20	*volts*
A 85-628. Scale 3 in.	£3 16 0	£3 16 0	£3 16 0	£3 16 0	*each*
A 85-630. Scale 6 in.	£9 0 0	£9 0 0	£9 0 0	£9 0 0	*each*

Range 0 to ..	50	120	200	250	*volts*
A 85-628. Scale 3 in.	£3 16 0	£3 17 6	£4 0 0	£4 0 0	*each*
A 85-630. Scale 6 in.	£9 0 0	£9 0 0	£9 10 0	£9 10 0	*each*



A 85-650—652.
Educational pattern.

AMMETERS AND VOLTMETERS, Portable, in square cases constructed from high quality insulating material, with terminals on top, rubber feet and carrying strap. Available with either protecting front or educational pattern with all-glass front. (*We supply educational pattern unless otherwise ordered.*) White enamelled dial, anti-parallax mirror, knife-edge pointer. Spring controlled movement fitted with Mumetal " irons " for use in any position. Ranges are listed as zero to maximum, but the first scale marking is always at 0·1 of full scale value in the moving iron type.



A 85-660—664.
With protecting front.

	Moving Iron.	Moving Coil.
Movement		
For use on	D.C. and A.C. 25 to 100~.	D.C. only.
Accuracy	First Grade, B.S. 89-1937.	First Grade, B.S. 89-1937.
Resistance (Voltmeters)	0–120 v. 1666 ohms. 0–260 v. 5200 ohms. 0–500 v. 15,600 ohms.	Normally 66·6 ohms/volt at top figure. May be 200 ohms/volt or 500 ohms/volt, to special order without additional cost.
Case	8½ × 8½ in.	8½ × 8½ in.
Scale length	8 in.	8 in.
Scale Divisions	Approx. linear down to one-fifth of top value, markings down to one-tenth.	Linear.
Damping	Pneumatic.	Inductive.
Period	2 secs. approx.	2 secs. approx.
Shielding	Internal soft iron box.	Internal soft iron box.
Momentary Overload Capacity	1000%.	1000%.

A 85-650. Ammeters, Moving Iron.

Range o to ..	0·5	1	3	5	*amps.*
tx	£7 19 3	£7 19 3	£7 19 3	£7 19 3	*each*

Range o to ..	10	20	50	100	*amps.*
tx	£7 19 3	£7 19 3	£7 19 3	£8 12 5	*each*

A 85-652. Voltmeters, Moving Iron.

Range o to	120	260	500	*volts*
tx	£8 12 5	£9 10 9	£10 10 0	*each*

A 85-660. Milliammeters, Moving Coil.

Range o to	1	10	100	500	*m.A.*
tx	£10 12 8	£10 12 8	£10 12 8	£10 12 8	*each*

A85-662. Ammeters, Moving Coil.

Range o to	1	5	10	20	30	50	*amps.*
tx	£10 12 8	£10 12 8	£10 12 8	£10 12 8	£10 12 8	£10 12 8	*each*

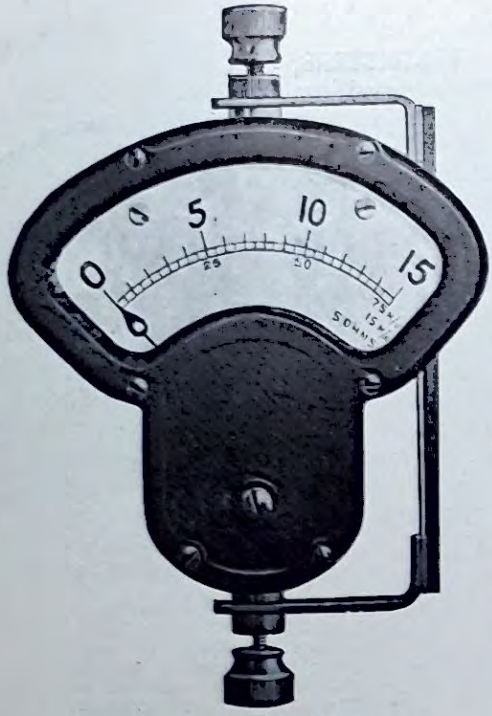
A 85-664. Voltmeters, Moving Coil.

Range o to	10	50	120	160	260	400	*volts*
tx	£10 2 2	£10 2 2	£10 15 3	£10 15 3	£11 17 2	£12 6 9	*each*

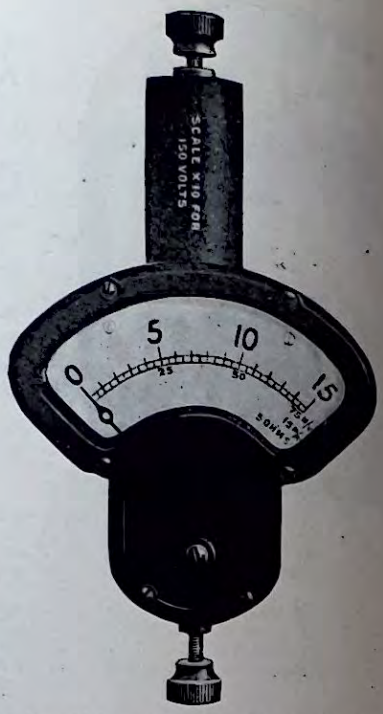
A 85-668. Voltmeters, Moving Coil, as **A 85-664,** but with two self-contained ranges, the lower being 0–75 millivolts. (*Please state additional range required.*)

Higher range	0–50	0–150	0–300	*volts*
	£11 7 6	£12 0 8	£13 2 6	*each*

A 85-670. Voltmeter, Moving Coil, as **A 85-664** with internal resistance and four terminals for ranges 0–150, 0–300, and 0–600 volts (150 scale divisions) .. ..*tx* £ 15 17 s. 8 d.



As an Ammeter with Shunt Attachment A 89—690a.



A 85-690.

As a Voltmeter with Resistance Bobbin Attachment A 89—690b.

A 85-690. "ALLTEST" INSTRUMENT. A portable pocket instrument which may be used as a milliammeter, millivoltmeter, ammeter, voltmeter, resistance indicator, etc., and, by means of the shunts and bobbin resistances listed below, has an almost unlimited range. External zero adjuster. With instructions for use .. .. *tx* 4 14 6

Movement	Moving Coil.
For use on	D.C. only.
Range (instrument alone)	15 mA., 75 mV. (5 ohms).
Accuracy	First Grade, B.S. 89-1937.
Resistance	Minimum resistance 66·6 ohms at top of scale, ohms/volt increasing as deflection decreases.
Case	4 × 3¼ in. (weight approx. 12 oz.).
Scale length	2⅝ in.
Scale Divisions	Linear.
Damping	Inductive.
Period	1 sec. approx.
Shielding	Complies with B.S. Specn. unshielded.
Momentary Overload Capacity ..	1000%.

As a **Milliammeter**, the range without external shunts is 0–15 milliamps. With standard shunts, range may be made 0–150 or 0–1500 milliamps.

As a **Millivoltmeter**, the range is 0–75 millivolts. With bobbin resistances, range may be made 0–150 or 0–1500 millivolts.

As an **Ammeter**, standard shunt attachments give ranges 0–1·5, 0–3, 0–6, 0–15 and 0–30 amps.

As a **Voltmeter**, the standard bobbin resistances give ranges of 0–1·5, 0–3, 0–6, 0–15, 0–30, 0–75 and 0–150 volts and any number of the bobbins may be connected in series, by means of screw and socket contacts provided, to cover any range.

Accessories for A 85-690

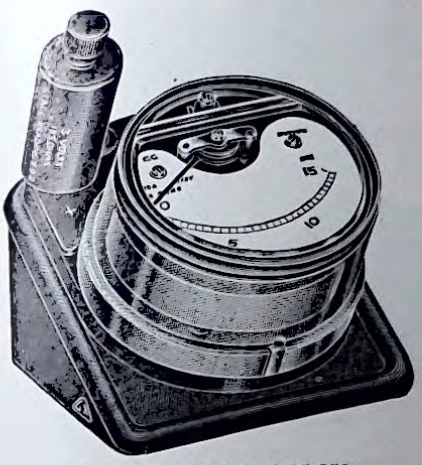
A 85-690. a Shunt Attachments, for direct attachment to "Alltest" instrument **A 85-690**, and for use with "Universal Indicators" **A 85-720—732**, by employing shunt carrier **A 85-736**.

Range 0 to ..	0·15	1·5	3	6	15	30 *amps.*
	tx 7/11	7/11	7/11	7/11	10/3	10/3 *each*

" " b. **Resistance Bobbin Attachments**, for direct attachment to both the "Alltest" instrument, **A 85-690**, and "Universal Indicators" **A 85-722—750**, for ranges of 0·15, 1·5, 3, 6, 15, 30, 75 or 150 volts. (Two 150 volt bobbins may be used in series for indications in 0–300 volt range) .. .. *each tx* 0 19 6

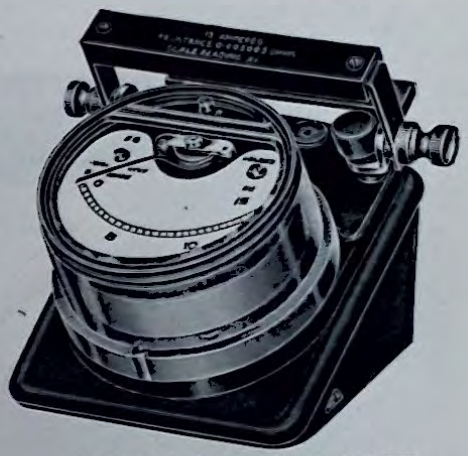
" " c. **Spike Terminal** to attach to bobbin resistance. With insulated lead and spear for battery testing .. .. *tx* 0 7 0

" " d. **Case**, for "Alltest" instrument, **A 85-690**, with compartments for all listed accessories. With lock and key and adjustable carrying strap .. .. *tx* 1 0 1



A 85-720 + 690 b + A 85-250.

UNIVERSAL INDICATOR. Used in conjunction with the shunts and bobbins listed under the "Alltest" Instrument **A 85-690** (*see previous page*), this instrument has the same adaptability as the "Alltest" Instrument, but is primarily intended for bench work. The movement is the same as in the "Alltest" Instrument but mounted in a circular transparent moulded case with terminals. With instructions for use.



A 85-720 + 736 + 690 a + A 85-250.

Movement	Moving Coil.
For use on	D.C. only.
Range (instrument alone)	0–15 mA., 0–75 mV. (5 ohms).
Accuracy	First Grade, B.S. 89-1937.
Resistance	Minimum resistance 66·6 ohms at top of scale, ohms/volt increasing as deflection decreases.
Base	$4\frac{3}{8} \times 3\frac{1}{4}$ in.
Scale length	$2\frac{5}{8}$ in.
Scale Divisions	Linear.
Damping	Inductive
Period	1 sec. approx.
Shielding	Complies with B.S. Specn. unshielded.
Momentary Overload Capacity	1000%.

	£	s.	d.
A 85-720. UNIVERSAL INDICATOR, as described above .. .. *tx*	3	16	2

A 85-722. **Ditto**, but with displaced zero, scaled 3–0–15 for null work. (**Note.**—*If used as a Galvanometer, damage would result if accidentally connected across a fully charged accumulator.*) *tx* **3 16 2**

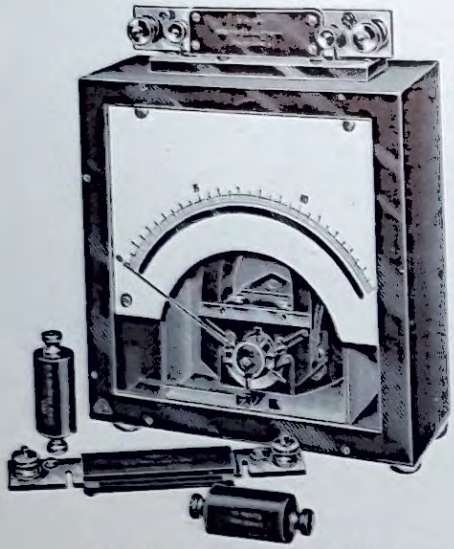
UNIVERSAL INDICATORS, as **A 85-720**, but with additional self-contained current and voltage ranges. (*Please state voltage ranges when ordering* **A 85-728—732.**)

Cat. No. ↓	Ranges			Price *tx*
	Current	Volts		£ s. d.
A 85-724	..	0–3 (200 ohms)	0–6 (400 ohms)	4 4 6
A 85-726	..	0–3 (200 ohms)	0–15 (1000 ohms)	4 4 6
A 85-728	..	With any two of the following ranges :— 150 mV., 1·5, 3, 6, 15, 30, 60 or 75 v.		4 4 6
A 85-732	0–3 amp. (0·075 ohms)	With any one of the following ranges :— 1·5, 3, 6, 15, 30 v.		4 7 1

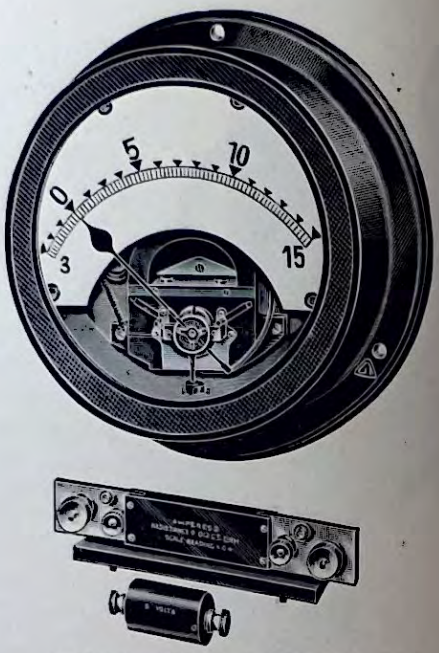
Accessories for A 85-720—732

A 85-736. **Shunt Carrier**, enabling "Alltest" pattern shunts **A 85-690 a** to be used with the above Universal Indicators, designed for correct sequence in coupling and uncoupling to prevent electrical damage to the instrument movement .. .. *tx* — £ s. d. **0 5 3**

Base, desk pattern, moulded resilient rubber, for above instruments. Provides a convenient angle for reading, avoids errors due to parallax and reduces risk of mechanical damage to instruments .. .. — see **A 85-250.**



A 85-760 + 785 a, b + A 85—690 b.



A 85-780 + 785 a, b + A 85—690 b.

UNIVERSAL INDICATORS. For all D.C. voltage and current measurements, using external shunts and resistances.

Movement	Moving Coil.
For use on	D.C. only.
Range	0–75 mV., 0–15 mA. self-contained, with multipliers for higher values.
Accuracy	First Grade, B.S. 89-1937.
Resistance (as a Voltmeter)	66·6 ohms at top figure on scale, increasing to infinity at zero. *If used as a voltmeter the "Universal Indicator" has a minimum resistance of 66·6 ohms/volt at full scale deflection,* i.e. *when indicating 15 volts on scale with a 15 volt bobbin in series. If with the same bobbin the indication is 3 volts, the resistance will be 333·3 ohms/volt.*
Case	8 × 8 × 3 in.
Scale Divisions	Linear.
Damping	Inductive.
Period	Less than 2 secs.
Shielding	Internal soft-iron box.
Momentary Overload Capacity	1000% with or without multipliers.
Special Feature	These instruments are suitable for use as indicators for class demonstrations, for induction and for thermo-couple experiments.

A 85-760. Universal Indicator, 8 in. scale, in case with glazed front, permitting inspection of the movement. Knife-edge pointer, anti-parallax mirror. Auxiliary terminals for potential leads (0·05 ohm) for use when shunts are not directly attached to the instrument .. .. *tx* £9 15 2

UNIVERSAL INDICATORS, as **A 85-760,** but in round, cast-iron, flange type cases, with knife-edge pointer, front terminals or back screw connections as required.

Length of scale	3½	6	8	*in.*
No. of divisions on scale	30	75	150	
A 85-765. Front terminals .. .. *tx*	£3 17 11	£6 13 0	£7 8 9	*each*
A 85-770. Back connections .. .. *tx*	£3 13 2	£6 6 11	£7 2 8	*each*

A 85-775. Universal Indicator, Demonstration, as **A 85-765,** with scale 8 in. long, fully glazed front, spade pointer, extra large and bold figures with wedge-shaped divisions. Readings visible at a distance of 30 ft. With pair of potential leads for connecting instrument to batten-mounted shunt carrier .. .. *tx* £7 8 9

A 85-780. Ditto, as **A 85-770,** but with displaced zero, calibrated 3-0-15 .. .. .. *tx* £7 8 9

Accessories for A 85-760—780

	£ s. d.
A 85-785 a. Shunts for above, slotted and provided with terminals. Increasing range of instrument to 0·15, 1·5, 3, 6, 15, 30, 60 amps .. .. *each tx* 0 17 6	
" " b. **Shunt Carrier,** as fitted to top of **A 85-760,** for fixing to carrying batten, to take shunts **A 85-785 a** .. .. *tx* 0 14 11	
Resistances, bobbin type, for use with **A 85-760—780.** Increasing range of instrument to 0·15, 1·5, 3, 6, 15, 30, 75, 150 volts (two 150 volt bobbins may be used in series for indications in 300 volt range) .. ..



A 85-840.



A 85-850.



A 85-860.

A 85-840. AVOMINOR D.C. TEST SET. A self-contained 2½ in. moving coil combination **for D.C. only**, for readings of current, voltage and resistance. It provides ranges of readings sufficient for extensive electrical measuring. Each instrument is provided with interchangeable crocodile clips and insulated testing prods, complete in case .. .. .. *tx* £4 4 0

The ranges of the instrument are:—

Current	0–6, 0–30, 0–120 milliamps.
Voltage	0–6, 0–12, 0–120, 0–240, 0–300, 0–600 volts.
Resistance	0–10,000, 0–60,000, 0–1,200,000 ohms, 0–3 megohms.

No external shunts or multipliers are required and the likelihood of incorrect readings due to faulty shunt contact are eliminated. The Avominor is a precision testing instrument at a low price.

A 85-850. AVOMINOR UNIVERSAL TEST SET. A small moving coil instrument **for A.C. and D.C.**, with 22 self-contained ranges of millivolts, volts, and ohms. Scale 3 in. long, marked 0–50 for current and voltage readings and 0–20,000 ohms. Total resistance 200,000 ohms. Full scale deflection of 500 volts takes 2·5 milliamps. Adjustment for variation of testing voltage on all resistance ranges. In Bakelite case mounted on rubber feet, leads, crocodile clips and test prods contained in compartment in back. *Ranges see table below* .. *tx* 8 10 0

Ranges of the Avominor Universal Test Set A 85-850

D.C. VOLTS	D.C. MILLIAMPS	A.C. VOLTS	RESISTANCE
0– 75 millivolts	0– 2·5 milliamps	0– 5 volts	0– 20,000 ohms
0– 5 volts	0– 5 ,,	0– 25 ,,	0–100,000 ,,
0– 25 ,,	0– 25 ,,	0–100 ,,	0–300,000 ,,
0–100 ,,	0–100 ,,	0–250 ,,	0– 2 megohms
0–250 ,,	0–500 ,,	0–500 ,,	0– 5 ,,
0–500 ,,			0–10 ,,

A 85-860. AVOMETER, Universal Model—40. A portable 40-range **D.C. and A.C.** measuring instrument, giving readings of current, voltage and resistance over wide ranges, self-contained, no external shunts, multipliers or transformers being required, designed for simplicity of operation and reading. With 40 ranges each approx. 5 in. scale length Accuracy of calibration to B.S. 89—1937 for 1st grade instruments .. .. .. *tx* 17 10 0

Ranges of the Avometer, Universal Model—40, A 85-860

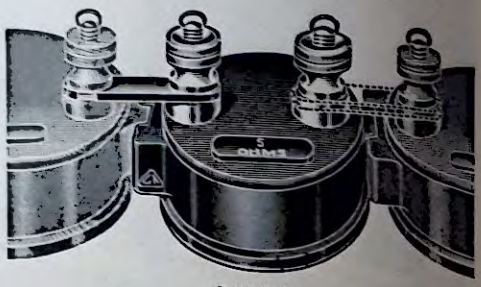
D.C. CURRENT		D.C. VOLTAGE		A.C. CURRENT		A.C. VOLTAGE	
Range	Value per division.	Range	Value per division	Range	Value per division	Range	Value per division
0– 6 mA	50 µA	0– 60 mV	0·5 mV	0– 6 mA	50 µA	0– 6 Volts	50 mV
0– 12 ,,	100 ,,	0– 120 ,,	1 ,,	0– 12 ,,	100 ,,	0– 12 ,,	100 ,,
0– 60 ,,	500 ,,	0– 600 ,,	5 ,,	0– 60 ,,	500 ,,	0– 60 ,,	500 ,,
0–120 ,,	1 mA	0– 1·2 volts	10 ,,	0–120 ,,	1 mA	0– 120 ,,	1 volt
0–600 ,,	5 ,,	0– 6 ,,	50 ,,	0–600 ,,	5 ,,	0– 240 ,,	2 ,,
0– 1·2 amp.	10 ,,	0– 12 ,,	100 ,,	0– 1·2 amp.	10 ,,	0– 480 ,,	5 ,,
0– 6 ,,	50 ,,	0– 60 ,,	500 ,,	0– 6 ,,	50 ,,	0– 600 ,,	5 ,,
0– 12 ,,	100 ,,	0– 120 ,,	1 volt	0– 12 ,,	100 ,,	0–1200 ,,	10 ,,
		0– 240 ,,	2 ,,				
		0– 480 ,,	5 ,,				
		0– 600 ,,	5 ,,				
		0–1200 ,,	10 ,,				

RESISTANCE

Range	First Indication		Indication Multiplier
0– 1,000 ohms ..	0·1 ohm	Using internal 1·5 volt Cell	1
0– 10,000 ,, ..	1·0 ,,		10
0–100,000 ,, ..	10·0 ,,	Using internal 9 volt Battery	100
0–1 megohm ..	100·0 ,,	Using external source of Voltage, A.C. or D.C. ..	1000

MICROID RESISTANCE UNITS

Interlocking Single Value Resistances for individual use and in building up resistance "boxes"



A 86-210

It is the experience of Science Masters that some students find difficulty in understanding that, with the normal type of resistance box, to put a resistance *in* circuit the plug is taken *out*. The view is that the construction of a resistance box is readily first made clear by the use of a number of single value resistances connected in series. With the conventional type of resistance, moulded in a Bakelite case for reasons of cheap large scale production and attractive appearance, the circular form does not enable a string of such resistances to be conveniently handled.

In these new Microid Resistance Units the circular design has been modified so that the resistances interlock. Robust, captive terminals are provided, one of which is fitted with a stout, non-removable, slotted copper lug. By this means, the function of a resistance box is made plain, an assembled line of resistances can be carried about in complete security, the burning out of one coil does not put the whole "box" out of commission, and for those with limited funds, the units can be economically purchased in small numbers, with the possibility of their dual use as single units and as variable resistance "boxes." No disadvantage to their use in the conventional manner results from the introduction of the lug and the interlocking features.

A 86-210. MICROID RESISTANCE UNITS, interlocking, in Bakelite cases, with robust terminals with captive heads, one terminal fitted with non-removable slotted copper lug. Bobbin non-inductively wound with double silk covered Eureka resistance wire, insulated and adjusted to 0·1 per cent.

Resistance ..	0·1	0·2	0·5	1	2	5	10	*ohms*
Max. current	0·8	0·7	0·6	0·5	0·4	0·26	0·16	*amp.*
p	10/6	10/6	10/6	10/6	10/6	10/6	10/6	*each*
Resistance ..	..	20	50	100	200	500	1000	*ohms*
Max. Current	..	0·12	0·06	0·05	0·044	0·018	0·016	*amp.*
p	10/6	11/6	11/6	12/6	12/6	12/6		*each*

A 86-220. RESISTANCE COILS, non-inductively wound, on wood bobbins with two terminals.



A 86-220—225.

Resistance	0·1	0·2	0·5	1	2	5	10	*ohms*
	4/-	4/-	4/-	4/-	4/-	4/-	5/-	*each*
Resistance ..	20	50	100	200	500	1000		*ohms*
	5/-	5/6	5/6	6/6	6/6	6/6		*each*

A 86-225. Ditto, Unknown Value, as **A 86-220,** without resistance marked on coil, but stated on slip sent with each coil.

Resistance	Low	Medium	High
Approx.	2	50	500 *ohms*
	4/6	6/-	7/6 *each*

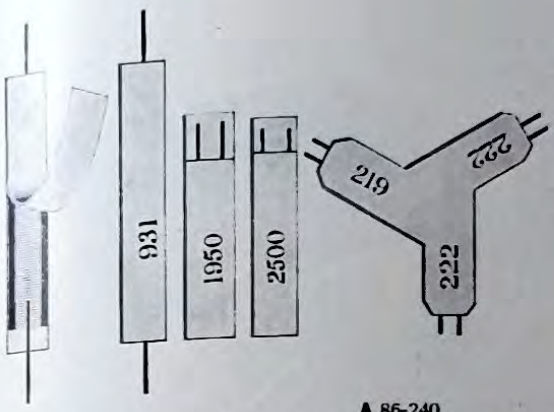


A 86-230 + 232

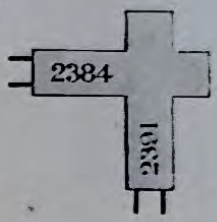
A 86-230. RESISTANCE COILS, non-inductively wound with double silk covered manganin wire, fitted in a brass case with ebonite top and double terminals, guaranteed correct to 0·05 per cent. **Without** copper poles.

Resistance ..	1	10	100	*ohms*
Max. Current ..	0·5	0·16	0·05	*amp.*
	£2 0 0	£2 0 0	£2 5 0	*each*
Resistance ..	1000	10,000	100,000	*ohms*
Max. Current ..	0·016	0·006	0·004	*amp.*
	£2 15 0	£3 5 0	£4 5 0	*each*

A 86-232. Copper Poles, Thick, for above .. .. *pair* £ s. d. 0 7 6

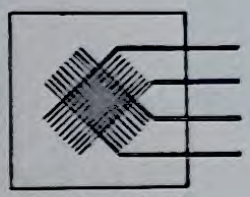


A 86-240

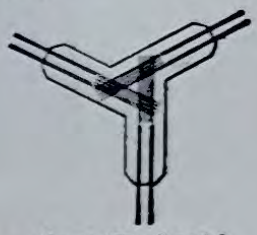




Gauge Nos. 1—6.



Gauge No. 7.



Gauge Nos. 8 and 9.

A 86-240. RESISTANCES, Electric, strain gauge, designed for use in measuring the strains in aircraft and engineering structures, through the change of electrical resistance induced by stress, but applicable also for general laboratory purposes. The gauges are inexpensive and moisture-proof resistances.

Gauge Number	Pattern	Gauge Width (mm.)	Gauge Length (mm.)	Approx. Resistance (ohms)	Prices £ s. d.
1	Single	4	12	120	0 3 0
2	Single	4	25	200	0 3 6
3	Single	4	25	400	0 3 6
4	Single	25	6	1000	0 3 6
5	Single	16	50	2000	0 3 6
6	Single	7	25	2500	0 3 6
7	90°	2 × 5	2 × 25	2 × 2500	0 7 0
8	Delta	3 × 4	3 × 25	3 × 400	0 8 6
9	Delta	3 × 4	3 × 25	3 × 200	0 8 6

These gauges, though developed primarily for use by the aircraft industry during the second World War, will be found to have many uses in the educational laboratory. As well as being generally useful in bridge work they will also serve to introduce the student to a phenomenon, hitherto but little dealt with in courses on electricity, viz. :—the change of electrical resistance of a conductor subjected to stress.

The gauges are made of eureka or nickel chrome wire 0·001 in. diam., wound with a very fine pitch on a circular mandrel covered with tissue paper. The "former" is withdrawn, flattened and then resin-bonded. Nickel-chromium leads are then spot welded to the winding, then served with other layers of tissue paper and finally again bonded. The resultant gauge is coated on one surface with an adhesive.

In measuring strain, the gauge is attached to the required point by dipping into acetone, shaking off the excess, and pressing it in position. It is then allowed to dry and attains full sensitivity in about 18 hours.

Resistance values for each batch of gauges are consistent to within ± 0·13 per cent. for resistances up to 800 ohms, and 0·10 per cent. for the higher values.

Sensitivity.—The change of resistance is not directly proportional to the change of length of the surface under strain. An increase or decrease in the length of the wire is accompanied by a decrease or increase respectively, in its cross-sectional area, so that the resistance, if estimated from dimensional aspects alone, would be subject to two simultaneous causes of variation of like sign. Thus if

L = unstrained length of gauge,
D = unstrained diameter of wire,
R = unstrained resistance,

$$\frac{R+\delta R}{R} = \left(\frac{L+\delta L}{L}\right)\left(\frac{D+\delta D}{D}\right)^2$$

since $\frac{\delta D}{D} = \rho\frac{\delta L}{L}$, ρ being Poisson's ratio, we have by substitution and simplification $\frac{\delta R}{R} = (1+2\rho)\frac{\delta L}{L}$. The quantity $(1+2\rho)$, which is the ratio of variation of resistance to strain, is termed the **sensitivity factor.** Theoretically this should be equal to 1·6 for eureka or nickel-chrome, but actually, the value generally lies between 2·00 and 2·25 depending on the type of gauge used, owing to the increase in specific resistance of the metal due to the stress.

Temperature characteristic.—Thermal compensation has to be made, which is effected by providing a "compensating" gauge, mounting it in exactly the same way as the test gauge, subjecting it to the same thermal influences, but keeping it free from strain. The two gauges are then so connected in a bridge circuit as to balance out thermal resistance variations. In the case of slow resistance change measurements, the two sources of heat affecting the reading are (1) the ambient temperature and self temperature of the surface on which the gauges are mounted, (2) the self-heating produced by the current through the gauge wire. Steady ambient and self temperatures are comparatively simple to obtain, but the self heating tends to vary owing to the slight initial inequality of the gauge resistances, and the additional inequality produced by the straining of the test gauge. Since the heating varies as the square of the current, this should be kept as low as possible. The maximum current for brief tests is 35 mA, and 5 mA for continuous tests, the gauge resistance being of the order of 2500 ohms.

The advantages of the electric strain gauge over visual-reading extensometers previously used have been summed up as follows (*Nature*, 1946, **158**, 4016) :—

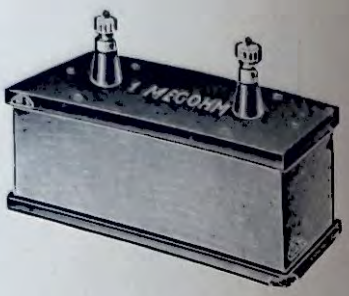
(1) very light and compact ;
(2) can be placed in almost any position ;
(3) requires no attention, once in position ;
(4) no mechanical adjustment necessary ;
(5) electrical recording lends itself to making a large number of readings in a short time (*e.g.* 500 in 2 hours) ;
(6) all readings can be taken at one central control point ;
(7) autographic recording can be adopted, and automatic switching devices can be used.
(8) can be left in position ready for repeat tests ;
(9) can be used for recording fluctuating stresses, and is practically free from inertia effects.
(10) three such gauges can be combined to compute the principal stresses without previously knowing their directions, owing to the short gauge length ;
(11) analysis of stresses in every part of a structure can be made if a sufficient number of gauges be used.

RESISTANCE





A 86-250.



A 86-255.

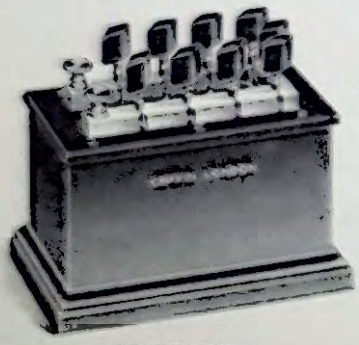
A 86-250. RESISTANCE COILS, Standard, non-inductively wound with carefully selected manganin wire and mounted in a nickel-plated brass box with perforated side and bottom for immersion in oil. Coils below 0·1 ohm are fitted with detachable sweating sockets for cable connection. Adjusted to an accuracy of ± 0·001 %.

Resistance ..	0·001	0·01	0·1	1	10	100	1000 ohms
Max. current	100	30	10	3	1	0·3	0·05 amps.
	£15 10 0	£15 0 0	£13 10 0	£13 0 0	£13 0 0	£13 10 0	£14 0 0 each

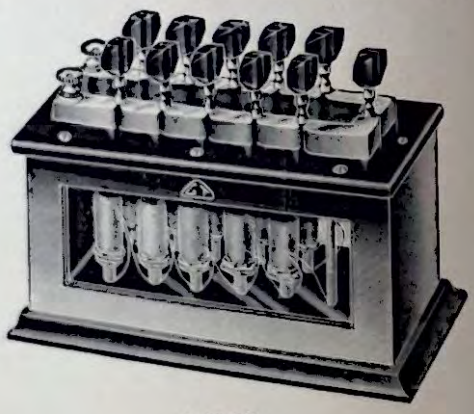
A 86-252. Ditto, N.P.L. Certified.

t £17 10 0 £16 13 4 £15 3 4 £14 13 4 £14 13 4 £15 3 4 £15 13 4 each

A 86-255. MEGOHM, single, in polished wood case with ebonite top and pillar type terminals, adjusted to an accuracy of 0·02 per cent. 1000 volts can be continuously applied .. *t* £ 14 0 0



A 86-270—278.



A 86-285.

RESISTANCE BOXES, Eureka, wound non-inductively, in polished wood boxes with ebonite top, brass blocks and moulded lozenge head plugs. Adjusted to the following limits of accuracy: 0·1 to 0·9 ohms ± 0·5 %, 1 ohm and higher values ± 0·1 %. **With C. & T. Certificate.**

	£	s.	d.
A 86-270. 4 Coils, 0·1, 0·2, 0·2, 0·5 ohm. **Total 1 ohm**	7	10	0
A 86-272. 4 Coils, 1, 2, 2, 5 ohms. **Total 10 ohms**	7	10	0
A 86-274. 8 Coils, 1, 2, 2, 5, 10, 20, 20, 50 ohms. **Total 110 ohms**	8	5	0
A 86-276. 12 Coils, 1, 2, 2, 5, 10, 20, 20, 50, 100, 200, 200, 500 ohms. **Total 1110 ohms** ..	10	10	0
A 86-278. 16 Coils, 1, 2, 2, 5, 10, 20, 20, 50, 100, 200, 200, 500, 1000, 2000, 2000, 5000 ohms. **Total 11,110 ohms**	11	0	0

CURRENT CARRYING CAPACITIES OF A 86-270—340

Resistance of coil	0·1	0·2	0·5	1	2	5	10	20 ohms
Max. current	0·8	0·7	0·6	0·5	0·4	0·26	0·16	0·12 amps.
Resistance of coil (in ratio arm) ..	50	100	200	500	1000	2000	5000	ohms
Max. current	0·08	0·05	0·04	0·03	0·02	0·02	0·013	amps.

The above figures apply to both Eureka and Manganin wound coils. A temperature rise of 2 to 3° C. is attained after 1 hour's continuous passage of current through not more than one coil at a time with the current values stated above. If more than one coil is in circuit the total current must not exceed that of the lowest current rated coil.

A 86-285. RESISTANCE BOX, Demonstration, Eureka, wound non-inductively, in polished wood box with ebonite top and Perspex sides, disclosing the coils and their connections. Brass blocks and moulded lozenge head plugs. 12 coils: 1, 2, 2, 5, 10, 20, 20, 50, 100, 200, 200, 500 ohms, total 1110 ohms. Adjusted to an overall accuracy of 0·1 per cent. Current carrying capacity, as **A 86-270—278. With C. & T. Certificate** 11 0 0

THE MICROID BAKELITE RESISTANCE BOX

A high-grade instrument at a moderate price

Regd. Design No. 772948.



A 86-295—297.

By employing the latest and most efficient methods of production we are able to offer at a low price a resistance box of pleasing appearance which embodies in its design several noteworthy and exclusive features.

SPECIFICATION

The case is of **Bakelite**, moulded in one piece enabling the unique properties of this material (lightness, strength, permanence, chemical immunity and high insulation resistance) to be utilised to the fullest extent.

The contact blocks, to which the coils are connected, are of ½ in. square section brass. During the process of manufacture, the blocks are embedded and keyed into the Bakelite top so securely that it is impossible to displace them, whatever pressure may be applied to the plugs. The upper faces of the contact blocks are flush with the Bakelite top, thus giving a smooth surface easily kept free from dust.

A special feature of the box is the introduction of **transverse slots** in the Bakelite between the end faces of the contact blocks. These slots increase the leakage path between the blocks and enable the high original standard of insulation resistance to be preserved.

The construction eliminates a source of trouble encountered with some of the ordinary types of resistance box. It will frequently be found that where a number of adjacent plugs have been wedged tightly home, the removal of an intermediate one loosens the remainder, owing to the ebonite top having sprung slightly under the unequal pressure and contact is, in the limit, reduced to a line. This cannot possibly occur with the Microid type. Further, due to this fact, the contact resistance remains very much more constant than in the type which has "elevated" contact blocks, since the whole of the surface of the tapered plug always remains in contact with the surface of the semi-cone on each side.

The tapered holes into which the plugs fit are taken right through the top of the box. This feature, in conjunction with a perforated metal cover which is screwed into a recess in the base, ensures that each coil shall be efficiently ventilated as it is brought into circuit. **The plugs** have lozenge heads, shaped to give a comfortable grip. Their distance apart has been adjusted so that it is possible to withdraw one plug without jamming the fingers between the adjacent plugs. **The coils**, 12 in number, are non-inductively wound on metal bobbins and impregnated with insulating varnish. Total resistance 1110 ohms. An infinity plug is also provided. The box is supplied with two grades of coils but the unique mechanical construction is the same in both cases. The current-carrying capacities of the coils are as stated on the previous page.

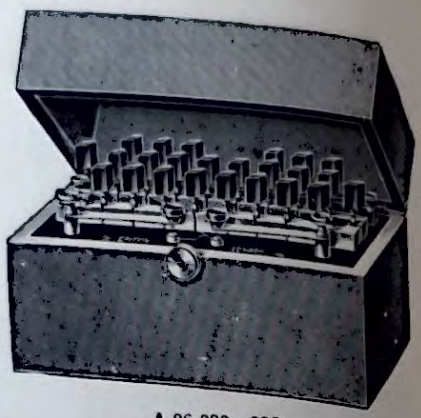
		£	s.	d.
A 86-295.	**MICROID BAKELITE RESISTANCE BOX**, 12 coils, having a total value of 1110 ohms, as above, wound with Eureka wire and adjusted to 0·2 per cent. accuracy	7	10	0
A 86-297.	Ditto, wound with Manganin and adjusted to 0·05 per cent. accuracy	8	5	0

•11

WHEATSTONE BRIDGES

Accuracy of adjustment

Nominal value of coil	Max. Error ± %	
	Eureka Coils	Manganin Coils
0·1 to 0·9 ohms	0·5	0·2
1 to 9 ohms	0·1	0·05
10 ohms and upwards	0·1	0·02
Ratio coils	0·05	0·01



A 86-320—326.

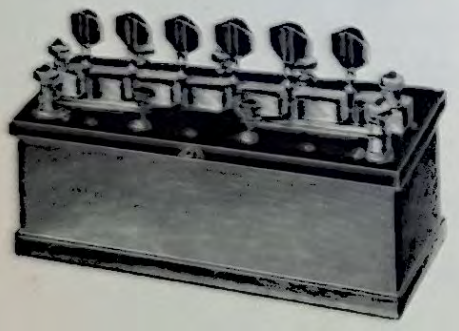
WHEATSTONE BRIDGES, Post Office Pattern, Eureka, non-inductively wound, plugs with moulded lozenge shape heads, tapping keys with platinum contacts, in teak case with carrying handle. Adjusted to an accuracy shown in table at head. **Each with G. & T. certificate.**

A 86-320. 8 Coils, 1, 2, 2, 5, 10, 20, 20, 50 ohms. **Total 110 ohms.** Ratio arm coils, 10 and 100 ohms .. .. £ 11 0 0

A 86-322. 12 Coils, 1, 2, 2, 5, 10, 20, 20, 50, 100, 200, 200, 500 ohms. **Total 1110 ohms.** Ratio arm coils, 10, 100 and 1000 ohms .. .. £ 13 10 0

A 86-324. 16 Coils, 1, 2, 2, 5, 10, 20, 20, 50, 100, 200, 200, 500, 1000, 2000, 2000, 5000 ohms. **Total 11,110 ohms.** Ratio arm coils, 10, 100 and 1000 ohms .. .. £ 14 10 0

A 86-326. WHEATSTONE BRIDGE, Post Office Pattern, Manganin. General construction as **A 86-324,** but with manganin wire coils on brass bobbins. Manganin wire thoroughly aged before final adjustment to an accuracy shown in table at head. **With G. & T. certificate** .. .. £ 22 10 0



A 86-340.

A 86-340. RATIO ARM BOX, for use with any resistance box, converting it into a Wheatstone Bridge, Post Office Pattern. Six Eureka coils, wound non-inductively: 10, 10, 100, 100, 1000, 1000 ohms, with brass blocks and lozenge head plugs, two contact keys and terminals. In polished teak box with ebonite top. Coils adjusted to 0·1 per cent., current carrying capacity as for **A 86-270—340. With G. & T. certificate** .. .. £ 7 10 0

DECADE RESISTANCE BOXES, Cambridge, coils wound with wire of low temperature coefficient and arranged in decades. Each set is on an independent fitting and contact is made by means of a laminated brush switch; contact position is defined by a ball-click, and the coil values are shown by a pointer moving over a dial; the current rating per dial is marked. Working parts are entirely enclosed. Coils adjusted to an accuracy of 0·1 per cent.



A 86-360—370.

Cat. No.	No. of Dials or Sections	Resistance value (ohms) Total	Max. Loading		Price
			Dial	Amps.	£ s. d.
A 86-360	5	111	×		2A 8 18 3
A 86-362		1,110	0·10	2·5	8 18 3
A 86-364	4	1,111	1·002	0·35	10 18 6
A 86-366		11,110	100	0·25	18 18 6
A 86-368	5	11,111	1000	0·075	15 18 6
A 86-370		111,110	1000	0·125	15 18 6
A 86-372	6	111,111	10,000	0·05	20 16 9



A 86-390—392.

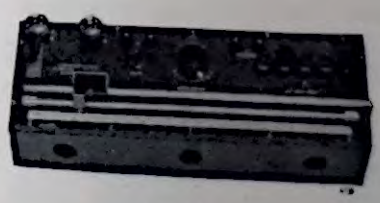


A 86-400.

A 86-390. **BRIDGE, decade resistance, self-contained, Cambridge,** coils wound with wire of low temperature coefficient; built-in short period robust galvanometer and battery with separate keys, large terminals for connection to the unknown. Two additional terminals for external battery, when measuring resistances for which the internal dry battery is inadequate. With four dials, resistance values from 1 to 11,110 ohms. Eight ratio coils, range of measurable resistance 0·01 to 10^7 ohms. Accuracy of adjustment 0·1 per cent. With carrying strap and detachable lid .. ..£x 31 1 0

A 86-392. **Ditto, without galvanometer,** construction and range as above, with terminals for connection to external battery and galvanometer .. ..£x 25 6 0

A 86-400. **BRIDGE, Universal, Cambridge,** for the measurement of D.C. resistance, self and mutual inductance, capacitance and frequency. The bridge is self-contained with battery and galvanometer detector for D.C. measurements, and reed hummer and single telephone detector for A.C. measurements. Selector and range switches are fitted and the bridge is direct reading for all quantities except frequency, where a table is provided. Resistance range 0·01 to 10^8 ohms. Self inductance 1 μH to 100 H. Mutual inductance, 10 to 11,000 μH. Capacitance 1 $\mu\mu$F to 11·1 μF. Frequency 400 to 7000 cycles ..£x138 0 0



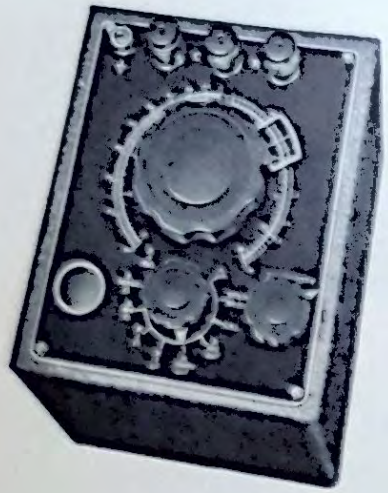
A 86-410.



A 86-420.

A 86-410. **BRIDGE, Kelvin Double, Cambridge,** for the accurate measurement of low resistances such as shunts and for specific resistance determinations. Comprises a variable standard resistance, nine multiplying ratios × 0·01 to × 100 ohms, and galvanometer key. The standard resistance consists of four shunts, each 0·002 ohms resistance and a 430 mm. slide-wire, approx. resistance 0·0022 ohms, calibrated throughout its length. The slider is designed to ensure a constant contact resistance. A conductivity attachment for holding test specimens can be supplied. Range of measurable resistance 10^{-4} to 1 ohm, accuracy of adjustment 0·05 per cent. or half a slide-wire division, whichever is greater ..£x 56 18 6

A 86-420. **BRIDGE, Callendar and Griffiths, Cambridge,** extensively employed in precision resistance thermometry. Eight manganin resistance coils, resistance 0·1 to 12·8 ohms arranged according to a binary scale, which enables them to be checked on the bridge itself. Each coil differs by 0·1 ohm from the sum of those below it. The 30 cm. platinum-silver bridge-wire, resistance 0·15 ohm, is accurately calibrated, and the exact ratio of the fixed arm can be determined on the bridge. A vernier is attached to the sliding contact, and a fine slow motion is provided. Special mercury contacts are fitted. Range of measurable resistance 0·0003 to 25·65 ohms, accuracy of adjustment 0·01 per cent. ..£x 51 3 6



A 86-440.

A 86-440. MEASURING BRIDGE, Universal, operated directly from the A.C. mains, of wide application in the measurement of resistance, capacitance and inductance. Especially useful in conductivity work, as the incorporated electron beam indicator gives visual signals, is more sensitive than, and eliminates the use of, the telephones used to give aural minima with the Kohlrausch bridge. In metal case about 7 × 6 × 6 in., weight 7 lb., with pentode valve, electron beam indicator (" magic eye "), and power unit with full-wave rectifying valve. For use on A.C. mains 100–150, 200–250 volts 40–10,000 cycles, consumption 14 watts. Complete with instructions for use .. .. £ 15 15 0

This instrument has numerous applications in research and routine testing laboratories. Apart from the measurement of resistances, capacities and inductances, it may be applied to many purposes in the radio and electrical industries. In physico-chemical work it may be employed in measuring the resistances of electrolytes and is valuable in conductometric and electrical titrimetric work. An oscillator and conductivity cell for these applications is shown later in this Catalogue in the section on Physical Chemistry. External standards may be used for conductance, condenser power factor and percentage error measurements.

The circuit is a Wheatstone bridge type. A rotary switch selects the measuring ranges, these being for resistances 0·1 ohm—10 megohms in four steps and capacities 10μμF—10μF in three steps. Accuracy on megohm range ± 5%. Accuracy on all other ranges ± 2%. The scale is open and clearly marked and gives direct readings, the actual value being obtained by multiplying the bridge reading by the value indicated by the range switch.



A 86-480.



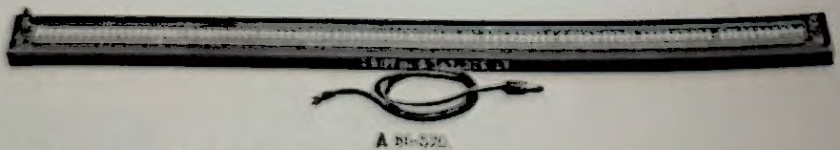
A 86-485.

	£	s.	d.
A 86-480. WHEATSTONE BRIDGE, half metre, polished wood base with boxwood scale in mm., attached jockey sliding on metal rod and copper strips with terminals	1	17	6
A 86-485. SLIDING CONTACT or JOCKEY, plated brass, 3 × ⅜ in., with knife edge, ebonite sleeve, and terminal at top for wire connection	0	4	0



A 86-510.

A 86-510. WHEATSTONE BRIDGE, Four Gap, 1 metre (Hadley: *Magnetism and Electricity for Students*; Worsnop and Flint: *Advanced Practical Physics for Students*), suitable for use as a **Carey Foster Bridge.** On polished wood base, with groove for a jockey of specially robust construction, copper strips and connecting bars, terminals and scale graduated in inches and millimetres. With jockey .. .. £ 4 0 0

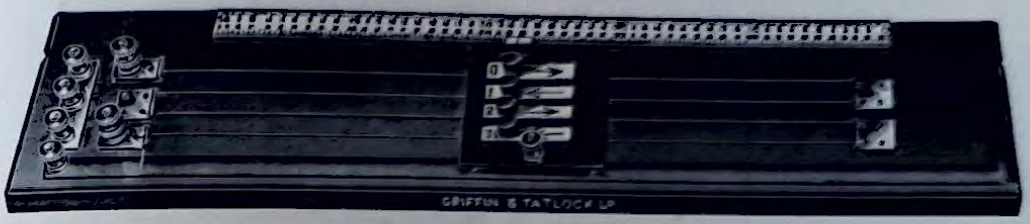


A 86-520.

A 86-520. POTENTIOMETER, two metre, on stout wood base, 1 metre long, with two, one-metre wires and boxwood rule graduated and figured both ways in millimetres. Three terminals are provided, enabling the apparatus to be used as either a one or two metre instrument. A length of heavy flex is supplied, fitted at one end with a spade terminal and at the other end with a knife-edge jockey with ebonite handle .. .. £ 2 5 0

THE MICROID 2-METRE BRIDGE-POTENTIOMETER

A new compact and convenient model



A 86-540

This instrument will appeal to those who are restricted either for bench or cupboard space. By arranging the wire in four half-metre lengths, placed side by side, it has been possible to make available an instrument with total length of slide wire 2 metres, on a base only 26 in. long. Also, the connections for the bridge-system are brought to one end of the base in a very convenient manner.

SPECIFICATION

The base is of oiled wood, 26 in. long, provided with rubber feet. It carries a boxwood scale figured 0–50 in both directions and graduated in millimetres, and four half-metre constantan wires firmly clamped to copper endplates. A sliding jockey is provided, having four tapping keys, with contacts which are constantan-tipped to eliminate thermoelectric E.M.F.'s. The keys are numbered 0, 1, 2, 3 and each is engraved with an arrow to indicate the direction in which the scale is to be read when contact is made with any selected wire.

The jockey is supported on four feet, two of which slide in a groove in the base, the other two sliding on a plated metal strip. Contact to the keys may be made either on a terminal fitted to the metal strip or on a terminal fixed to the jockey frame.

The former method enables connection to be made to the galvanometer without wire which moves with the jockey.

A copper strip carrying three terminals is provided at the left hand end for making the necessary Wheatstone bridge connections. All the terminals on this instrument are of an extra heavy pattern, convenient to handle, those at the ends of the slide wire being provided with an extra knurled collar, for the connection of two wires.

A 86-540. MICROID 2-METRE BRIDGE-POTENTIOMETER, on wood base 26 in. long with rubber feet, four half-metre wires, four contact jockey, boxwood scale engraved both ways, and terminals .. .. £ 5 0 0

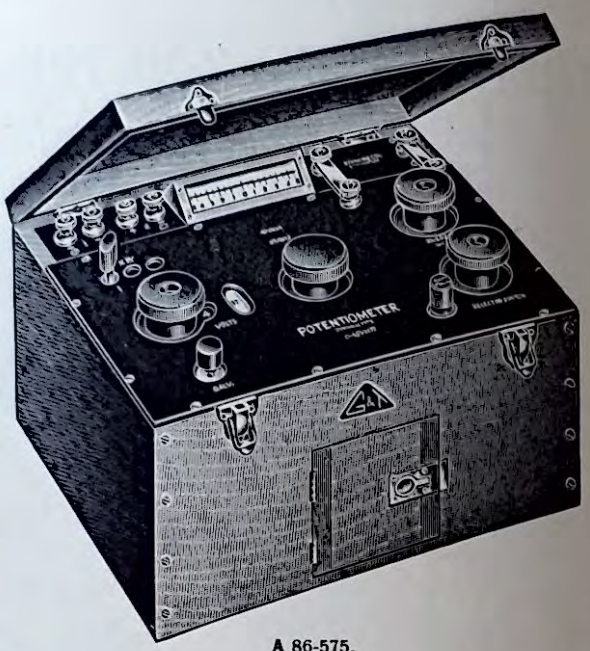


A 86-550.

A 86-550. POTENTIOMETER, varnished wood board 45 ins. long, graduated in 1 cm. divisions, with 6 one-metre resistance wires, 7 terminals and jockey 3 10 0



A 86-570.



A 86-575.

£ s. d.

A 86-570. POTENTIOMETER, General utility pattern, three range, 2 dial, overall measuring range minus 5 microvolts to plus 1·9 volts. All switches, etc., are mounted on an ebonite sub-panel and are protected from dust and fumes by a black Bakelite cover panel, the dial settings being read through slots in the cover panel. In polished teak case, overall dimensions 15 × 9 × 6 in., weight 14 lb. As specified below .. .. £ 34 13 0

SPECIFICATION

Normal range.—5 millivolts negative to 1·905 volts positive in steps of 0·1 volt on the main dial, and — 5 to + 105 millivolts in 220 divisions of 0·5 millivolt, on the slide wire dial. Width of each slide wire division 1·5 mm.

Other ranges.—Obtained on a plug range key. 0·1 normal range, 0·19 volts subdivided in 50 microvolts per division; 0·01 normal range, 0·019 volts sub-divided in 5 microvolts per division.

Accuracy.—On normal ranges errors do not exceed 0·2 millivolt. Agreement of accuracy on other ranges with normal range is within 0·05%.

Standardisation.—Carried out on an independent standardising circuit on any range and without reference to the potentiometer dial settings. A standard cell voltage of 1·01824 International volts is assumed.

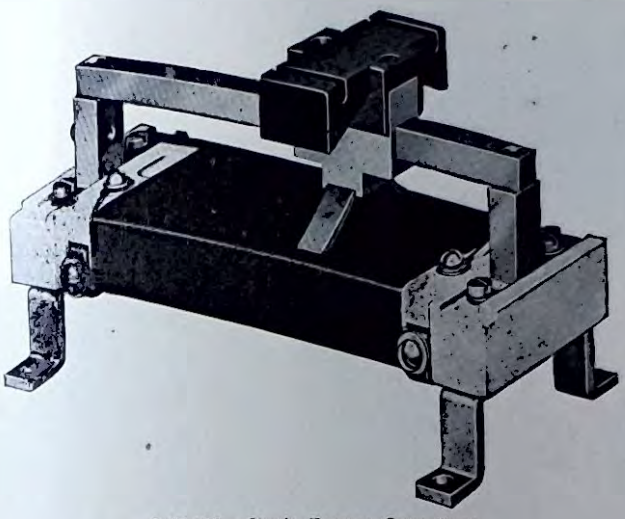
Potentiometer resistance.—About 20 ohms/volt.

Battery circuit.—Requires a 2-volt accumulator capable of giving a steady discharge of 50 milliamps.

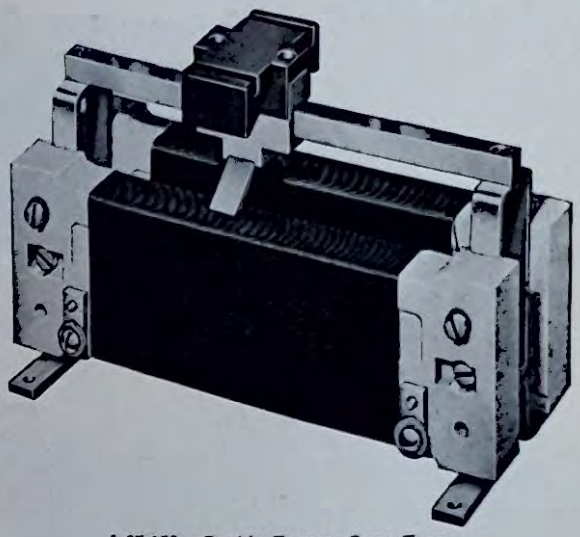
The potentiometer has on the panel (additionally to the two, dial-control knobs and the plug range multipliers) a continuously-variable current control, a three-position selector switch knob, galvanometer and battery key, and terminals for the battery, standard cell, galvanometer and two X circuits.

A 86-575. POTENTIOMETER, General utility pattern, portable model, with built-in reflecting galvanometer. General specification similar to **A 86-570,** but including standard cadmium cell, reflecting galvanometer with lamp and scale, jelly-acid accumulator for the potentiometer and 4-volt dry battery for galvanometer lamp supply, complete in polished teak case with detachable lid and carrying strap. On the panel independent switches are provided for both batteries. If required, they can be replaced by external sources of supply. The standard cell is easily removed from the case for inspection or checking. The galvanometer is a robust, taut-suspension, short period instrument, giving a spot clearly visible under all normal conditions. It can easily be removed from the case for inspection. Overall dimensions of complete instrument 15 × 11 × 10 in., weight 28 lb. .. .. £ 51 19 6

Your attention is drawn specially to the numerous new and distinctive designs in this Catalogue. They are of exceptional interest to you.



A 87-120.—Single Former, Open Type.



A 87-120.—Double Former, Open Type.

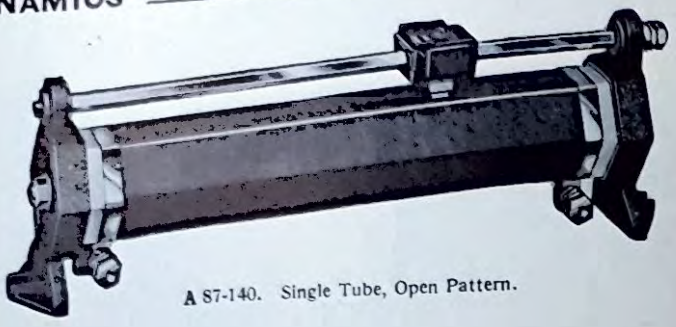
RESISTANCES, Sliding.—Specification: Formers of strong moulded ceramic material, with high insulation properties and freedom from metallic veins. Windings of first quality nickel-copper oxidised wire, corrosion free, close wound so as to employ the maximum gauge of wire for any given rating. Laminated phosphor-bronze brushes with Bakelite finger grips of improved design. Three screw terminals **for series or potentiometer use.** The " protected " pattern complies with Home Office regulations, covers are of perforated pressed steel, designed so that the operator cannot come into contact with any live parts. The slider bar is completely protected and the terminals enclosed. Illustration, see **A 87-150.**

Please order as :—*Cat. No., Former length, single or double, resistance + accessories,* **A 87-130.**

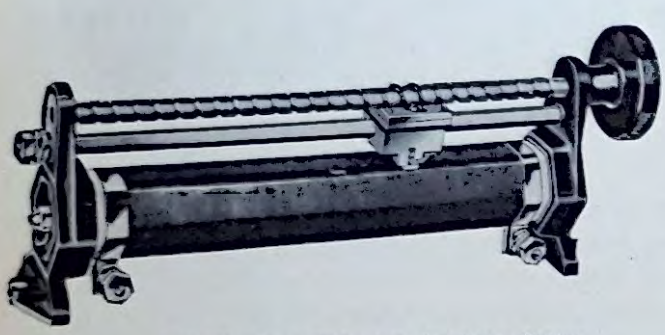
CURRENT Amperes ↓	OHMS 5½ in. Former		OHMS 7 in. Former		OHMS 9 in. Former		OHMS 12 in. Former	
	Single 75 watts	Double 150 watts	Single 100 watts	Double 200 watts	Single 150 watts	Double 300 watts	Single 200 watts	Double 400 watts
0·3	720	1440	1080	2160	1560	3120	2280	4560
0·35	550	1100	830	1660	1200	2400	1750	3500
0·45	342	684	514	1029	741	1482	1083	2166
0·55	236	472	354	708	512	1024	747	1494
0·8	106	212	159	318	230	460	336	672
0·95	76	152	115	230	166	332	242	484
1·1	57	114	86	172	124	248	181	362
1·3	43	86	64	128	92	184	135	270
1·9	22	44	32	64	46	82	68	136
1·9	18	36	27	54	39	78	58	116
2·8	9	18	13	26	19	38	28	56
3·2	6·4	12·8	9·6	19·2	14	28	20	40
4·2	3·8	7·6	5·7	11·4	8·2	16·4	12	24
5·5	2·3	4·6	3·4	6·8	4·9	9·8	7·2	14·4
6·5	1·6	3·2	2·3	4·6	3·3	6·6	4·8	9·6
8·5	1·0	2·0	1·5	3·0	2·2	4·4	3·0	6·0
10·0	0·7	1·4	1·1	2·2	1·6	3·2	2·4	4·8
A 87-120. Open £	10/6	21/-	12/-	26/-	15 6	30/-	18/-	36/-
A 87-125. Protected £	17/6	29/-	20/-	34/9	24/-	40/-	28 6	45/9

Accessories for A 87-120—180

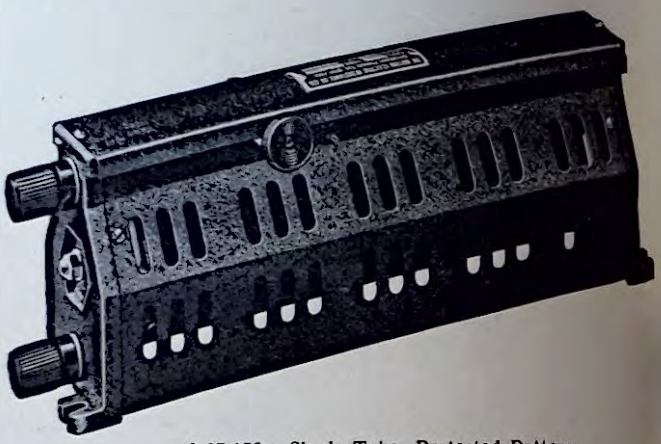
		£	s.	d.
A 87-130 a.	Tumbler Switch, fitted to end cover of protected type	£0	6	0
" " b.	Leadscrew Motion, fitted to open type (see illustration, A 87-145)	£0	15	0
" " c.	Outside Terminals on protected type (see illustration, A 87-130)	£0	2	6
" " d.	Adjustable Stop on Slider Bar	*No extra charge.*		
" " e.	Off Position for slider	£0	1	10
" " f.	Engraved Scale of volts	£0	5	0
" " g.	Ditto, ohms	£0	5	0



A 87-140. Single Tube, Open Pattern.



A 87-145.—Single Tube, with Leadscrew Motion.

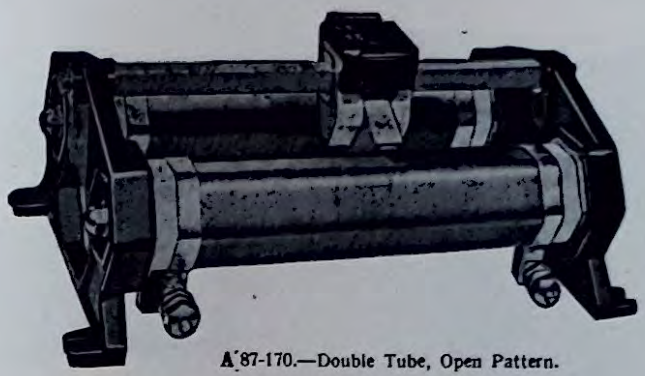


A 87-150.—Single Tube, Protected Pattern

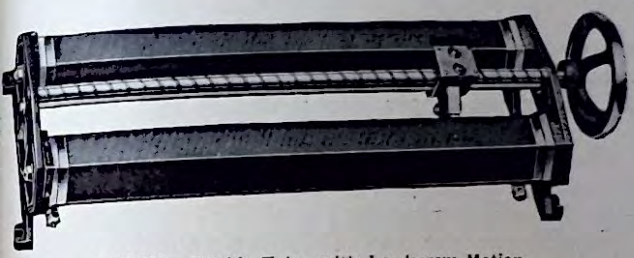
RESISTANCES, Sliding, Single Tube, with copper-graphite self-lubricating brushes operating on the flat surface of a hexagonal vitreous enamelled steel tube, fitted with three terminals **for use either as Series Resistances or Potentiometers.** Nickel-copper alloy winding having negligible temperature coefficient, so that the resistance remains constant under load; advantage is taken of the insulating properties of the oxidised surface of the wire, obviating the necessity for spacing the turns. Non-rotatable hexagonal vitreous enamelled steel tube former mounted in Micanite end-caps fitted into end-castings. Solid copper-graphite brush with pigtail connection and two strong pressure springs to maintain good contact. The graphite provides sufficient lubrication to prevent wear on wire but not sufficient to short out turns of the finest gauge wire employed. Approx. area of contact 0·22 sq. in. ensuring low current density and cool running. Moulded Bakelite slider knob. On protected pattern the finger grip design renders it impossible for the operator to come into contact with the slider bar or winding and thus meets Home Office regulations.

Please order as:—*Cat. No., diam. of tube, length of tube, resistance + accessories,* **A 87-130 a, d—g.**

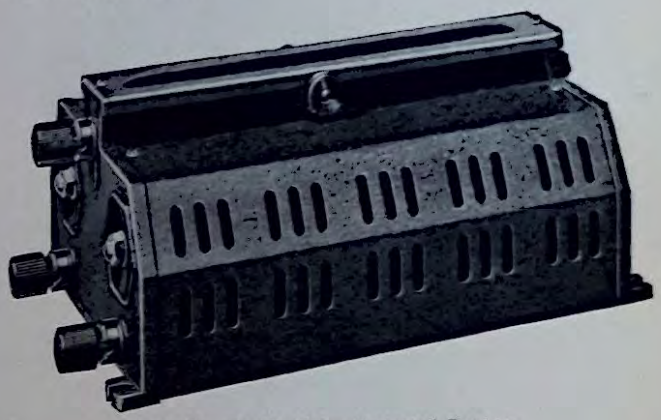
Diam. of tube, in.	1¼				2				2½			
Length, .. in.	6	8	10	12	10	12	14	16	14	16	18	20
AMPS.	OHMS				OHMS				OHMS			
0·3	822	1232	1650	2055	2250	2810	3375	3940	3680	4800	4900	5500
0·6	266	398	531	664	694	867	1040	1210	1180	1375	1570	1770
1·0	185	277	369	461	508	635	762	890	860	1004	1150	1290
1·5	60	90	120	150	159	198	238	277	268	312	356	402
2·0	34	51	68	85	93	116	139	165	161	188	214	245
3·3	14·25	21·4	28·5	35·6	38·3	47·9	57·5	67	63·5	74·2	85	95
4·0	10·10	15·1	20·2	25·2	28·2	35·2	42·3	49·2	46·8	54·6	62·5	70·2
5·0	7·50	11·25	15	18·75	19·75	24·7	29·6	34·5	33·7	39·4	45	50·5
6·5	4·20	6·3	8·4	10·5	12	15	18	21	22·6	26·3	30·5	33·9
8·5	2·70	4·00	5·41	6·76	7·24	9·04	10·8	12·7	12·8	14·9	17·1	19·2
10	1·61	2·41	3·21	4·02	4·81	6·02	7·24	8·43	8·43	9·84	11·3	12·7
A 87-140. Open Pattern .. *f*	**25/3**	**30/6**	**34/-**	**36/-**	**38/-**	**43/-**	**45/6**	**48/6**	**53/6**	**58/-**	**63/6**	**68/3**
A 87-145. Ditto, Leadscrew Motion .. *f*	**43/-**	**48/6**	**51/3**	**55/-**	**56/6**	**61/6**	**63/6**	**66/9**	**69/6**	**77/9**	**82/6**	**88/-**
A 87-150. Protected Pattern .. *f*	**33/9**	**39/-**	**43/-**	**47/6**	**48/6**	**53/6**	**55/-**	**58/-**	**63/6**	**68/3**	**70/-**	**79/6**



A 87-170.—Double Tube, Open Pattern.



A 87-175.—Double Tube, with Leadscrew Motion.



A 87-180.—Double Tube, Protected Pattern.

RESISTANCES, Sliding, Double Tube, open and protected types.

Please order as:—*Cat. No., diam. of tube, length of tube, resistance + accessories,* **A 87-130 a, d—g.**

Diam. of tube, in.	1½				2				2½			
Length, .. in.	6	8	10	12	10	12	14	16	14	16	18	20
AMPS.	OHMS				OHMS				OHMS			
0·3	1644	2464	3300	4110	4500	5620	6750	7880	7360	9600	9800	11000
0·6	532	796	1062	1328	1388	1734	2080	2420	2360	2750	3140	3540
1·0	370	554	738	922	1016	1270	1524	1780	1720	2008	2300	2580
1·5	120	180	240	300	318	396	476	554	536	624	712	804
2·0	68	102	136	170	186	232	278	330	322	376	428	490
3·3	28·5	42·8	57	71·2	76·6	95·8	115	134	127	148·4	170	190
4·0	20·2	30·2	40·4	50·4	56·4	70·4	84·6	98·4	93·6	109·2	125	140·4
5·0	15	22·5	30	37·5	39·5	49·4	59·2	69	67·4	78·8	90	101
6·5	8·4	12·6	16·8	20·1	24	30	36	42	45·2	52·6	61	67·8
8·5	5·4	8·12	10·82	13·52	14·48	18·08	21·6	25·4	25·6	29·8	34·2	38·4
10	3·22	4·82	6·42	8·04	9·62	12·04	14·48	16·86	16·86	19·68	22·6	25·4
A 87-170. Open Pattern .. *t*	**43/-**	**51/6**	**58/-**	**63/-**	**64/3**	**69/6**	**78/-**	**82/6**	**91/-**	**99/-**	**108/-**	**116/6**
A 87-175. Ditto, Leadscrew Motion .. *t*	**61/3**	**68/3**	**74/-**	**79/6**	**82/9**	**91/3**	**96/-**	**101/3**	**110/9**	**119/-**	**127/9**	**136/-**
A 87-180. Protected Pattern .. *t*	**51/3**	**63/-**	**69/6**	**74/-**	**77/6**	**81/3**	**89/-**	**93/3**	**101/3**	**110/-**	**118/6**	**126/6**

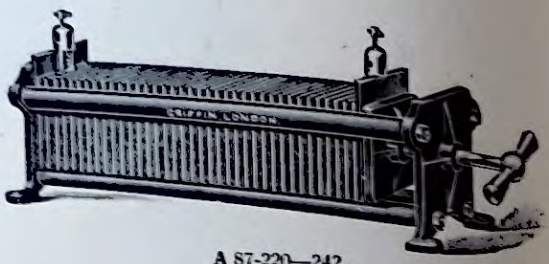
Ratings are continuous and are based on the tubes being mounted vertically in free air. Should it be necessary to mount the tubes horizontally the current should be reduced to 75 per cent. of the list value.

Graded Windings.—A number of sections of different gauges of wire gradually decreasing from one end to the other, reduce the size of resistances when the line voltage and load resistance are constant. When ordering please state ohmic value, max. and min. currents. *Prices on application.*

Non-Inductive Windings eliminate magnetic fields. Any resistance can be non-inductively wound where the current is above 2 amps., the max. ohmic value in each size being 25 per cent. of those listed, with an increase of 100 per cent. in current carrying capacity. *Prices on application.*



A 87-196 + 197.



A 87-220—242.

RESISTANCES, Adjustable.—Small power type toroidal wound resistances with fine rotary action, replacing the larger sliding resistances **A 87-120—180** for controlling small loads, with great economy of space. Wound with nickel-copper alloy wire, up to 500 ohms and nickel-chromium wire 500–4000 ohms, on refractory ring formers with copper-graphite self-lubricating brush contacts. Supplied unmounted with large milled head and three terminals **for series or potentiometer use**, or mounted in ventilated Bakelite case, with knob and circular scale graduated 0–100. Overall dimensions 3 × 2¾ × 2½ in. high. Resistance tolerance ±10 per cent. Temperature rise 160° C. at 25 watts dissipation.

	Ohms	10	13	17	25	32	45	70	77	83	100	130	
	Amps.	1·6	1·4	1·2	1·0	0·9	0·75	0·6	0·58	0·55	0·5	0·44	
A 87-190. Unmounted	£	18/-	18/-	18/-	18/-	18/-	18/-	21/-	21/-	21/-	21/-	21/-	*each*
A 87-195. Mounted	£	24/6	24/6	24/6	24/6	24/6	24/6	26/6	26/6	26/6	26/6	26/6	*each*
	Ohms	180	230	320	440	625	980	1280	1750	2100	3100	4000	
	Amps.	0·37	0·33	0·28	0·24	0·2	0·16	0·14	0·12	0·11	0·09	0·08	
A 87-190. Unmounted	£	21/-	21/-	21/6	21/6	21/6	21/6	23/6	23/6	23/6	23/6	23/6	*each*
A 87-195. Mounted	£	25/-	25/-	26/-	26/-	26/-	26/-	28/-	28/-	28/-	28/-	28/-	*each*

A 87-197. Switch, giving "off" position at end of anti-clockwise rotation of knob, fitted to any of the above. Must be specified at time of ordering .. .. *extra* £ s. d. 0 1 9

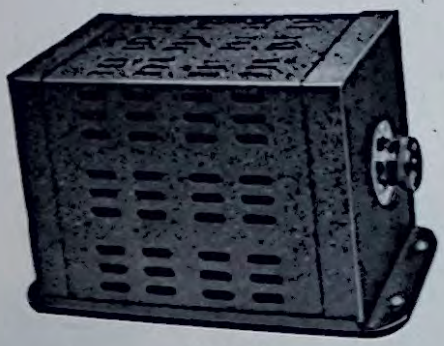
RHEOSTATS, Carbon Plate. Convenient for fine current-control or where a non-inductive heavy-current regulator is required. Two substantial iron castings are connected together by insulated steel rods between which carbon plates are fitted. Current is led into the resistance by means of copper plates to which terminals are attached. These metal plates may be inserted in any intermediate position so as to include one or more carbon plates up to the maximum. The range of control is thus considerably extended. The ohmic values stated are only approximate. The special value of this type of resistance is that *continuous* current adjustment is possible.

Cat. No.	Number of Plates	Watts Dissipated	Min. Ohms	Max. Ohms	Dimensions Inches	Weight Lbs.	Price £ s. d.
Size of Plates .. .. 2 × 2 × ¼ in.							
A 87-220	24	200	0·07	1·4	11 × 3½ × 3½	5½	3 7 6
A 87-225	40	350	0·12	2·35	15 × 3½ × 3½	7	3 15 0
Size of Plates .. .. 3½ × 3½ × ⅜ in.							
A 87-230	24	450	0·017	0·18	15 × 5 × 5½	15	4 15 3
A 87-235	40	750	0·003	0·29	21 × 5 × 5½	19	6 2 6

A 87-238. Carbon Plates, Spare, 2 × 2 × ¼ in. .. .. *each* 0 0 9
A 87-240. Carbon Plates, Spare, 3½ × 3½ × ⅜ in. .. .. *each* 0 1 3
A 87-242. Terminal Plates, Spare, for A 87-220–235. (*Please state size when ordering*). .. *each* 0 2 10



A 87-310.



A 87-340.

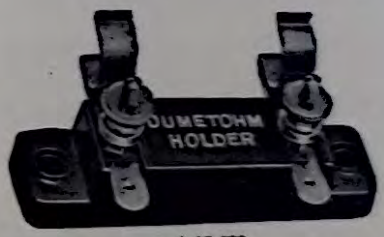
A 87-310. **LAMP RESISTANCE BOARD,** with three standard lamp holders, 2-pin plug connection to mains, two output terminals, 5-amp. fuse, mounted on wood base board. **Without** lamps .. .. £ 2 0 0

A 87-340. **RESISTANCES,** to enable Class F Projector Type Lamps, 6 and 12 volts, 24 watts, **A 58-495,** either to be run as rated or over-run at 7 and 14 volts respectively. Recommended for the lamps incorporated in many of the optical projection apparatus in this catalogue. In fully protected, ventilated metal cases with 2-pin plug connection to mains and 2-pin socket connection to lamp, terminal strip with tappings so that resistance box can be used on 100, 110, 200, 210, 220, 230, 240 and 250 volts A.C. and D.C.

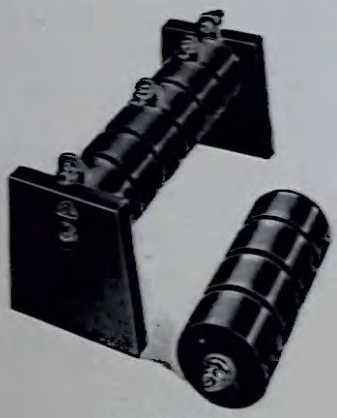
Output ..	6	7	12	14	volts
£	£8 5 0	£8 5 0	£8 5 0	£8 5 0	each



A 87-370.



A 87-372.



A 87-390—394.

A 87-370. **RESISTANCES, Metallised.** Suitable for use in the standard cell part of a potentiometer circuit for preventing damage to the standard cell by the discharge of too heavy a current. The resistances are rated to carry 1 watt and 100 hour tests at 100 per cent. overload have shown that the initial value of the resistances does not vary by more than 3 per cent. A wide range of resistances is available, of which the following is a selection—1000, 2500, 5000, 10,000, 25,000, 50,000, 100,000, 250,000, 500,000 ohms .. .. .. *each* £ 0 1 6

Please state resistance when ordering.

A 87-372. **Holders** to accommodate any of the above metallised resistances .. .. *each* £ 0 2 0

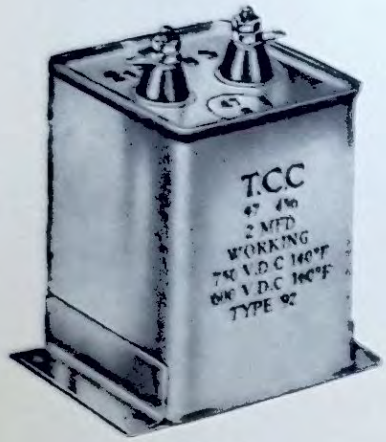
A 87-390. **HIGH RESISTANCE UNITS, 0·5 megohm.** Wound with silk covered Eureka wire, having negligible temperature coefficient, on Bakelite bobbins with threaded brass connections at each end arranged so that any number of bobbins can be screwed together to obtain resistances of higher ohmic value and dissipation capacity. Diam. 2¼ in. Correct to ± 0·5 per cent. .. .. *each* £ 1 15 0

Also available in lower resistance values—Prices on application.

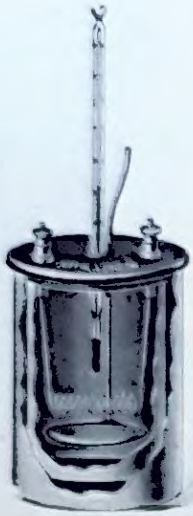
A 87-392. **Terminal Strips** for intermediate tappings when a number of 0·5 megohm bobbin units are connected together .. .. *each* £ 0 1 6

pair £ 0 11 0

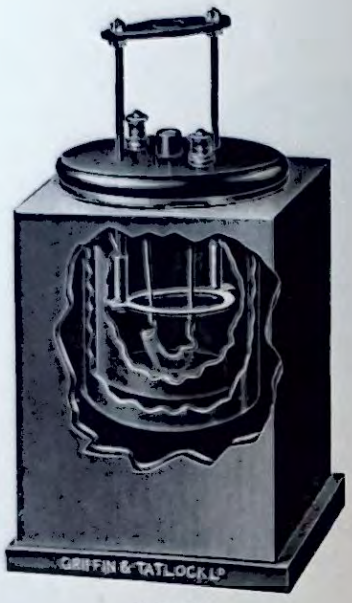
A 87-394. **End Supports,** Bakelite .. ..



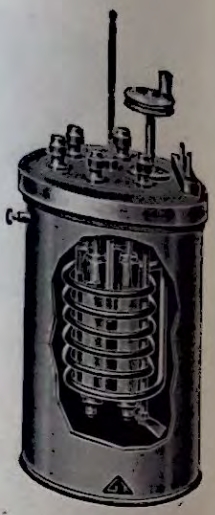
A 87-490



A 87-520.



A 87-530.



A 87-540.

A 87-484. CONDENSER, Subdivided, 0·1, 0·2, 0·2, 0·5, total 1 μF. Paper insulation, in polished wood case 9 × 5 × 5 in. with ebonite top and five plugs .. .. £ 12 10 0

A 87-490. CONDENSERS (Capacitors), paper dielectric, vacuum impregnated, in hermetically sealed metal cans, filled with petroleum jelly ; with terminals. Working voltage at 60° C., 750 v. D.C. Tested at 1500 v. D.C. Standard capacitance tolerance ± 15 per cent.

Capacity ..	0·10	0·25	0·50	1	2	4	6	8	10	μF
	4/9	5/3	5/6	6/6	11/-	16/-	21/-	27/-	32/6	*each*

A 87-520. CALORIMETER, Joule, (Noakes: *Text-Book of Heat*, pp. 63–67), brass inner vessel 3 × 4 in., and tin outer vessel 3½ × 4½ in., fitted wood top with hole for thermometer and two terminals to which a spiral of resistance wire is connected. With stirrer. **Without** thermometer 0 17 6

Thermometer, 0° to 100° C. in 1° engraved on stem .. .. .. see **B 47-635.**

A 87-530. CALORIMETER, Joule, polished wood box 5 × 5 × 6 in., containing a tin vessel 3½ × 4½ in., in which, insulated from it, is placed a copper vessel 3 × 4 in., with wood cover carrying terminals, resistance spiral and annular copper ring stirrer. **Without** thermometer 2 15 0

Thermometer, − 5° to 105° C. in 0·2° engraved on stem .. .. see **B 47-675**

A 87-540. RESISTANCE-TEMPERATURE COEFFICIENT APPARATUS. Four resistance coils — bare copper, aluminium, iron and Constantan wound on insulated formers, are attached to an asbestos-cement disc forming part of the cover of the calorimeter, the whole unit with stirrer and thermometer being removable from the calorimeter. Leads from the coils are brought out to terminals with insulated captive heads mounted on the removable disc. Stirrer arranged for either hand operation or belt drive. Copper oil container 9 × 7 in. diam. with earthing terminal, asbestos-cement ring, metal-sheathed heating element loading approx. 900 watts, with 2-pin plug connection (*Please state mains voltage when ordering*). **Without** thermometer 18 5 0

Thermometer, − 5° to 105° C. in 0·2° engraved on stem .. .. see **B 47-675.**

THE MICROID TEMPERATURE COEFFICIENT OF RESISTANCE COIL

A simple effective design for liquid immersion



A 87-570—575.

SPECIFICATION

A single layer of enamelled wire is non-inductively wound on a Pyrex glass tube about 8 × ¾ in. The enamel is of a special composition, resistant to the action of boiling water. It eliminates the use of paraffin and similar objectionable liquids. The gauge of the wire is selected so that the initial resistance is high and, in the case of **A 87-570**, the change of resistance great enough to be measurable with sufficient accuracy on elementary apparatus. The coil is soldered to stout, anchored, insulated leads.

The coil is available wound with copper or manganin wire, intended to exhibit their marked difference in behaviour when subjected to temperature change. It is instructive to compare the results obtained with these materials. The reason for the use of manganin in standard resistances is clearly shown when these results are plotted in the form of a graph.

	£ s. d.
A 87-570. MICROID TEMPERATURE COEFFICIENT OF RESISTANCE COIL, Copper, wound on glass tube about 8 × ¾ in. and provided with insulated leads	0 10 0
A 87-575. Ditto, Manganin (temperature coefficient of resistance negligible for many purposes)	0 12 6

EXPERIMENTAL NOTES

Connect the coil into a Wheatstone Bridge or Post Office Box circuit and immerse the wound section in a beaker of water. If desired, a thermometer may be supported at the centre of the winding by means of a suitable cork placed in the upper, open end of the tube. After attainment of thermal equilibrium take the temperature of the water and then measure the resistance of the coil. Now heat the water slowly to boiling point and again measure the resistance. It is then convenient to divide the change of resistance into a number of equal steps (say 0·5 ohm) and to alter the P.O. Box or Wheatstone Bridge setting by an amount equal to the value of one step (0·5 ohm).

The beaker is then allowed to cool and the temperature noted at which the resistance of the coil passes through the changed setting, i.e., the temperature noted at which the bridge is again balanced. This process is repeated until the temperature has fallen almost to its initial value. A graph is then plotted of temperature (abscissæ) against resistance (ordinates). The graph will exhibit the linearity of the temperature-resistance relation over the range investigated. The resistance at two selected temperatures (of which R_0 should be one) can then be read off and the temperature coefficient of resistance evaluated.

It is important to keep the liquid in the beaker calorimeter thoroughly stirred. If used with a rotary motion, the coil itself may be employed for the purpose.

SPECIMEN RESULT.

Determination of temperature coefficient of resistance of copper.

Resistance (from graph) at 100° C. .. .. = 30·20 ohms.
Resistance (from graph) at 0° C. .. .. = 21·30 „

$$\alpha = \frac{R_{100} - R_0}{R_0 \times 100} = \frac{9 \cdot 0}{21 \cdot 30 \times 100} = 0{\cdot}00418 \text{ per } ^\circ\text{C.}$$

A great variety of Apparatus for all branches of Physics, Chemistry and Biology is made in our own factories and approved by rigid inspection in our own Test Rooms.

THE MICROID ELECTRICALLY HEATED CALORIMETER

Robust design with heating element insulated from, but in close contact with, the calorimeter



A 87-610.

The type of electrically heated calorimeter, which employs a submerged resistance coil, is subject to a number of disadvantages. Electrolysis and corrosion can take place and the free motion of the stirrer is often impeded by the coils of bare wire which are readily short-circuited.

The present type employs an element mounted in intimate contact with the walls of a well at the base of the calorimeter. The metal of the calorimeter has a high thermal conductivity, and a highly polished surface. Temperature equilibrium is therefore rapidly established and radiation loss minimised. Good values for specific heats and for the mechanical equivalent of heat can be obtained.

SPECIFICATION

The calorimeter is of turned aluminium, about 7 cm. high by 5 cm. diameter, with walls about 1 mm. thick. The interior is cylindrical for about 3 cm., at which depth the walls slope to join a well about 3·5 cm. diameter by 14 mm. deep. The outer wall of the well is thoroughly insulated and wound with a nickel chromium heating element which carries 3 amps. at 6 volts. The winding is suitably lagged and is protected from damage by a tube which is a tight sliding fit over it.

The leads to the heating elements are insulated by porcelain beads and are brought out to two terminals mounted near the base. Three strings are provided for suspending the calorimeter on a balance. The specific heat of the metal of which the calorimeter is made is stamped on the body.

	£	s.	d.
A 87-610. MICROID ELECTRICALLY HEATED CALORIMETER. Aluminium calorimeter about 5 cm. diam. by 7 cm. high, wound with lagged element to carry 3 amps. at 6 volts. With terminals	1	10	0

EXPERIMENTAL NOTES

In all forms of electrically heated calorimeters, precision results can be obtained only if close attention is paid to the evaluation of the radiation corrections and to the accuracy of the measuring instruments employed. The radiation loss with this form of calorimeter is small and amounts, electrically, to about 0·15 watts per °C. difference in temperature between the calorimeter and its surroundings while the rate of consumption of electrical energy is 18 watts.

1. Radiation corrections may be investigated by three methods.

(a) A cooling curve may be constructed as the heated liquid cools.

(b) Regnault's method may be employed by commencing the experiment with the initial temperature below that of the room, and continuing it until the final temperature rises as much above atmosphere as the initial temperature was below it.

(c) A steady current of 2·5–3·0 amperes may be passed through the apparatus and the equilibrium temperature measured. It will then be possible to calculate the heat lost per second, or the watts lost per degree Centigrade difference in temperature between the calorimeter and the room.

The calorimeter is normally suspended by the threads provided but may, if necessary, be surrounded by a larger, jacketed calorimeter to ensure uniformity of radiation loss.

2. Accuracy of the Measuring Instruments Employed.—The accuracy of commercial measuring instruments is not high. It should not be overlooked, therefore, that unless precision ammeters and voltmeters are used and unless certified thermometers are available, the errors arising from these causes are liable to exceed errors to which the method is inherently subject.

Such errors may result from deposition of dew on the outer surface of the calorimeter, which method (b) above is ideal for it sets the temperature at the free liquid surface in the calorimeter. (This last may amount to 0·06 watts per °C. difference of temperature between the calorimeter and its surroundings.)

(continued overleaf)

A 87-610. The Microid Electrically Heated Calorimeter—*continued*

SPECIMEN RESULTS

3. Determination of Radiation Loss of the Calorimeter and Emissivity of Aluminium.

The calorimeter contained initially 50·0 gm. of water and a current of $0{\cdot}51_8$ amps. was passed through it continuously for a period of 48 hours. The average equilibrium temperature above the room was $3{\cdot}47 \pm 0{\cdot}08°$ C. and in this period it lost 10·0 gms. of water by evaporation from the open water surface.

The resistance of the calorimeter coil was $2{\cdot}1_7$ ohms, so that $0{\cdot}16_4$ watts was spent per ° C. difference in temperature. This corresponds to a total emission of $0{\cdot}039_2$ calories per sec. ($0{\cdot}029_4$ cals. per sec. by direct emission and $0{\cdot}009_8$ cals. per sec. by evaporation).

The total area of the emitting surface of aluminium was 146 sq. cm.

$$\therefore \text{Emissivity of the aluminium surface} = \frac{2{\cdot}9_4 \times 10^{-4}}{1{\cdot}46 \times 10^{2}}$$

$$= 2{\cdot}0_1 \times 10^{-4} \text{ cals./° C. sec. sq. cm.}$$

4. Determination of the Mechanical Equivalent of Heat by Electric Heating.

Wt. of calorimeter containing water	=	140·33 gms.
Wt. of calorimeter empty	=	101·77 „
∴ Wt. of water	=	38·56 „
Sp. Ht. of aluminium calorimeter	=	0·219 cals/gm. °C.
∴ Total water equivalent	=	$38{\cdot}56 + 0{\cdot}219 \times 101{\cdot}77$
	=	60·86 gms.

(The negligibly small corrections for the difference of the values of the specific heats of the winding, lagging, etc., from the value for aluminium are ignored.)

The *average* values of the current, C and the voltage, E, taken with instruments (accurate to 1 per cent.) were 2·57 amps. and 5·57 volts.

Temperatures were recorded as follows :—

						max.	
Temperature ..	17·2	19·8	23·0	25·8	28·6	29·1	28·9 ° C.
Time	0	1	2	3	4	5	6 *mins.*

Room temperature = 15·0° C. Temperature rise = 11·9° C.

Time of flow of current t = 240 secs.

$\therefore$ Electrical energy used = $2{\cdot}57 \times 5{\cdot}57 = 14{\cdot}3_3$ watts.

The average temperature taken over the five minutes before the maximum temperature was recorded was 23·9° C. The radiation correction found in the previous experiment was 0·039 cals./sec.° C. difference in temperature.

$\therefore$ Heat lost by radiation = (23·9° C. — 15·0° C.) (300 sec.) (0·039)

= 104 cals.

Now Heat supplied electrically = Heat used in raising temp. of calorimeter and contents, + Heat lost by radiation.

$$\therefore \frac{ECt}{J} = \text{(Water equivalent) (Rise in temp.)} + 104$$

$$\frac{5{\cdot}57 \times 2{\cdot}57 \times 240}{J} = 60{\cdot}86 \times 11{\cdot}9 + 104$$

$$\frac{3435}{J} = 724{\cdot}2 + 104$$

$$\therefore J = \mathbf{4{\cdot}15 \text{ joules per cal.}}$$

Correct value = $4{\cdot}18_4$ joules per cal.

Estimated accuracy in temperature measurements = 1 per cent., on instruments = 1 per cent. each, on time = 0·3 per cent., and on radiation correction 0·3 per cent.

Measurements of the specific heats of liquids are carried out in precisely the same way as determinations of J.



A 87-720.

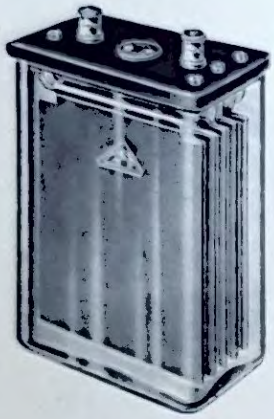


A 87-725.

A 87-720. VOLTAMETER, Copper. Two copper plates about 3 × 2 in. mounted on wood supports each provided with a terminal. In circular glass jar 5½ in. high × 3½ in. diam. — £ 0 7 6

A 87-725. VOLTAMETER, Copper, with double anode carried by an ebonite top with terminal. The cathode projects through a slot in the top and is fitted with a terminal. Each of the anode plates is provided with two ebonite distance pieces so that the possibility of internal short circuiting is eliminated. With glass jar 5 × 2¼ × 1⅞ in. .. .. .. — 0 17 6

Please use our Catalogue Numbers in your requisitions and orders. They are a complete specification of your requirements.



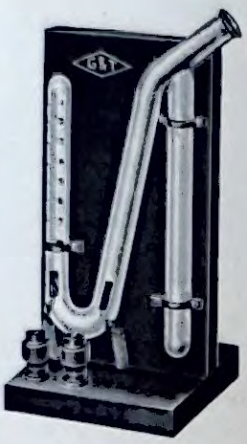
A 87-740—742.



A 87-760



A 87-765.



A 87-775.



A 87-780.

A 87-740. VOLTAMETER, Copper, Parsons (*School Sci. Rev.*, 1935, **17**, 171). Three thin sheet copper anodes and two cathodes, approx. 14 × 12 cm., are suspended from U-shaped copper rod bridges from which they are easily removed for cleaning and weighing. The bridges are attached to the underside of the ebonite cover of the rectangular glass box, the plates being clear of the bottom of the glass box for anode mud to collect .. £ 2 0 0

A 87-742. Anodes and Cathodes, Copper, only, for above .. .. .. *set of five plates* £ 0 17 6

The voltameter will pass currents up to 13 amps. so that reasonable deposits are obtained by passing a current for only a few minutes. If two sets of cathodes are used, one set can be dried and weighed while the other is receiving a deposit, so that it is possible to verify Faraday's First Law, or to calibrate an ammeter in a single forty-five minute period. The electrolyte is a saturated solution of copper sulphate (A.R.) containing 1 ml. per litre conc. sulphuric acid. The cathode should be thoroughly cleaned with emery paper before use and care taken to avoid touching the cleaned surfaces. The plates should be washed in water containing a few drops of conc. sulphuric acid, rinsed under the tap and dried between several thicknesses of blotting paper, as soon as possible after removal from the electrolyte to avoid oxidation.

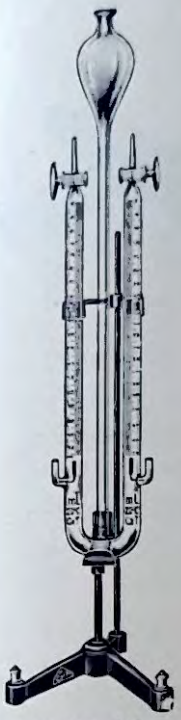
A 87-760. VOLTAMETER (Allen and Moore, *Text-Book of Practical Physics*, p. 530). Funnel 10 cm. diam. with nickel electrodes sealed in stem and with connecting wires. With two tubes 4 × ½ in., and spring clip for supporting tubes from a retort stand .. £ 0 6 6

A 87-765. VOLTAMETER, U-tube 4 × ½ in. with graduated tube 7 ml. × 0·1 ml., fitting inside each limb for collection of gas. Including platinum electrodes .. .. £ 0 18 0

A 87-775. VOLTAMETER (Schuster and Lees, *Intermediate Course of Practical Physics*, p. 221). A reversed N-shaped glass tube fitted with platinum electrodes, one limb being graduated to 8 ml. in 0·2 ml., mounted on a wood stand 4½ × 4 × 7 in. high, with Bakelite-shrouded terminals .. .. £ 2 0 0

The closed, graduated limb can be readily filled with dilute acid by filling the remainder of the apparatus and then filling it in the direction of the graduated limb. As gas collects in this closed limb, the displaced acid flows back into the right-hand limb. Designed for use quantitatively, to determine the electro-chemical equivalent of a gas, e.g. hydrogen or oxygen.

A 87-780. VOLTAMETER, Mixed Gas (Allen and Moore, *Text-Book of Practical Physics*, p. 527). A glass tube fitted with platinum electrodes, one limb being graduated to 60 ml. in 1 ml., mounted on a wood stand 5½ × 4½ × 9 in., with Bakelite-shrouded terminals .. £ 2 7 6



A 87-805—810.



A 87-815—818.

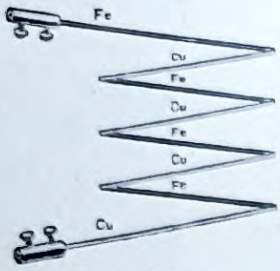


A 87-850.

	£	s.	d.
A 87-800. VOLTAMETER, Hofmann, ungraduated, with platinum electrodes, for use in the electrolysis of water. Limbs 50 ml. capacity, fitted with stopcocks. Mounted on special cradle stand with clamp for reservoir and with terminals	3	10	0
A 87-802. Ditto, glass parts only. **Without** stand	2	5	0
A 87-805. VOLTAMETER, Hofmann, graduated, with platinum electrodes, for use in the electrolysis of water. Limbs graduated 50 ml. in 0·2 ml., fitted with stopcocks. Mounted on special cradle stand with clamp for reservoir and with terminals	4	0	0
A 87-808. Ditto, glass parts only. **Without** stand	2	15	0
A 87-810. Metal Stand for **A 87-800—808,** with cradle support, clamp and terminals ..	1	5	0
A 87-815. VOLTAMETER, Hofmann, ungraduated, with carbon electrodes, for use in the electrolysis of hydrochloric acid or ammonia. Electrodes fitted with terminals and mounted in rubber stoppers inserted in ends of limbs 50 ml. capacity, fitted with stopcocks. Mounted on special cradle stand with clamp for reservoir tube and with terminals	2	15	0
A 87-818. Ditto, glass parts only. **Without** stand	1	5	0
A 87-825. VOLTAMETER, Hofmann, graduated, with carbon electrodes, for use in the electrolysis of hydrochloric acid or ammonia. Electrodes fitted with terminals and mounted in rubber stoppers inserted in ends of limbs, graduated 50 ml. in 0·2 ml., fitted with stopcocks. Mounted in special cradle stand with clamp for reservoir and with terminals ..	3	7	6
A 87-828. Ditto, glass parts only. **Without** stand	1	15	0
A 87-830. Metal Stand for **A 87-815—828,** with cradle support, clamp for reservoir and terminals	1	5	0
A 87-835. Electrodes, Carbon, for **A 87-815—828,** fitted with terminals and rubber stoppers *pair*	0	7	6
A 87-838. Ditto, Platinum, with rubber stoppers, for use in electrolysis of water *approx. pair*	0	16	0
A 87-850. VOLTAMETER, Goddard, for electrolysis of Hydrochloric Acid. U-tube 5 in. long, with rubber stoppers and carbon electrodes copper plated at top, is provided with a connecting tube and tap. A second U-tube 3½ in. long is connected to the electrolysis U-tube by glass tubing of smaller diameter and is supplied with rubber tubing and levelling bulb	1	10	0

Full instructions for using this apparatus are contained in Goddard, "*Fundamental Experiments in Chemistry*," pp. 51-60. Briefly, the right U-tube is half-filled with concentrated HCl, the carbon electrodes inserted, the plug of the tap removed and a current of approximately constant strength passed through the electrodes. A current of about 3·4 amp. flows and is continued for at least half an hour to saturate the electrolyte.

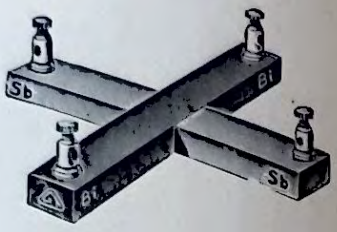
Without interrupting the flow of current, a saturated solution of $CaCl_2$ is run into the levelling bulb from which it passes into the V-tube. The plug of the tap is replaced and turned to the "off" position. The H_2 and Cl_2 evolved at the electrodes now pass down the connecting tubes and their volumes are measured by the fall in the levels of the calcium chloride solution, pressure being maintained at atmospheric inside the apparatus, by lowering the levelling bulb as electrolysis proceeds.



A 88-130.



A 88-135.



A 88-140.

A 88-125. THERMOCOUPLE, simple, copper-constantan wires, each 12 in. long, brazed together; to show the production of a thermo-electric current .. .. £ 0 2 0

A 88-130. THERMOPILE, simple, copper-iron, multiple. A number of copper and iron wires joined together form four thermo-junctions to be heated in a Bunsen flame, and three "cold" junctions. With brass connectors .. .. £ 0 9 0

A 88-135. THERMOCOUPLE, bismuth-antimony bars each about $3 \times \frac{1}{2} \times \frac{1}{8}$ in., mounted on board 4 × 3 in. .. .. £ 0 13 0

A 88-140. PELTIER CROSS, bismuth-antimony. Two thick bars joined together at the centre in the form of a cross. With terminals .. .. £ 1 7 6

When a current is sent across one of the junctions, a heating or cooling effect is produced depending on the direction of current flow, *i.e.* when current passes from the bismuth bar to the antimony bar, heat is absorbed at the junction; when it passes from antimony to bismuth, heat is evolved. The effect is observed from the deflections of a galvanometer connected with a D.P.D.T. switch across the junctions.



A 88-160.



A 88-170.



A 88-220.

A 88-160. THERMOCOUPLES, set of six wires of different material .. .. £ 0 17 6

Iron, brass, copper, platinum, manganin and constantan wires are connected to a small brass disc, mounted in a glass tube 6 × ¾ in., and insulated by means of mica rings. With the six wires fifteen different couples can be tested.

A 88-170. PLATINUM THERMOMETER (Noakes: *Text-Book of Heat*, pp. 15-16; Watson: *Intermediate Physics*, pp. 448-9). A thin platinum wire, resistance about 1 ohm, non-inductively wound on a mica frame is enclosed in a Pyrex glass tube, together with a pair of compensating leads. A Bakelite cap is fitted with two pairs of terminals for the platinum wire and the compensating leads .. .. £ 1 0 0

A 88-220. THERMOPILE, 12 pairs of plates, bismuth and antimony, in brass frame on lacquered brass foot 4 in. diam. With polished cone. Stand about 6½ in. high .. .. .. £ 5 5 0

THE MICROID THERMOPILE

A new robust design of exceptional sensitivity

SPECIFICATION

The pile consists of a series of junctions formed by copper plating half turns of flat spirals of constantan wire mounted on insulating bars. This compact unit is carried in a metal case supported on stand with universal joint. Apertures are provided in the case at the back and front, one being fitted with a large silver-plated cone with velvet lined cap and the other with a removable metal cap.

	£	s.	d.
A 88-230. MICROID THERMOPILE, plated wire type, on stand with universal joint, cone and caps	1	4	5 0

EXPERIMENTAL NOTES

An exceptional combination of qualities is secured by the plated wire construction in which the thermo-elements are formed by the junction of copper plated constantan wire with unplated constantan wire in a continuous series. The standard unit of 140 piles is only about 1 inch square. The method involves only four soldered joints as against two hundred and seventy-nine in the usual Bismuth-Antimony type with the same number of elements, and thus eliminates largely the possibilities of failure at these points and also maintains with a high degree of constancy the characteristics of the pile. It is very robust and can confidently be placed in the hands of students. The galvanometer spot takes its final position very quickly. Its unusual rapidity in response and good zero keeping quality arise from the fineness of the constantan wire used. It is, of course, remarkably sensitive owing to the large number of elements incorporated. With a suitable galvanometer, radiation from a Leslie's cube is easily detected and demonstrated.

This combination of desirable characteristics has so far been obtainable only in much more expensive instruments.

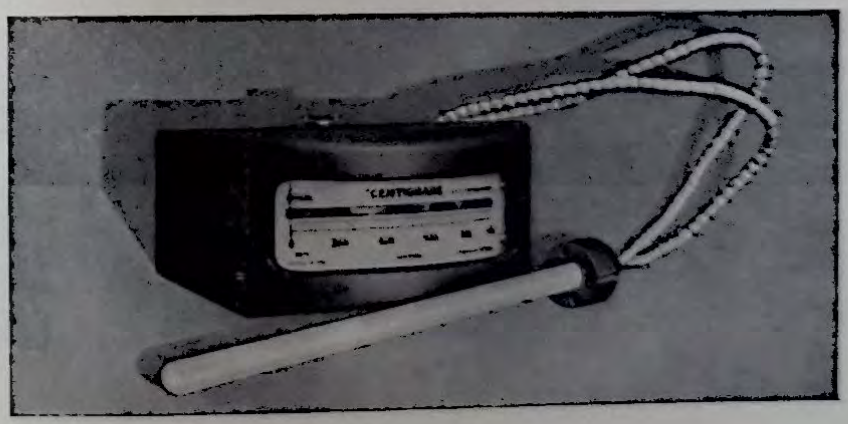


A 88-230.—Elements removed from case.



A 88-230.

Although the resistance of the Microid Thermopile is high compared with that of the usual bismuth-antimony types and it will, therefore, give good deflections with a galvanometer of comparatively high resistance, the best results are obtained on a low resistance galvanometer (Ansley: *Temperature Control* (1942), p. 78).

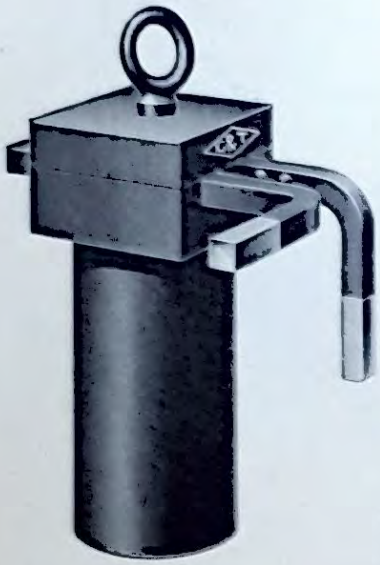


A 88-260.

	£	s.	d.
A 88-260. **PYROMETER OUTFIT, base metal,** 9 in. long Chromel-alumel thermocouple, enclosed in refractory sheath ⅜ in. outside diam. with metal fixing collar, extension leads 24 in. long, insulated with porcelain beads. Sector type indicator with anti-parallax mirror and 4 in. scale reading 0-700° C.	9	7	0
A 88-270. **Ditto, platinum, platinum-rhodium,** thermocouple, 10 in. long, for temperatures up to 1400° C., enclosed in refractory sheath ⅜ in. outside diam. with metal terminal head and fixing flange. Twin braided compensating cable 4 ft. long connected to terminal head, tags fitted to free end for attaching to indicator terminals. Temperature indicator as in outfit **A 88-260** but calibrated 0-1400° C.	14	0	8

THE MICROID THERMO-MAGNET

A Heavy Current Thermopile



A 88-320.

An impressive and very instructive illustration of the relatively heavy current produced under suitable conditions by thermo-elements.

SPECIFICATION

A loop of ½ in. square copper is fitted in slots between two iron blocks. Two constantan bridges connect the two limbs of the loop and form with it two thermo-couples connected in parallel. The bottom block is loaded to a weight of about 20 lbs. The upper block is fitted with a ring for lifting. The faces between the two blocks are accurately machined to ensure good contact. The ends of the couple loop are bent as shown in illustration.

A 88-320. MICROID THERMO-MAGNET, complete with copper loop and iron blocks .. .. £ 4 5 0

A 88-325. Test-Coil, 50 turns .. .. £ 0 10 6

EXPERIMENTAL NOTES

Constantan being of a much higher specific resistance than copper, two constantan bridges are used in parallel in order to keep the total circuit resistance low and so to increase the current.

The horizontal end of the loop is heated by a Bunsen or other burner and the vertical end immersed in water. The heat is rapidly conducted to one pair of thermo-junctions. Since the total circuit resistance is of the order of a few microhms, a current of, say, 100 to 150 amperes is readily produced, though the E.M.F. is only a few millivolts. The magnetic effect of this current passing through the loop, though it is only a "single turn," is such that the whole of this heavy apparatus may be lifted by the ring on the upper block.

To ascertain the minimum current to be produced by the thermo-couples to operate the apparatus, a coil of 50 turns of insulated wire may be substituted for the copper loop. When this coil is used, the current needed to operate the apparatus is about one ampere and will be one-fiftieth of that required when the loop is used.

The apparatus also illustrates Ohm's law from an unusual angle and affords an interesting example of the transformation of energy —thermal to electrical.

It may be observed that the loop is not insulated from the iron blocks, because the contact resistance is so much higher than the resistance of the loop itself.

The machined surfaces of the blocks, when not in use, should be protected from rust by greasing.

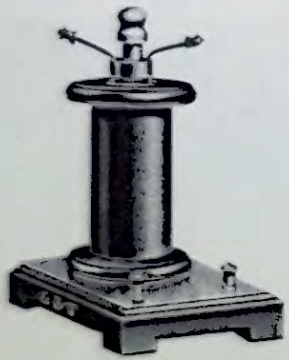
The **grease** should, of course, be **removed** before performing any experiment.

The upper and lower iron blocks are each marked with a dot on one of their sides. The dots should be opposite one another and care should be taken to ensure that the upper block rests firmly on the lower without leaving any air gap.

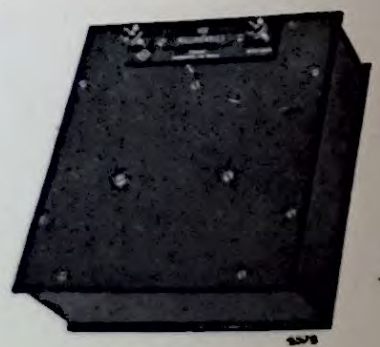
By structural modifications of this thermo-magnet, involving the addition of a platform to accommodate slotted weights, a total load of 100 kilos has been supported.



A 88-540.



A 88-545.



A 88-580.

A 88-540. INDUCTION COILS, demonstration. Secondary coil of insulated wire wound on wood former 5 × 1¼ in., primary coil of heavy gauge wire wound on former 5 × ⅞ in. and iron core 5 × ½ in. with wood knob .. .. £ 1 7 6

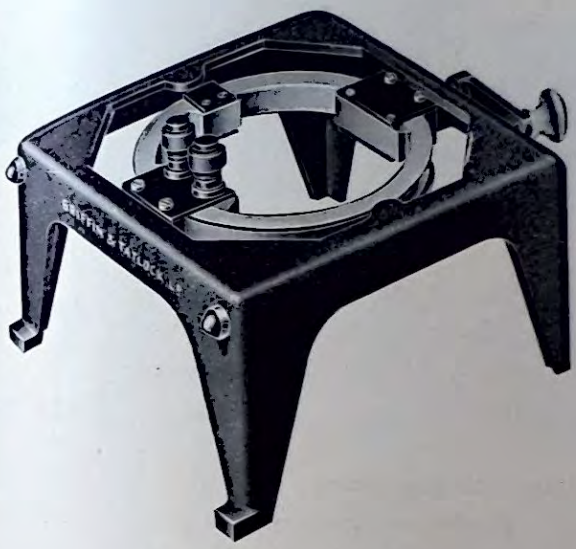
A 88-545. INDUCTION COILS, similar to **A 88-540.** Mounted on polished base 8 × 6 in., provided with terminals, fixed secondary coil 6 in. long, sliding primary coil of same length and iron core 5 × ⅝ in. with wood knob .. .. £ 2 17 6

A 88-580. SELF-INDUCTANCE STANDARDS, Cambridge, accurately adjusted at a frequency of 800 cycles per second, to a definite value. Wound with solid wire on mahogany bobbins, metal parts being reduced to a minimum to avoid changes in effective resistance. In case 18 × 18 × 10 cm.

	1	10	20	40	100	1000	*millihenries*
in	£2 19 10	£2 19 10	£4 8 7	£4 8 7	£4 8 7	£6 0 9	*each*

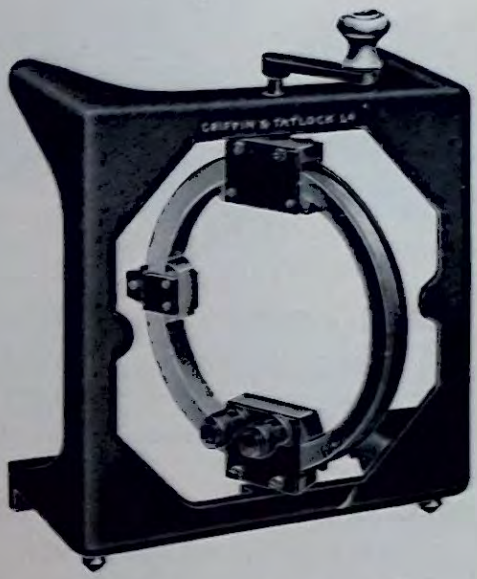
THE MICROID EARTH INDUCTOR

A modern, compact, all-metal production



Position for determination of V.

A 88-600.



Position for determination of H.

Interest attaches to the earth inductor from two points of view: its historical importance and its present day employment in the determination of the angle of dip.

In its traditional form, the earth inductor is unwieldy, though its dimensions have probably been controlled by the sensitivity of the galvanometers available. The greater sensitivity of modern galvanometers makes it possible to present the earth inductor in a compact, convenient form, and yet to obtain results which are at least comparable in accuracy with those obtainable with the larger models.

SPECIFICATION

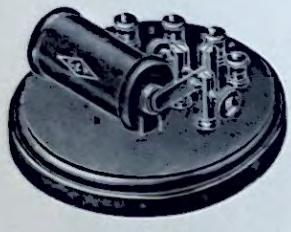
The present apparatus is noteworthy chiefly in regard to its small size and its all-metal construction.

The coil is wound on a metal former about 13 cm. internal diam. Blocks attached to this former carry spindles on which the coil is rotated, and a stop limiting the amount of rotation to 180°.

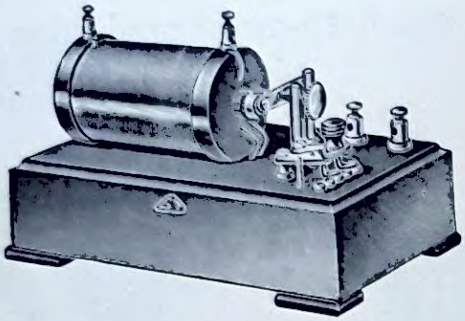
The cradle supporting the coil is about 22 cm. square by 11·5 cm. high and is cast in non-magnetic alloy. It may be placed either on its base or its side, so that the axis of rotation of the coil is either horizontal or vertical.

It has been found advisable to eliminate any form of commutator, so that continuous rotation is not possible. Terminals are mounted on one of the blocks. Positive connection is thus made between the coil and the external circuit.

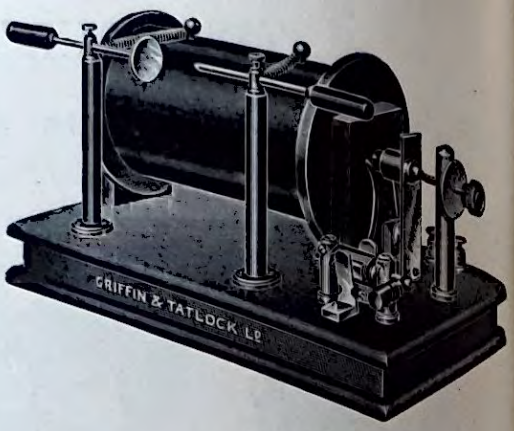
		£	s.	d.
A 88-600.	**MICROID EARTH INDUCTOR**, all metal, wound on metal former, with terminals and carried in non-magnetic cradle	8	10	0



A 88-650.



A 88-670.



A 88-680.

A 88-650. INDUCTION COIL (*cf.* Rae and Reilly: *Physico-Chemical Practical Exercises*, p. 226), for use in conductivity and other electrometric work. Mounted on circular polished wood base, with light, flexible trembler arm, platinum contact and tension screw for adjusting frequency of trembler, which operates almost inaudibly .. .. £ s. d. 3 15 0

A 88-670. INDUCTION COILS, with ordinary commutator, allowing primary current to be reversed but not allowing it to be switched off. Paraffin wax insulated throughout, adjustable trembler break, with silver contacts ; condenser in polished base.

Spark in air ..	6	12	20	*mm.*
Current ..	4 × 2	4 × 2	6 × 2	*volt* × *amps.*
	£3 5 0	£5 15 0	£6 10 0	*each*

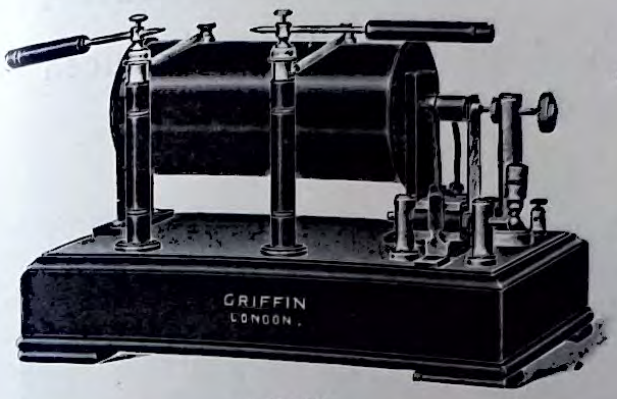
A 88-675. Ditto, with Ruhmkorff commutator, allowing primary current to be both reversed and switched on-and-off.

Spark in air ..	25	30	40	*mm.*
Current ..	6 × 2·5	6 × 3	8 × 3	*volts* × *amps.*
	£10 0 0	£11 0 0	£13 5 0	*each*

A 88-680. INDUCTION COILS, with Ruhmkorff commutator, better quality, wound with silk covered wire, mounted on polished base, condenser, discharge points mounted on ebonite pillars.

Spark in air ..	50	75	100	150	*mm.*
Current ..	8 × 4	10 × 6	10 × 7	12 × 8	*volts* × *amps.*
	£14 10 0	£15 5 0	£17 5 0	£22 10 0	*each*

The Microid Series is a range of distinctive designs in Scientific Apparatus for the demonstration of physical principles. These special models have been developed in our own Technical Department and in collaboration with independent authorities expert in their various subjects.



A 88-690.



A 88-710.

A 88-690. INDUCTION COILS, improved design and superior construction, coil mounted in ebonite end supports, condenser in polished mahogany base. Secondary wound with insulated wire in sections, highly insulated from each other. Ruhmkorff commutator, heavy platinum make and break, battery terminals.

Spark in air ..	25	50	75	100	*mm.*
Current ..	6 × 3	8 × 5	10 × 6	10 × 7·5	*volts × amps.*
r	£14 10 0	£20 10 0	£23 15 0	£25 15 0	*each*
Spark in air ..	.. ..	150	200	250	*mm.*
Current ..	.. ..	12 × 9	10–18 × 10	10–18 × 12	*volts × amps.*
r		£32 15 0	£42 0 0	£52 10 0	*each*

Coils giving 8 and 10 in. spark are provided with a three-section primary winding which can be connected for series or parallel operation. Discharge pillars with adjustable points as illustrated are fitted only on coils of 3 in. spark and over, below 3 in. the discharge points are fitted to terminals on the top of the coil.

Coils giving 3 in. spark and upwards are fitted with an extra pair of terminals for connection to a separate interrupter. (*Details of Interrupters on application.*)

A 88-710. HIGH FREQUENCY UNIT, an inexpensive source of high frequency, readily available for demonstration and experimental work, for determining the approximate vacuum in any glass system, for tracing minute leaks in glass vacuum assemblies and for short period operation of discharge tubes. The unit comprises a high tension transformer, suitably housed, with adjustment for regulating the high frequency output, high voltage lead in insulated handle. Supplied for any one voltage 100–250 A.C. or D.C. (*Please state voltage and current when ordering*) .. .. *tx* £4 1 6

HIGH FREQUENCY UNIT.—This provides an easy method of showing very approximately, the vacuum in glass systems, without the use of gauges connected in the evacuated system and without sealed-in metal electrodes. The high frequency discharge from the generator, in the case, is applied to the glass walls of the system being tested. A discharge takes place, the nature and colour of which, as shown below, give a rough indication of the vacuum present.

At 0·1 to 0·01 mm. Hg. .	red or violet light surrounds anode.
At increasing vacuum .	fading of the red and increase of the green light.
At about 0·001 mm. Hg. .	green fluorescence in the whole tube.
At higher vacuum . .	disappearance of the green fluorescence.

The unit also indicates leaks in glass apparatus. After exhaustion if the electrode is passed over the glass, leaks will be indicated by a bright spot of light where the discharge enters.

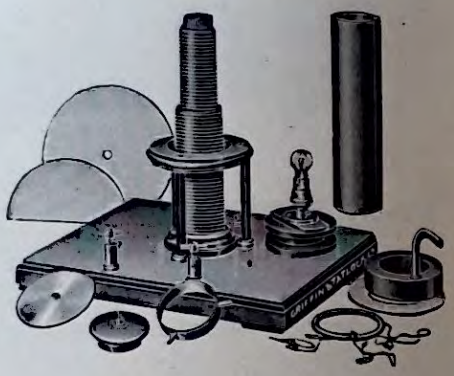
Customers abroad indenting through an agent would oblige by quoting our name and address in full, and sending a copy of order direct to us

INDUCED ALTERNATING CURRENT APPARATUS

A set of apparatus to demonstrate the properties of induced alternating currents

SPECIFICATION

A solenoid of heavy gauge insulated copper wire is wound on a core of soft iron wires 9 × 1½ in. and mounted on a polished baseboard 12 × 10 in. provided with terminals. A wood gallery on which an asbestos ring can be placed, surrounds the solenoid. The auxiliary apparatus with which the experiments are carried out include (**1**) a light aluminium ring, (**2**) a heavy copper ring attached to three cords fitted with spring clips, (**3**) a 4 volt lamp with flat induction coil and lampholder, (**4**) a copper disc 6 in. diam., (**5**) a semicircular copper plate 6 in. diam., (**6**) a wood cap with a pivot, (**7**) a copper disc 3 in. diam. with an agate centre, (**8**) a hollow copper annular ring 3½ × 2 × ⅞ in. with filling tube, (**9**) a brass cylinder 9 × 2¼ in.



A 88-750.

	£	s.	d.
A 88-750. INDUCED ALTERNATING CURRENT APPARATUS, with electromagnet mounted on baseboard, and with accessories enumerated above	11	0	0

EXPERIMENTAL NOTES

The electromagnet may be operated from a D.C. supply with a suitable current interrupter or from any A.C. supply which will carry 10-15 amperes at a pressure of at least 60 volts at the terminals of the coil. For alternating current very satisfactory results are obtained by transforming the mains supply to approximately 100 volts, and connecting to the coil in series with a suitable resistance. The following experiments are among those which can be performed.

I.—Repulsion by Induced Currents.

(*a*) Place the light aluminium ring on the platform and switch on the current through the solenoid. The ring will be thrown upwards and off the platform, due to the repulsion between the induced and inducing currents.

(*b*) Place the copper ring on the platform and hook the clips attached to the strings on to the eyes provided on the base. On starting the current the ring floats near the top of the core.

II.—Induced Current in a Coil of Wire.

Place the flat induction coil, with lamp in the socket, on top of the iron core, and switch on. The lamp lights. Interpose the 6 in. copper disc between the coil and the core. The lamp does not now light, due to the screening effect of the copper.

III.—Rotation of Copper Disc.

Place the wood cap, containing the pivot and 3 in. copper disc, on top of the iron core. The magnetic field is symmetrical with respect to the disc, which remains stationary. Hold the semicircular plate over the pivoted disc so that a diameter of each coincides. The magnetic field then becomes asymmetrical and the pivoted disc rotates. Turn the semicircular plate round the pivot as axis, and a position will be reached where the pivoted disc changes its direction of motion.

IV.—Heating Effect of Induced Currents.

(*a*) In I. (*b*) above, hold the copper ring down on the platform. It quickly becomes too hot to hold.

(*b*) Take the hollow copper annular ring and introduce about 10 ml. of water into it. Close the inlet tube with a cork and place on the asbestos ring on the gallery surrounding the coil. The contained water quickly boils, expelling the cork and issuing as steam.

V.—Effect of Self-Induction.

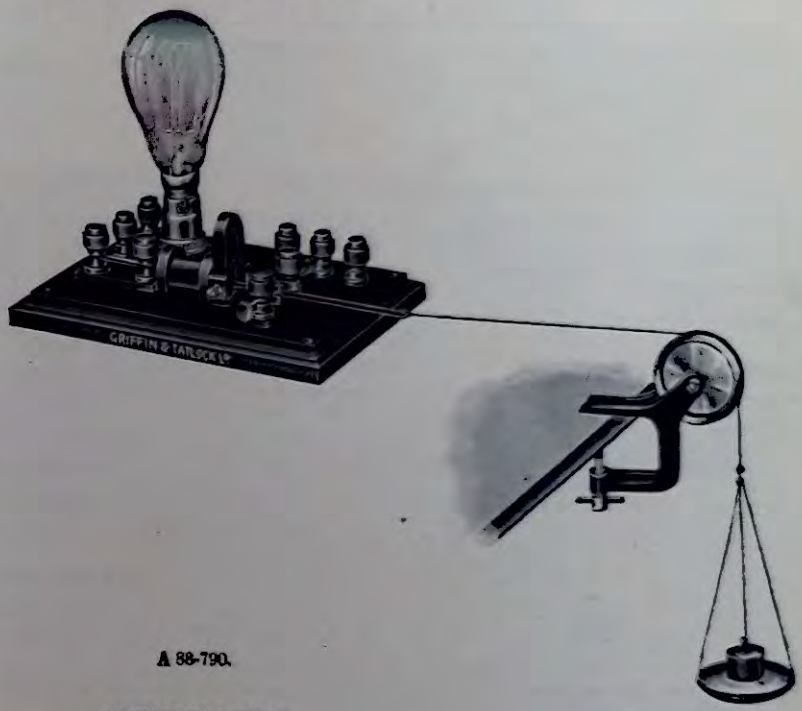
When the current is switched on in the primary circuit, a note may be heard corresponding in frequency with that of the supply. Lower the brass cylinder slowly over the coil, the note rises in frequency.

Leaflets on new apparatus supplementary to this catalogue are frequently published.
Names added to our Mailing List on request.

THE MICROID ELECTRICAL VIBRATOR

A quantitative apparatus for the measurement of capacities of condensers, electromotive force of cells, alternating current frequencies and for Melde's experiments

The apparatus is primarily designed to illustrate the laws of vibration of stretched strings directly and without tedious experimental adjustments. It is positive in action and its accuracy is remarkable. The experiments can readily be followed by a large class. The experiments with condensers rely on fundamental definitions and the theory is easily followed by beginners. They form a good introduction to the study of capacity. At the same time, the capacity is readily found for a wide range of condenser values, merely from the reading of a galvanometer.



A 88-790.

SPECIFICATION

A steel rod about 9 in. long and 1/16 in. diameter is used as a vibrator and is adjustably clamped near one end so that the length of its vibrating portion can be varied. It passes through the centre of a solenoid and then between the poles of a specially constructed magnet. The solenoid is wired in series with a suitable lamp so that direct connection may be made from the A.C. mains.

Adjustable contact points are provided, one at each side of the vibrator to make alternating electrical connection with a third contact on the steel rod. Each of the three contacts is wired to a separate terminal. The steel rod has a small hole drilled at one end for the attachment of string. The whole is mounted on a polished ebonite base.

	£ s. d.
A 88-790. MICROID ELECTRICAL VIBRATOR, comprising solenoid, vibrator, permanent magnet, terminals labelled "galv.," "cond." and "batt.," the whole mounted on a polished ebonite base, with pulley, clamp and scale pan	5 10 0
Lamps, mains voltages suitable for use with above, ...	see A 58-360.

EXPERIMENTAL NOTES

The apparatus is designed to make use of the standardisation of the frequency of the A.C. supply as a basis of time measurement.

When an alternating current passes through the coil, the vibrator is magnetised longitudinally with polarity which reverses as the current changes sign. The interaction with the field of the permanent magnet sets up lateral forces tending to make the rod vibrate with the frequency of the mains. If now the length of the rod is slowly adjusted, a position will be found when the frequency of its vibrations is the same as that of the A.C. supply. For this position of resonance a satisfactory amplitude of vibration is maintained.

To illustrate the laws of vibration of stretched strings, a length of thread is attached to the vibrator, is then passed over a pulley and has weights attached to the free end. The thread, which should be as long as is conveniently possible, vibrates in segments when the vibrator is in operation. The wavelength may then be measured.

Since the frequency of the mains is constant and since $n = \frac{1}{\lambda}\sqrt{\frac{T}{m}}$

where n = frequency
λ = wavelength
T = tension
m = mass of thread per unit length.

we have to show that the right-hand side of the equation remains constant for different values of T and m.

[continued overleaf

A 88-790. The Microid Electrical Vibrator—*continued.*

Expt. No. I.—To show that $n \propto \sqrt{T}$.

A 20-gram load is fixed to the free end of the thread and the corresponding wavelength measured. The load is now increased to 80 grams and it is found that the wavelength is doubled whilst with 180 grams load the wavelength is three times the initial length.

Expt. No. II.—To show that $n \propto \sqrt{\frac{1}{m}}$.

Different kinds of thread, cotton and string are used with the same load and the masses of equal multiples of wavelengths compared. Then :—

$$\frac{\sqrt{m_1}}{\sqrt{m_2}} = \frac{\lambda_2}{\lambda_1}$$

Expt. No. III.—To find the actual frequency of the A.C. mains.

The thread is set vibrating with various loads and observations made as shown in the specimen result below.

Specimen Result.

Length of thread (l) = 816 cm.
Mass of thread = 0·5289 gm.
Mass of thread per unit length (m) = 0·0006466 gm./cm.

Tension in thread T (gms. wt.)	No. of loops S	Wavelength $= \lambda$ cm. $= \left(\frac{2l}{S}\right)$	Frequency $= \frac{1}{\lambda}\sqrt{\frac{T \times 981}{m}}$
28·1	25	65·44	99·72
33·1	23	71·12	99·56
38·1	22	74·36	102·2
43·1	20·25	80·78	100·1
48·1	19·5	83·9	101·7
53·1	18·25	89·64	100·1

Average frequency of supply = 100·56 ∽ per sec.
Stated frequency of supply = 100·00 ∽ ,,

Expt. No. IV.—To determine the capacity of a condenser.

The apparatus lends itself to a straightforward and rapid determination of capacities ranging from those of simple parallel plate condensers to those of the order of microfarads.

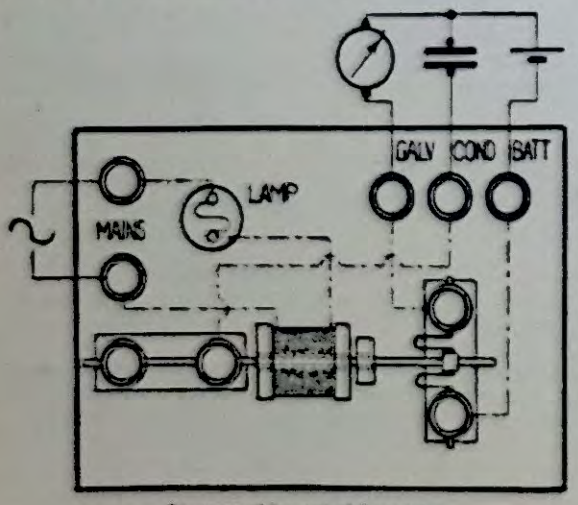


Diagram of layout of Apparatus.

Theory.—The condenser, a battery of known voltage, and a galvanometer are connected as shown. When the rod vibrates it makes contact during one half cycle between the battery and the condenser and charges the latter to the voltage of the former. During the next half cycle the condenser is discharged through the galvanometer. This is repeated f times per second where f is the frequency of the supply. At each discharge there passes through the galvanometer a certain quantity, Q, of electricity given by the equation $Q = CV$

where C = capacity and V = potential

$\therefore$ Quantity of electricity *per sec.* passing through condenser $= CVf$

But $Q = tI$ and since for f charges *per sec.* t = unity,

$$\therefore Q = I.$$

Hence $I = CVf$

$$\therefore C = \frac{I}{Vf} \quad \text{That is, capacity} = \frac{\text{Current}}{\text{Voltage} \times \text{frequency}}$$

It is essential that the galvanometer used should be deadbeat, and in this case the reading of the instrument is perfectly steady. For capacities below the order of 0·01 μF a Microid Adaptable Galvanometer (**A 84-150,** 50 ohm) is recommended, whilst for large capacities of the order of 1 μF a milliammeter is satisfactory, (*e.g.*, **A 85-320,** 2–0–2 milliamps.).

Specimen Results.

(*a*) **Two microfarads wireless condenser.**

E.M.F. of battery = 9 volts
Reading of milliammeter = 1·8 milliamps.
Frequency of supply = 100 ∽ per sec.

$$\text{Capacity} = \frac{\cdot 0018}{9 \times 100}$$

= **2 microfarads.**

(*b*) **Parallel plate (wireless) condenser** with semicircular vanes.

Stated maximum capacity = ·001 μF
E.M.F. of battery used = 9 volts.

Dial reading (degrees)	90°	75°	65°	55°	45°
Current in microamps.	1·01	0·86	0·76	0·66	0·56
Capacity in microfarads	·0011	·0009	·0008	·0007	·0006
Dial reading (degrees)	**35°**	**25°**	**15°**	**5°**	**0°**
Current in microamps.	0·46	0·33	0·23	0·13	0·06
Capacity in microfarads	·0005	·00036	·00025	·00015	00007

Expt. No. V.—To compare the E.M.F.'s. of two cells.

If the apparatus is fitted up as in Expt. IV. we know that

$$\text{Capacity} = \frac{\text{current}}{\text{E.M.F. of battery} \times \text{frequency}}$$

or

$$\text{E.M.F. of battery} = \frac{\text{current}}{\text{Capacity} \times \text{frequency}}$$

If the condenser is unaltered and a reading is obtained first with a Leclanché Cell and then with a Daniell Cell :—

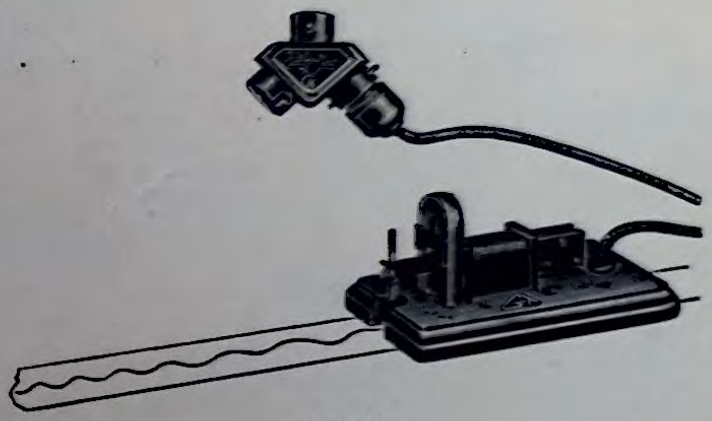
$$\frac{\text{E.M.F. of Leclanché}}{\text{E.M.F. of Daniell}} = \frac{\text{1st Current}}{\text{2nd Current}}$$

For full scale deflection on the Microid Galvanometer **A 84-150,** 50 ohm, deadbeat, it is convenient to use a condenser of one microfarad (approximately) with a supply of frequency 50 cycles.

THE MICROID MOBILE A.C. FREQUENCY APPARATUS

A simple, inexpensive apparatus for use as a time-marker and in the direct measurement of the frequency of an A.C. supply

This apparatus forms a compact and convenient device for measuring the frequency of the A.C. mains in a simple, direct manner, that is easily appreciated by pupils. The apparatus has other interesting and useful applications, among which may be mentioned its use as an accurate time-marker of known periodicity in determinations involving a free fall, moments of inertia of rotating bodies, speed of an electric motor, reaction time, etc.



A 88-820.

SPECIFICATION

A spring steel strip, about 4 in. long and provided with an ink-brush, is adjustably clamped between two plates firmly mounted on a polished wood base about 5½ × 3 in. The steel strip passes through a solenoid connected in series with a 15 watt metal filament lamp run from the 200–250 volt A.C. mains. A two-way series lamp adapter is supplied for the purpose. A permanent horse-shoe magnet is clamped to the end of the solenoid. The base of the apparatus is fitted with three smooth steel studs in order that it may slide easily over a paper on which the trace of the brush is recorded.

N.B.—The apparatus must not be connected direct to the mains without the use of the series adapter.

		£	s.	d.
A 88-820.	**MICROID MOBILE A.C. FREQUENCY APPARATUS.** Wooden base about 5½ × 3 in. fitted with smooth steel studs and carrying solenoid, permanent magnet and vibrator with brush. Complete with 6 ft. flexible wire connection and two-way lampholder. Without lamp	1	2	5 0
A 88-825.	**Lamp**, for above, 15 watt, metal filament, vacuum, clear, b.c. cap ..	(a)	1	0 2 1

Please state voltage when ordering.

EXPERIMENTAL NOTES

When an alternating current is passed through the coil the steel vibrator is longitudinally magnetised with a polarity which reverses as the current changes sign. The interaction with the field of the permanent magnet causes alternate attraction and repulsion of the brush-holder, which therefore vibrates with an amplitude which may be increased by adjustment of its free length until it is in resonance with the frequency of the mains supply.

[*continued overleaf*

A 88-820. The Microid Mobile A.C. Frequency Apparatus—*continued.*

To determine the frequency of A.C. Mains.

The simplicity of the method is such that little explanation is needed.

The brush is inked and one student commences to draw the apparatus slowly over the surface of a long sheet of paper. Immediately after this motion has started, another student switches on the current and starts a stopwatch; the ink-brush traces waves which are recorded on the paper. After ten seconds or more, the current is switched off and simultaneously the watch is stopped. The number of complete waves traced by the vibrator is counted and divided by the time taken, *e.g.* in one experiment 1001 waves were traced in 20 seconds. The frequency of the A.C. supply therefore equalled $\frac{1001}{20}$ or 50·05 ∿ per sec.

The accuracy depends upon the time interval employed. Experience has shown that if this exceeds ten seconds the average results lie between $50 \pm 0{\cdot}1$. The brush provided gives a perfectly clear wave for wavelengths as small as 1 mm. This means that the apparatus may be moved as slowly as 5 cm. per second and a ten-second run is easily recorded on a paper one metre long. A length of paper as used on a cash register is convenient for recording a long run.

Specimen Results.

Time of run : secs.	10	10	10	10	10
No. of Waves .	491	504	492	507	506
Frequency .	49·1	50·4	49·2	50·7	50·6

Average value of frequency = 50 ∿ per sec.

Alternative Method.

This method, although not so direct as the previous one, avoids the necessity of counting a large number of waves. A cardboard disc is placed on the turntable of a gramophone and the steady speed of the latter is determined by a stopwatch. The current is switched on to the vibrator, which is then allowed to touch the revolving disc. From the resulting trace, the number of vibrations per revolution is determined. Since the time of one revolution is known the number of vibrations per second can be found.

The gramophone and disc of the Microid *g* Apparatus **A 22-900**, p. 48, may be usefully employed for this method.

To determine the value of *g*.

A piece of wood, 2 feet long and 3 inches wide, is held vertically and the vibrator, also fixed vertically, is placed so that the brush just bears on a sheet of paper fixed to the board. The current is switched on and the board then allowed to fall as in the conventional falling plate experiment. On the resulting trace, distances s_1 and s_2, which contain the same number of waves, are marked off in the usual manner. Then, from standard velocity formulæ :—

$$g = \frac{s_2 - s_1}{n^2} \times 50^2,$$

where *n* is the number of waves.

Specimen Results.

s_2 cms.	9·55	13·6	15·55	31	36·6
s_1 cms.	4·8	10·1	9·2	16·9	17·3
n	3½	3	4	6	7
g	970	972	992	979	985

Average value of g = **980 cm./sec.²**

Time Marker Application.

To determine the Moment of Inertia of a Flywheel, the conventional flywheel is used, but the vibrating arm is replaced by the electrical vibrator. The time taken to trace each wave is known accurately to 0·02 seconds. A good trace can be obtained by holding the apparatus in the hand with the brush bearing lightly on paper wrapped round the flywheel. Gummed paper as used for parcels can easily be fixed to the flywheel.

To measure the Speed of a Motor.

A stout circular cardboard disc is fixed to the shaft of the motor and the vibrator is fixed, or held, so that the brush bears on the flat surface of this disc. If the motor is of a slow speed type it is switched on and when it has reached its steady speed, the current energising the vibrator is switched on for a short period. This period should be less than that taken for one revolution or waves will be superimposed. The number of waves traced in half a revolution can be counted and the speed determined. Alternatively, with a high speed motor, a record of the acceleration of the motor from rest to steady speed may be obtained as follows :—Place the brush in contact with the disc near the circumference. Switch on the current to the vibrator and slowly move it towards the centre of the disc. Start the motor. The waves of the resulting trace lie on a spiral from which the speed for successive revolutions can be found.

The appended results, obtained by placing a cardboard disc on the turntable of a gramophone, indicate how quickly the latter attains a constant speed.

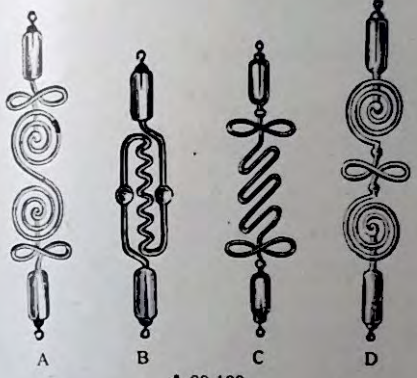
Rev. No. . .	1	2	3	4	5	6
No. of Waves . .	85	44	37	36·5	36·5	36·5
Time for 1 rev. : secs	1·7	0·88	0·74	0·73	0·73	0·73

Measurement of Reaction Time.

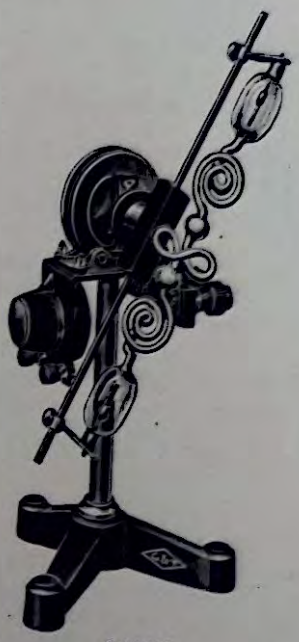
The student runs the apparatus over a long strip of paper and at the same time watches the lamp, which is in series with the vibrating coil. A metre rule may be placed on the paper as a guide. The operator switches on and the student, seeing the lamp light up, pushes the vibrator to one side as quickly as he "reacts." The number of waves on the straight portion of the trace is a measure of his reaction time. This furnishes an interesting experiment for "Open Days."

All Microid Apparatus is approved after exacting test by our technical staff.

Atomic Physics



A 89-130.



A 89-140.



A 89-205.



A 89-210.

A 89-130. TUBES, Geissler, in a variety of forms, in clear and uranium glass for showing the effect of an electric discharge in a rarefied gas. British made.

Length	10	20	30 *cm.*
	10/6	12/6	15/- *each*

Please state shape required, A, B, C or D.

A 89-140. ROTATOR for Geissler Tubes. A tripod base is fitted with a stem carrying a metal platform on which a small electric motor is mounted. Small terminals and a series rheostat for control of the motor speed are fitted to a metal panel at one side and bakelite shrouded terminals for connection to the induction coil are mounted on an insulated strip at the other side. Attached to the motor spindle is an ebonite slip ring with brush, the induction coil circuit being completed via the frame of the motor. Arms, each 5½ in. long, with spring clips for holding the Geissler tube, are provided. Complete with 20 cm. Geissler tube .. .. £ s. d. £3 15 0

The motor operates on voltages between 2 and 8 but, in conjunction with the rheostat fitted, 2 volts gives a satisfactory range of speed for this purpose. The Geissler tube should be placed symmetrically on the rotating arm so that the motor is not unbalanced.

The principle of the stroboscope may readily be demonstrated. When the speed of the motor bears an integral relationship to the frequency of the coil discharge, the circle traced out by the rotating tube is divided into a stationary segmental pattern, the number of segments formed depending upon the integer.

This method has been, and is being, applied to the accurate determination of motor and dynamo speeds using a standard, fixed frequency-regulator, such as a tuning fork, or a standard, variable frequency-regulator such as a calibrated monochord.

A 89-205. VACUUM TUBE, containing a single mineral, **phosphorescing** under the influence of the cathode stream. Cylindrical form about 30 cm. high, 4 cm. diam.

Price on application.

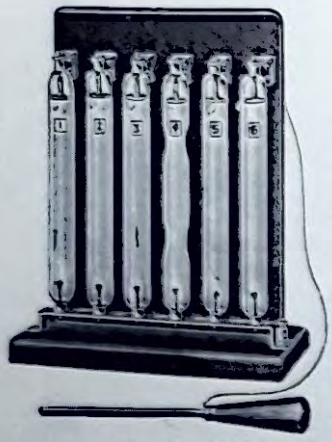
A 89-210. VACUUM TUBE, about 5 in. long, containing a number of pieces of various brilliantly **phosphorescing** minerals. On wood foot .. .. *Price on application.*

A 89-250. VACUUM TUBE to demonstrate the various phenomena of electrical discharge at reduced pressures. With two electrodes and stopcock for connection to vacuum pump.

Length × diam.	25 × 4	50 × 4 *cm.*
	32/6	35/- *each*



A 89-250.



A 89-270—272.

A 89-270. **VACUUM SCALE, Cross.** Six tubes about 20 cm. long, exhausted to different degrees of evacuation, mounted on stand about 9 × 4 in. Overall height about 11½ in. .. £ 2 10 0

A 89-272. Ditto, without stand .. .. £ 1 10 0

No. 1—40 mm. pressure : Violet band at anode and radiating luminous thread.

No. 2—10 mm. „ : Broadening of thread and beginning of positive column.

No. 3—6 mm. „ : Cathode glow, positive column and Crookes dark space.

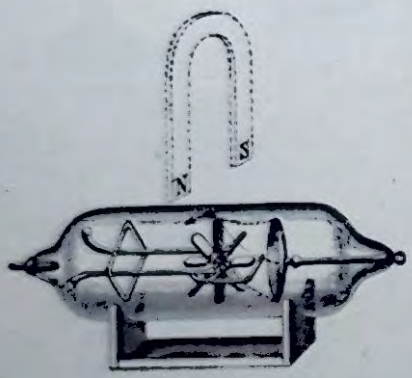
No. 4—3 mm. „ Stratification and beginning of Faraday dark space.

No. 5—0·14 mm. „ : Bluish green fluorescence on tube.

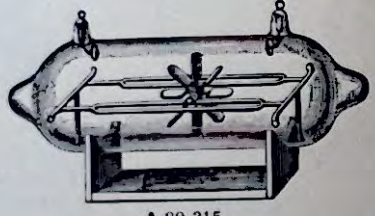
No. 6—0·03 mm. „ Cathode rays and green fluorescence of tube.



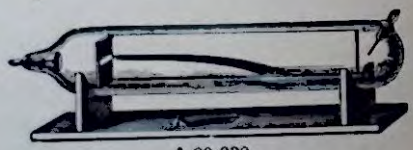
A 89-305.



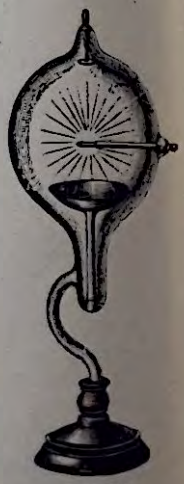
A 89-310.



A 89-315.



A 89-320.



A 89-325.

A 89-305. TUBE, Crookes', containing a hinged light metal cross. Length about 30 cm. Complete on wood foot .. .. *Price on application.*

If the cross is allowed to stand normally to the cathode stream, a sharp shadow will be formed at the end of the tube. After a while, if the cross be shaken down, the part of the tube which was formerly in shadow will fluoresce more brilliantly than the surrounding parts. The glass fatigues with the bombardment and ceases to fluoresce as brilliantly as at first.

A 89-310. MILL WHEEL TUBE, Crookes', about 30 × 5 cm., for demonstrating the deflection of the cathode rays by a magnetic field. If the rays are not deflected they impinge equally on the top and bottom vanes and the wheel does not rotate. On wood stand. *Price on application.*

A 89-315. RAILWAY TUBE, Crookes' (Thomson: *The Conduction of Electricity through Gases*, p. 7), about 30 × 5 cm., in which a light wheel with mica vanes is mounted on glass rails. Complete on wood stand .. .. *Price on application.*

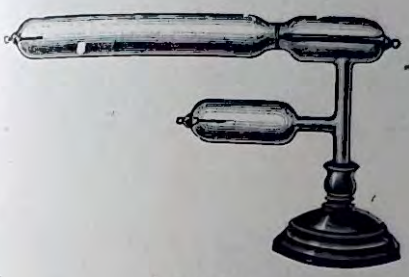
When a discharge passes through the tube the cathode rays strike the upper vanes and the wheel rotates and travels away from the cathode. The motion is probably due to an effect similar to that observed in the radiometer, as the impact of the rays makes one side of the vanes hotter than the other.

A 89-320. TUBE, Crookes', about 30 × 5 cm., to show that the cathode stream is deflected by a magnetic field. On wood stand .. .. *Price on application.*

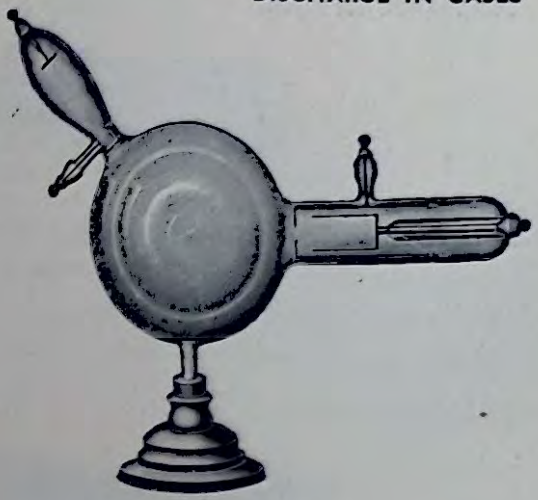
A 89-325. TUBE, Crookes', to demonstrate the thermal effect of cathode rays, with a piece of platinum foil at the focus of the concave spherical cathode. When a discharge is passed through the tube, the bombardment heats the platinum foil to incandescence. Bulb diam. about 12 cm. On wood foot .. .. *Price on application.*



A 89-340.



A 89-345.



A 89-360.

A 89-340. TUBE, Crookes', about 30 × 5 cm., to show the repulsion between two cathode streams. Complete on wood stand .. .. *Price on application.*

When one of the disc electrodes alone is made the cathode, the path of the rays is shown in the illustration by the dark lines. When both of the electrodes are cathodes simultaneously, the paths are indicated by the dotted lines. The divergence of the streams in this case was considered by Crookes to be due to the repulsion between the negative charges of electricity travelling with the rays.

A 89-345. TUBE, Goldstein, to show the existence of Canal rays. Large tube about 30 × 4 cm. On wood foot .. .. *Price on application.*

The cathode is perforated and the Canal rays are observed as luminous streams passing through the holes in the cathode on the side remote from the anode. These rays are only slightly deflected by a magnet and excite a slight phosphorescence, usually of a mauve colour, on the walls of the tube. The cathode rays will be observed, proceeding, as usual, from the surface of the cathode towards the anode.

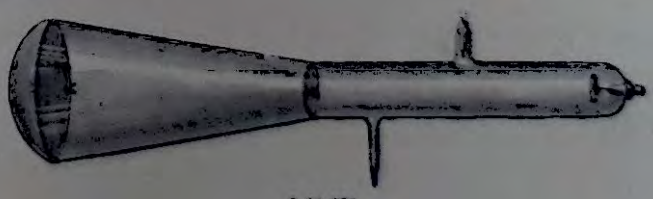
The light emitted by the stream of canal rays may be used to show the Döppler effect. If the stream is pointed towards a spectroscope, a line is observed shifted towards the violet end of the spectrum, due to its high velocity. If the stream is in the reverse direction, the shift is towards the opposite end of the spectrum. When the stream is perpendicular to the collimator axis of the spectroscope, the shift is absent. (Wood: *Physical Optics*, 1934, 3rd Edn., p. 27.)

A 89-360. VACUUM TUBE, Perrin-Thomson, with bulb about 20 cm. diam., to demonstrate that the cathode rays carry a negative charge. Complete on wood foot .. *Price on application.*

The top left-hand electrode is made the cathode and the one below it, the anode. In the long tube at the right, there are two coaxial metal cylinders. The inner one should be connected to an electrometer and the outer, screening cylinder, to earth.

On starting the discharge, a phosphorescent spot appears on the wall of the tube diametrically opposite to the cathode.

The cathode rays are then deflected by means of a magnet until the beam falls on the aperture in the screening cylinder. The electrometer then becomes charged and investigation of its polarity by means of a coil, will indicate that the charge is negative.

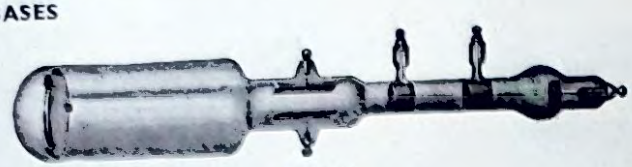


A 89-370.

A 89-370. CATHODE RAY TUBE, Braun, with diaphragm which allows only a narrow beam of the cathode rays to strike the phosphorescent screen at the end of the tube. Length about 40 cm., maximum diam. about 7 cm. .. .. .. *Price on application.*

A 89-372. Support, Wood, for above .. .. *Price on application.*

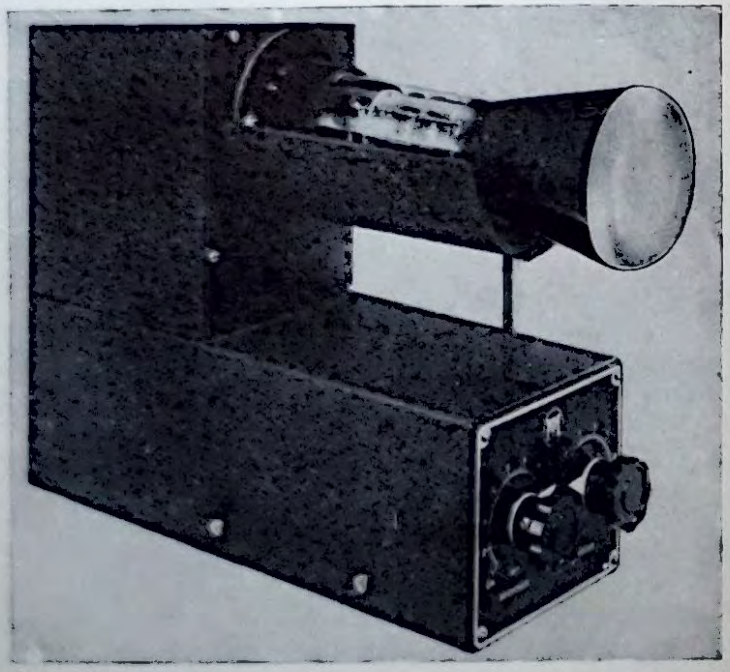
The deflection of the rays by a magnet is clearly demonstrated with this tube and in a variable magnetic field the change of position of the spot of light on the screen will indicate the variations of the field. The wave form of an alternating current can be delineated with this tube.



A 89-380.

A 89-380. CATHODE RAY TUBE, Thomson, with phosphorescent screen on aluminium plate for measuring the deviation of the cathode rays by electrostatic and magnetic fields. With this apparatus the ratio of the charge to the mass of the electron can be determined. Length about 60 cm., diam. about 10 cm. .. .. *Price on application.*

A 89-382. Support, Wood, for above .. .. *Price on application.*



A 89-405—410.

A 89-405. CATHODE RAY TUBE UNIT. [3 in. diam. high vacuum cathode ray tube, built-in power supply for heater and 800 volts high tension, for use direct from 50 cycle mains and adjustable for any voltage between 100 and 250. Control potentiometers for brightness and focussing mounted on front panel ; terminals for all four deflector plates and final anode (at earth potential) fitted at back of instrument casing. Magnetic screen under tube shields it from the mains transformer field. In ripple finish metal casing ..tx £ 12 12 0

A 89-410. Cathode Ray Tube, spare, for above .. ..tx £ 3 10 0

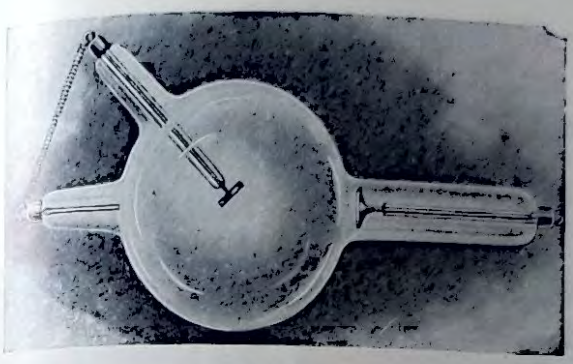
SPECIFICATION

Mains Input (50 c/s.)	100–130 and 200–250 volts.
Power Consumption (approx.)	15 watts.
Final Anode Potential (approx.)	800 volts.
Vertical Deflection Sensitivity (approx.) ..	0·2 mm./volt.
Horizontal Deflection Sensitivity (approx.) ..	0·2 mm./volt.

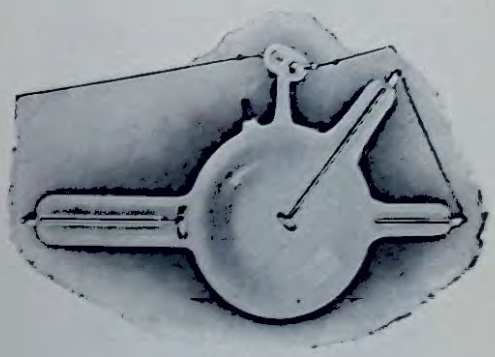
Dimensions :—

Length (over Knobs and Terminals)	13 in.
Width	4½ in.
Height	8½ in.
Weight (approx.)	9½ lbs.

When the majority of applications of the cathode ray tube call for a complete equipment, including a vertical deflection amplifier and a linear time base generator, there are many occasions when the tube only is required for demonstration. The Cathode Ray Tube Unit **A 89-405** has been designed with this in view. In schools and technical colleges it may be used with great advantage to illustrate alternating current theory, while its low price makes it possible for each laboratory group of students to have its own cathode ray tube and so become familiar with the use of a most valuable tool.



A 89-620.



A 89-625.

A 89-620. **X-RAY TUBES,** without vacuum regulator, for use with small coils and for light therapeutic work, with currents of 0·5 to 1 milliamp.

Diam. of bulb ..	65	80	100	125	150	*mm.*
Spark length of coil	4–8	8–10	10–12	15	20	*cm.*
t	£3 10 0	£4 0 0	£4 15 0	£6 5 0	£7 10 0	*each*

A 89-625. **Ditto,** but fitted with vacuum regulator.

Diam. of bulb ..	65	80	100	150	170	*mm.*
Spark length of coil	4–8	8–10	10–12	20	25	*cm.*
t	£4 5 0	£5 0 0	£5 15 0	£9 0 0	£10 10 0	*each*

X-Ray tubes are termed soft, medium, or hard, in order of progressively higher evacuation. Soft tubes are more easily started than hard tubes, but the latter suffer less from overrunning than the former. All tubes, however, tend to become harder in use, due to occlusion of the residual gas by the parts of the tube.

Accordingly, it is desirable that some device should be fitted to the tube so that the degree of exhaustion can be regulated and hard tubes softened for convenience in starting.

The regulating device in tubes **A 89-625** consists of a plug of asbestos tissue, on which gas is occluded, contained in a small bulb connected to the main bulb. Wires are fitted to the tube and can be brought near to the anode and cathode terminals proper. If the tube be hard, the discharge first passes through the asbestos tissue and liberates gas, which softens the vacuum in the main tube through which the discharge can then pass. The wires are then removed from proximity to the anode and cathode terminals.

A 89-650. **FLUORESCENT SCREENS, Barium Platino-cyanide.** Mounted in wood frames, with Bakelite backing.

Size of screen	4 × 4	7 × 5	8 × 6	10 × 7	12 × 9	*in.*
t	£2 0 0	£3 11 6	£5 0 0	£7 3 0	£11 0 0	*each*

Prices subject to market variation.

A 89-655. **FLUORESCENT SCREENS, white salt** (calcium tungstate), fluorescing green. Mounted in wood frames, with Bakelite backing.

Size of screen	4 × 4	7 × 5	8 × 6	10 × 7	12 × 9	*in.*
t	17/6	£2 0 0	£2 10 0	£3 12 6	£5 10 0	*each*

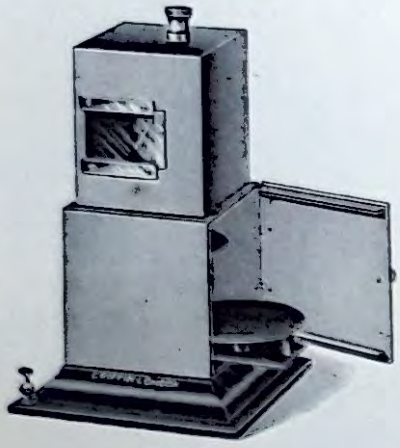
A 89-670. **LEAD GLASS PLATES,** for use with **A 89-620–625,** to protect the observer from X-rays, standard thickness of glass 10 mm., giving a lead equivalent of 2·5 mm.

Size of plate	4 × 4	7 × 5	8 × 6	10 × 7	12 × 9	*in.*
t	18/6	£1 0 0	£2 15 0	£4 0 0	£6 15 0	*each*

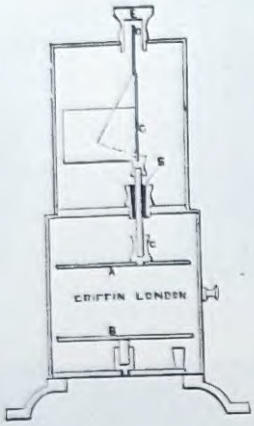
The screen should be enclosed between a sheet of lead glass and a Bakelite plate for two purposes. The Bakelite plate prevents pressure upon the material on which the fluorescing crystals are deposited, which pressure reduces the fluorescence of the part involved. The X-Rays can pass readily through the Bakelite. The lead glass, placed on the side nearer the observer, protects him from the harmful effects of the X-Rays.

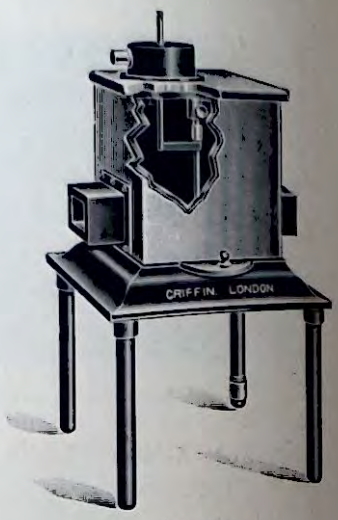
Screens should not be exposed to excessive heat or humidity.

A 89-675. **INTENSIFYING SCREENS,** .. .. *Prices on application.*



A 89-810.





A 89-820.

A 89-810. ELECTROSCOPE, Alpha Ray, as designed by Lord Rutherford, for the accurate comparison of activities measured by α rays. Made of aluminium, mounted on cast iron base 10 in. high × 6½ in. square at base. Fitted with reading microscope with micrometer scale eyepiece .. .. £ 27 0 0

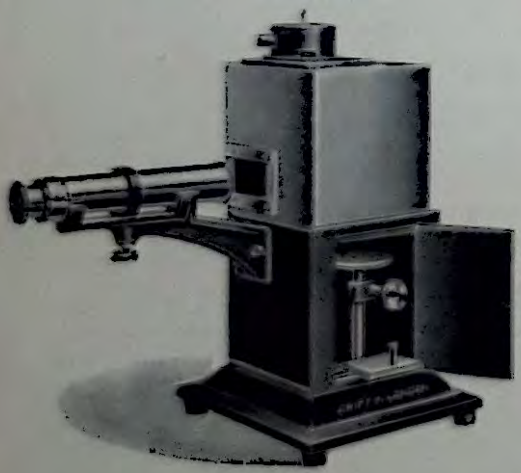
The instrument consists of two parallel plates, A and B. A is connected to the gold or aluminium leaf system C, through the sulphur cone S, plate B is connected to the base. It is charged by touching the projecting rod D, which after charging is covered by the meta cap E. The material to be tested is placed in a suitable metal vessel on the lower plate B, which is made to slide in and out, by this means the material can be located in a definite position without disturbing the upper plate. The instrument has a very low natural leak and can be used for the determination of very small activities. The movement of the leaf is observed, through the reading microscope. All parts are easily removable, to admit of rapid replacement of the leaf or plates should they by accident become contaminated by radio-active matter.

A 89-820. ELECTROSCOPE, Combined Beta-Gamma, as designed by Lord Rutherford. With reading microscope .. .. £ 30 0 0

A 89-825. Ditto, with tele-microscope fitted .. .. £ 35 10 0

The body of the electroscope is a lead box surrounded by an aluminium box mounted on a cast iron base. The thickness of the lead is such that only the γ rays penetrate inside the box and cause the discharge of the gold or aluminium leaf system. The gold leaf system is attached to the underside of the cover of box and is easily removable; it is insulated by a cylinder of quartz and is charged by means of the spring-controlled arm on the top of the box. The charging arm is insulated from the box by a quartz sleeve and works against a spring which prevents its moving too far and automatically brings it back to its original position, at the same time earthing it. The windows on either side of the instrument are lead-lined, prevent the entrance of β rays, and admit the of measurement of the movement of the leaf by means of a reading microscope with micrometer scale eyepiece.

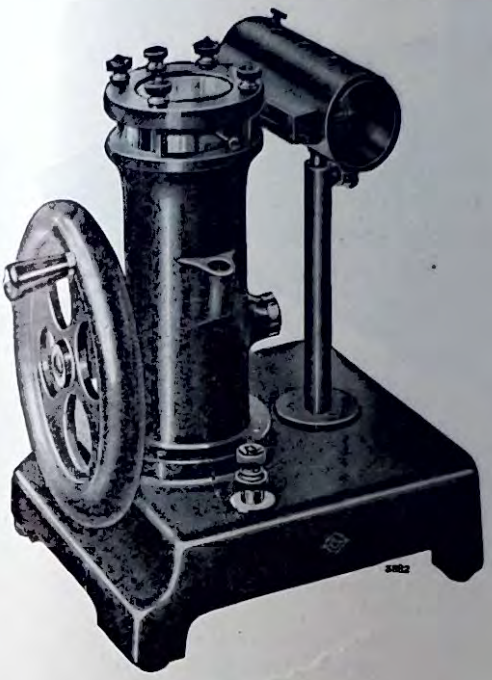
In the base of the instrument the lead lining is cut away immediately beneath the leaf and the aperture is closed by a thick lead plate. When it is desired to admit the β rays, the lead plate is replaced by a thin plate of aluminium.



A 89-830

A 89-830. ELECTROSCOPE, Combined Alpha-Beta-Gamma, Dr. Lazarus-Barlow type. With reading microscope .. .. .. £ 55 0 0

This instrument consists of two boxes, each about 4 in. cube, the upper one being aluminium and the lower one gun-metal. The lower box is fitted with a rack and pinion table fixed to a movable slide, arranged to admit of being withdrawn through door. The upper box, of aluminium, is removable and has a removable top, this top being similar in construction to that of the beta-gamma type. All insulations are of quartz. Fitted to the upper box inside, and on one side, is a sheet of lead, the opposite side being thin aluminium foil. At the bottom of the upper box, and fixed to the upper side of the lower box is a brass gauze held in place by a metal ring. Fitted to the lower box, as shown in illustration, is the tele-microscope mounted on a gun-metal bracket. The complete instrument is mounted on a cast iron base with earthing terminal.



A 89-850.



A 89-855 + 856.

A 89-850. RAY TRACK APPARATUS, Cambridge, on metal base 11 × 8 in., with driving wheel, expansion chamber, observation plate through which tracks are examined, and cylindrical lamphouse with 20 watt lamp (*Please state voltage when ordering*) .. ..tx **34 10 0**

The Cloud expansion apparatus was first described by C. T. R. Wilson and subsequently modified by Mr. Shimizu. This present apparatus has been introduced to supply the need for a simple educational model.

In this apparatus the paths of ionising particles through a gas are made visible by condensing water vapour upon them immediately after their liberation. Direct observation of the ray tracks is made by the operator.

A piston 55 mm. diam., 10 mm. stroke, is connected to a crank which is driven by the wheel. The glass observation plate on the top is covered on the inside with a film of water and the gas in the cylinder is thus saturated with water vapour. Radioactive material for the production of the rays is introduced on the end of a pin provided, which fits into a tube in the glass cylinder surrounding the chamber.

As the piston reciprocates, at each expansion, clouds are formed on the ionised particles in the ray tracks, thus making the paths visible. In order to dissipate these clouds, an electrostatic field is set up in the expansion chamber, by charging the water film on the observation plate, negatively to a potential of about 200 volts with respect to the metal piston. Terminals are provided for this purpose.

A projection on the side of the body communicates with an annular groove surrounding the skirt of the piston and water is thereby introduced to seal the apparatus effectively against leakage at all points in its travel.

To obtain a good background for the tracks, a filter paper saturated with Indian ink is placed on the head of the piston. The chamber is illuminated by means of a parallel beam of light from a lamp, the position of which is adjustable.

A 89-855. IONISATION COUNTER, Cambridge, (*Wynn-Williams Patent*), for detecting α and β particles, γ and cosmic rays, comprising gas filled relay with necessary operating accessories housed in case 17 × 18 × 12 cm., with full instructions. **Without** batteries or receiver tube .. ..tx **40 5 0**

A 89-856. Receiver tube in lead lined case for β particles and γ rays .. ..tx **2 16 5**

A 89-857. Ditto, for α particles .. ..tx **3 6 9**

This instrument has been designed as a simple, low voltage counter. On account of its simplicity, it is very suitable for demonstration purposes.

The equipment consists of two parts: a receiver tube, and a gas-filled relay, with its essential accessories. The receiver tube, which takes a slightly different form according to whether α or β particles are to be counted, is enclosed in a lead-lined brass case (seen on the right of the illustration), while the gas-filled relay is shown mounted on the control box in the centre of the illustration.

The receiver tube is a cylindrical glass bulb filled with an inert gas at low pressure. It contains a nickel cylinder, which forms one electrode, and a nickel wire forming a second electrode situated at the axis of the cylinder. When the tube is to be sensitive to β particles, the end of the bulb is blown very thin, so that the particles can enter the tube. To admit α particles the end of the bulb is fitted with a mica window, having a thickness equivalent in its stopping power of α particles to 2 cms. in air.

The maximum counting speed is limited to about 25 per second by the inertia of the meter and by the necessity of allowing sufficient time for the counting tube to de-ionise before the potential is restored.

The apparatus is sensitive to cosmic rays and will count these whatever type of tube is used. A preliminary determination must therefore be made, and allowance made for cosmic ray particles when counting any other ionising particles.

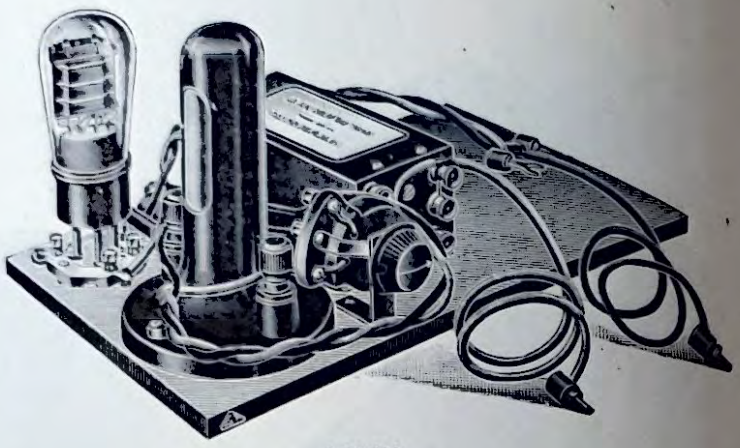
Terminals are provided which also enable the relay and counter to be used in conjunction with a valve amplifier for other counting purposes.



A 89-900.



A 89-910.



A 89-930.

A 89-900. RADIOACTIVE SOURCE, metal container 6 cm. diam. with cover, containing gauze-protected pad impregnated with 1 microgram of radioactive salt .. .. .. £ 0 10 0

This radioactive source may be used in a number of instructive experiments on radioactivity when used in conjunction with a suitable electroscope, *e.g.* **A 89-830.** α rays are cut off by an aluminium sheet 0·1 mm. thick. β rays are cut off by a lead sheet 2 mm. thick. Then, only γ rays enter instrument.

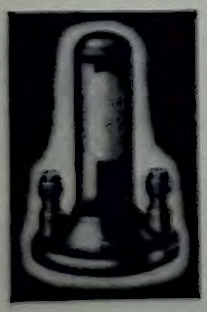
The natural rate of leak of the instrument having been found, γ rays are determined by interposing successive thicknesses of lead between source and electroscope until the natural leak rate is reached. Thus the absorption coefficient of lead for γ rays is evaluated.

The absorption coefficient of a material, *e.g.* cardboard for β rays, may be similarly determined. The total ionisation of α, β and γ rays may be used as a measure of their intensity.

A 89-910. SPINTHARISCOPE, Crookes, or SCINTILLOSCOPE, about 1½ in. long with fluorescent screen, in front of which is a movable pointer carrying a small quantity of radium. With eyepiece for viewing the scintillations produced by the disintegration of the crystal structure of the material of the fluorescent screen. A cap is provided to cover the eyepiece when not in use. The instrument may be used in daylight if the eye is given time to accommodate itself to the darkness of the inner, ionising, chamber 2 0 0

A 89-930. SELENIUM CELL, experimental kit, comprising selenium cell with relay, rotary resistance (0·1–7 megohms) on mounting bracket, fixed condenser (0·25 μF), grid leak (5 megohm) and valve holder. Complete with baseboard 11 × 7 in., for mounting and all necessary flex and plugs. **Without valve** and unassembled .. .. £ 4 10 0

This set of apparatus, mounted as illustrated, is a form of one-valve amplifier. Current consumption 3·5 *m*A, operated by a 120 volt H.T. battery, with a 2-volt accumulator for heating the valve filament, the valve recommended being a Mullard PM2DX. The apparatus can be used to show the automatic operation of street lighting, or, in conjunction with a beam of light projected on to the selenium cell, the operation of beam controlled counters, burglar alarms, etc.



A 89-940.

A 89-940. SELENIUM CELL only, as supplied with **A 89-930**, mounted in glass envelope in moulded Bakelite case, with two terminals, overall height 5 in. .. £ 1 11 6

A 89-950. PHOTOELECTRIC CELL, selenium, self generating, 60 mm. diam., effective cell diameter 40 mm., mounted in ebonite with two back terminals, and fitted with nickel-plated brass bezel and protecting glass window. Average output 0·6 μA/sq. cm./foot candle .. £ 4 14 6



A 89-950.

THE MICROID MILLIKAN OIL DROP APPARATUS

A simplified form of Millikan's apparatus arranged for use at low voltages in the determination of the electronic charge value *e*

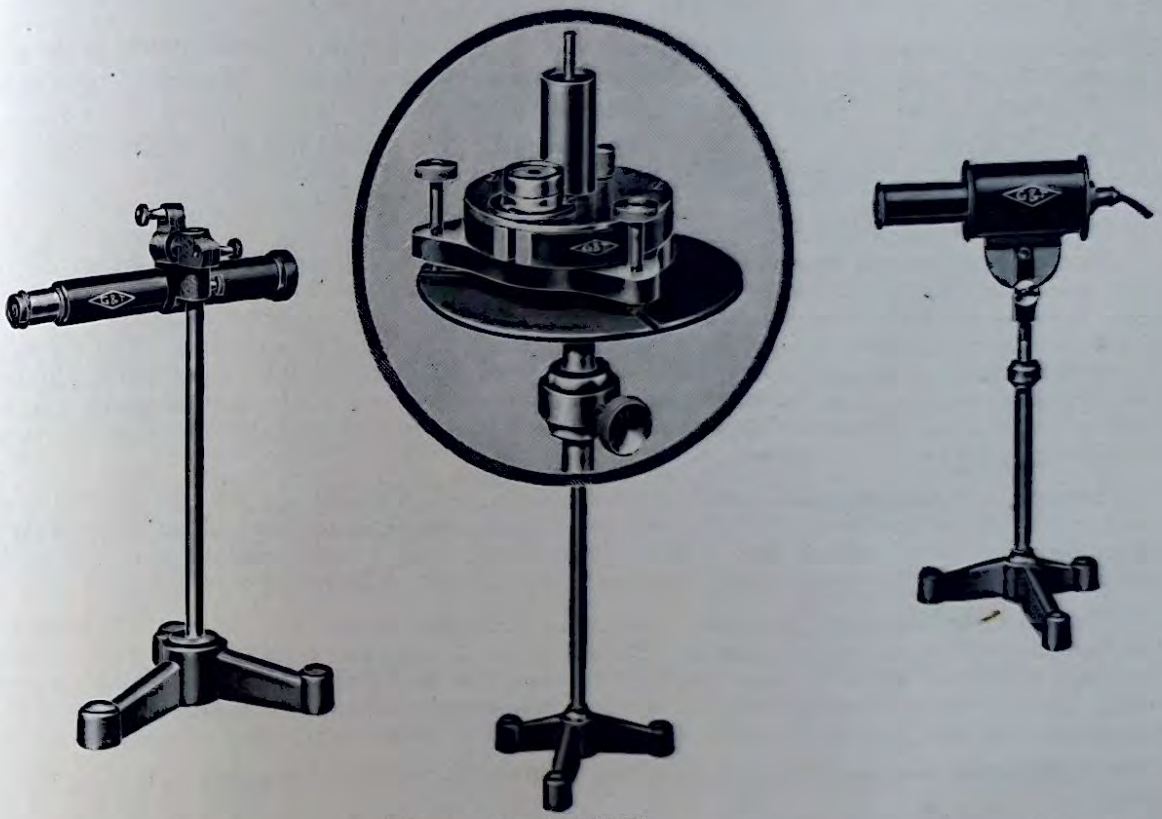


Fig. 1. A 89-980.

The important classical experiment of Millikan involving his celebrated "oil-drop" method of measuring the fundamental unit of electric charge, although simple in principle, has, owing to the complexity of the original apparatus, always been considered a difficult experiment to perform. The lack of a simple apparatus has, in the past, directed attention almost entirely to critical discussion of the method, often with a limited appreciation of the actual experiment. The "oil-drop" method has considerable instructive value and, therefore, it is very desirable to have an apparatus, so constructed that it may readily be set up to illustrate fully the physical principles and difficulties of Millikan's pioneer investigations, while at the same time maintaining a high degree of accuracy in the determined value for the fundamental electronic charge.

The Microid Millikan Oil Drop Apparatus has been designed to satisfy these conditions. It is so simple that the whole apparatus may be set up within a few minutes and the motion of charged particles in an electric field observed. Particularly interesting are the relative motions of the particles carrying different positive and negative charges; but most impressive of all is the observation of a particle suddenly gaining or losing either one charge or perhaps all of its charges. It then suddenly descends uninfluenced by the electrostatic field. Striking as these effects are, the vivid impression left presents a realistic picture of atmospheric electricity; and whether carried by electrons, ions or charged rain-drops, the motion of such drops is always influenced by the earth's electric field, particularly during the intense fields associated with active thunderclouds.

SPECIFICATION

Two polished, circular metal plates about 6 cm. in diam. are mounted on an ebonite ring with their plane faces parallel to form an electrical parallel-plate condenser. Two small windows are so inserted in slots provided in the ebonite ring that they are almost diametrically opposite. Through the wider window an intense vertical strip of light may be focussed on to the central axis of the plates. Through the narrower window, a long focal length microscope may be focussed for use in observing the charged droplets. This window is surrounded by a rectangle of white enamel, the scattered light from which illuminates the eyepiece scale in the microscope.

[*continued overleaf*

A 89-980. The Microid Millikan Oil Drop Apparatus—*continued.*

On the upper plate there is provided a hollow cylinder which may be closed by a special reversible piston having at its lower end a thin rod passing into the cell through a hole in the upper plate and thus projecting into the illuminating beam. The microscope is readily focussed on the illuminated rod (the axis of the two plates). Oil mist is introduced into the cell through the cylinder. Insertion of the piston into the cylinder in an inverted position closes the hole and prevents convection air currents from disturbing the motion of the oil drops. Terminals are attached to the upper and lower plates. The inner surfaces of the plates are chemically blackened to minimise background illumination.

The lower plate is provided with levelling screws which are located in three radial grooves in the metal table on which the cell is supported during observations. A spirit level is fitted. The cell constant (the distance apart of the plates in cm.) is stamped on each cell.

The design has been evolved to obtain the utmost simplicity, convenience and accessibility. The upper plate is readily removed for the periodic cleaning of the inner surfaces.

Accessory apparatus required includes:—

(i) **Microscope.**—The type recommended, and illustrated in Fig. 1, contains an optical system designed to satisfy three important conditions. (1) High magnification and, therefore, ease in observing the charged droplets; (2) Long working distance and, therefore, ease in adjusting and setting up the apparatus; (3) Image of cell aperture just fills the field of view, giving maximum overall accuracy of measurement. The microscope is mounted on a tripod base and is adjustable for height, inclination and direction. It is complete with achromatic objective, eyepiece, and eyepiece micrometer for measuring the movement of the charged drops. A stage micrometer (a 3 × 1 in. microscope slide with scale engraved in 0·1 mm.) is available for use in determining the magnifying power of the microscope.

(ii) **Lamp.**—The lamp employed is the Microid Projector Lamp **A 58-420.** It has been selected as very suitable for use with this apparatus. The short, straight, filament may be focussed to form, at the centre of the condenser plates, a vertical strip of light of great intrinsic brightness—a very important point in providing for ease in observation. The lamps used are 24 watt, 6 or 12 volt. **A 58-495.**

(iii) **Potentiometer.**—Intended to be used, either from D.C. mains or with two 120 volt H.T. batteries to vary the potential difference applied to the Millikan cell plates. It comprises a high resistance potentiometer mounted in a metal case with a reversing switch which also earths the Millikan cell plates during the process of reversal. A 100,000 ohm current-limiting resistance is incorporated in the circuit to prevent damage to the potentiometer windings. An on-off switch, and battery and cell leads are provided.

The potential difference applied to the plates may be measured to sufficient accuracy with an electrostatic voltmeter.

(iv) **Atomiser.**—For introducing oil mist into the cell through the hollow cylinder on the upper plate. Glass body with metal jets and rubber hand-bulb.

(v) **Oil.**—Specially prepared water-free.

A 89-980. MICROID MILLIKAN OIL DROP APPARATUS, complete set, comprising:—Millikan Oil Drop Cell with supporting table on tripod foot, Microid Projector Lamp (without lamp), Observation Microscope, Stage Micrometer, Potentiometer, Atomiser and 50 c.c. special water-free oil £18 15 0

Component and Extra Parts for A 89-980

		£ s. d.
A 89-980 a.	**Microid Millikan Oil Drop Cell**, on supporting table with tripod foot	£6 12 6
„ „ b.	**Microscope** on tripod foot with adjustments. Achromatic objective, eyepiece and micrometer eyepiece	£6 15 0
„ „ c.	**Potentiometer** for use with **A 89-980 a**	£3 15 0
„ „ d.	**Batteries, Dry, High Tension**, 120 volt (two required)	each £0 14 2
„ „ e.	**Atomiser** for introducing oil-mist	£0 10 6
„ „ f.	**Oil**, 50 c.c. bottle special water free, for use with **A 89-980 a**	£0 2 0
	Stage Micrometer, for use in standardising **A 89-980 b**. Scale 10 mm. in 1 mm. and last mm. in 0·1 mm., on 3 × 1 glass slide	See **A 12-810.**
	Microid Projector Lamp	See **A 58-420.**
	Lamps for above, 24 watt, straight filament gas filled, s.b.c. cap. ..	See **A 58-495.**
	Voltmeter, Electrostatic, 2½ in. diam., range 50-300 volts	See **A 85-460.**

A 89-980. The Microid Millikan Oil Drop Apparatus—*continued.*

EXPERIMENTAL NOTES

The principle of this experiment is the determination of the separate charges on a number of oil-drops carrying multiples of the electronic charge by observing their rate of fall under gravity, and rate of ascent under a known electric field. If a sufficient number are considered, the least difference in charge between the drops, which must be the electronic charge, is found.

Theory.—The rate of fall of a spherical drop falling through air of viscosity η under gravity alone is given according to Stokes's Law by the relation

$$V_1 = \frac{2ga^2}{9\eta}(\sigma - \rho) \quad . \quad . \quad . \quad (1)$$

where a is the radius and σ the density of the drop and ρ the density of the air. Neglecting this last quantity we have

$$V_1 = \frac{2ga^2}{9\eta}\sigma \quad . \quad . \quad . \quad (2)$$

which is obtained by equating the gravitational force $\frac{4}{3}\pi a^3\sigma g$ and the viscous force $6\pi a\eta V_1$ acting on the drop when it moves uniformly.

The mass m of the drop is $m = \frac{4}{3}\pi a^3\sigma$
or substituting for a from equation (2)

$$m = \tfrac{4}{3}\pi\sigma\left(\frac{9\eta}{2g\sigma}\right)^{\frac{3}{2}} V_1^{\frac{3}{2}} \quad . \quad . \quad . \quad (3)$$

If e_n (E.S.U.) is the charge on the drop ascending with velocity V_2 in the applied electric field of strength F (E.S.U.), since the terminal velocities are directly proportional to the forces acting then :—

$$\frac{V_2}{V_1} = \frac{Fe_n - mg}{mg} \quad Fe_n > mg \quad i.e.\ e_n = \frac{mg}{F}\cdot\frac{V_1 + V_2}{V_1} \quad (4)$$

or from equation (3)

$$e_n = \tfrac{4}{3}\pi\left(\frac{9\eta}{2}\right)^{\frac{3}{2}}\left(\frac{1}{g\sigma}\right)^{\frac{1}{2}}\frac{(V_1 + V_2)\,V_1^{\frac{3}{2}}}{F}\ \text{(E.S.U.)} \quad . . \quad (5)$$

Now if V volts is the potential difference between the plates and d cm. their distance apart, F in the above equation is given by

$$F = \frac{V}{300\,d}$$

and the total charge carried by the drop is then

$$e_n = 400\,\pi d\left(\frac{9\eta}{2}\right)^{\frac{3}{2}}\left(\frac{1}{g\sigma}\right)^{\frac{1}{2}}\cdot\frac{(V_1 + V_2)\,V_1^{\frac{3}{2}}}{V}\ \text{(E.S.U.)} \quad (6)$$

It should be noted that the quantity

$$400\,\pi d\left(\frac{9\eta}{2}\right)^{\frac{3}{2}}\left(\frac{1}{g\sigma}\right)^{\frac{1}{2}} = k \quad . \quad . \quad (7)$$

is a constant for the apparatus and once determined simplifies subsequent calculations.

The last factor in equation (6)

$$\frac{(V_1 + V_2)\,V_1^{\frac{3}{2}}}{V}$$

may be written

$$y^{\frac{3}{2}}\frac{(t_2 + t_1)}{t_1^{\frac{3}{2}}t_2}\cdot\frac{1}{V}$$

where y is the distance travelled by the drop under gravity alone in time t_1 sec. and in time t_2 sec. with the field applied, hence

$$e_n = k\,y^{\frac{3}{2}}\frac{(t_2 + t_1)}{t_1^{\frac{3}{2}}t_2}\cdot\frac{1}{V}\ \text{(E.S.U.)} \quad . \quad . \quad (8)$$

Now it has been shown by Millikan (Ref. 1) that Stokes's Law is not valid for drops of the small radius used in this experiment and a correction must, therefore, be applied to equation (2), the observed value of V_1 being then given by

$$V_1 = \tfrac{2}{9}g\frac{a^2\sigma}{\eta}\left(1 + \frac{b}{pa}\right) \quad . \quad . \quad . \quad (9)$$

where p is the atmospheric pressure measured in cm. of mercury and b a constant 0·000617. Since the correction term is small, the radius a occurring in this may be obtained with sufficient accuracy by solving the uncorrected equation (2) (Ref. 2). The mass m of the drop from equation (3) is now

$$m = \tfrac{4}{3}\pi\sigma\left(\frac{9\eta}{2g\sigma}\right)^{\frac{3}{2}}\left(\frac{V_1}{1 + \frac{b}{pa}}\right)^{\frac{3}{2}} \quad . \quad . \quad . \quad (10)$$

and finally as before

$$e_n = k\left(1 + \frac{b}{pa}\right)^{-\frac{3}{2}}\frac{(V_1 + V_2)\,V_1^{\frac{1}{2}}}{V}\ \text{(E.S.U.)} \quad . \quad (11)$$

Ref. 1.—*cf.* Millikan : *Electrons*, 92, 113. Ref. 2.—*ibid.*, 101.

Adjustment of the Apparatus.—Arrange the apparatus as shown in Fig. 1 and carefully level the cell on the stand. A suitable distance of the lamp from the Millikan cell is about 50 cm. The microscope must be directed on to that window of the cell surrounded by the white enamel. Complete the electrical connections to the plates according to the circuit diagram (Fig. 2).

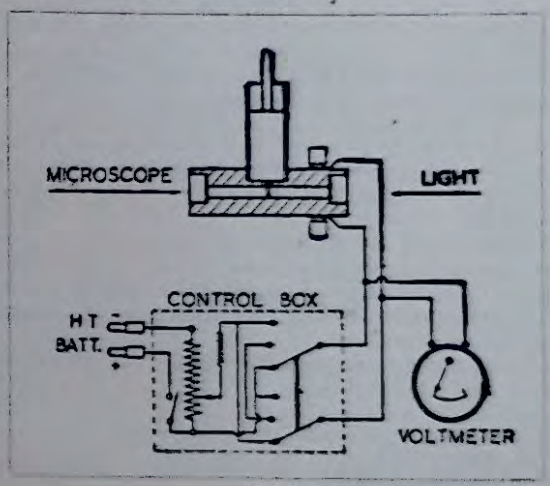


Fig. 2.

A suitable dry battery between 100 and 200 volts, or the 200 volt D.C. mains, will be a convenient source of potential difference for connection in series with the potentiometer box and the Millikan cell.

Adjust the lamp, Millikan cell and microscope to the same height. A glass water trough, although not essential, may be interposed between the lamp and the Millikan cell to make quite certain that air currents are not produced in the chamber by heating from the lamp.

Focus the lamp filament on a white card held by the centre of the hollow cylinder on the Millikan cell. Move the lamp slightly to pass the beam radially through the small window. It is now focussed on the axis of the plates.

Place the stopper with its small pin downwards through the small hole in the cylinder. Adjust the microscope opposite the second window and focus on the pin. This is readily achieved by slight movement in a horizontal plane of the light beam and microscope so that the pin is seen as a bright line by the light scattered from its side. The microscope is now focussed on the centre of the chamber.

Experiment.—Remove the stopper and spray a cloud of small oil-drops into the cylinder. Some of these drops sink through the hole into the space between the plates and are visible there when viewed through the microscope as bright specks of light rising across the field of view with various velocities in the bright vertical strip of light, the microscope producing an apparent inversion of the motion. A final slight adjustment of the lamp and microscope on the windows will often greatly increase the brightness of the drops. Replace the inverted stopper to close the hole. Some of the drops

[*continued overleaf*

A 89-980. The Microid Millikan Oil Drop Apparatus—*continued.*

acquire charges by friction and from the ions present in the air. Such drops may be distinguished by applying a potential difference between the plates. A field opposing gravity causes them to slow up, or, if they are small enough and carry sufficient charge, to reverse their motion altogether. By continual reversal of the field the large and uncharged drops and those insufficiently charged to be controlled by the field strength selected, fall to the bottom plate. Finally one single drop of suitable size and charge is selected and held for repeated observations.

Observe the rate of fall under gravity alone for this drop by taking with a stopwatch or clock the time for it to traverse a definite part of the scale. With the field applied and maintained at a suitable strength by adjustment of the potentiometer, note the corresponding time to traverse the same part of the scale in the opposite direction. Repeating this process gives an average value for the respective times: furthermore, the history of the charge carried by the drop may be studied—a sudden gain or loss of charge being noticed as a sudden change in velocity when it is moving uniformly under the influence of the field. If the charge is lost completely, the drop falls away irrespective of the field being on or off. The times corresponding to the different charges carried by the drop should be tabulated and grouped and treated in the manner suggested by Millikan in the determination of **e** (*see* Millikan: *Electrons*, 90), or that illustrated in the following specimen result.

Repeat this process for a number of different drops, each drop being kept under observation for a considerable time. The specimen result shows observations on a single drop extending over a period of more than half an hour.

To determine the absolute velocity of the drops the scale in the microscope eyepiece must be calibrated. To calibrate the eyepiece scale, set up the 0·1 mm. scale supplied with the instrument at the focus of the microscope and effect a comparison between its magnified image and the eyepiece scale.

In addition to the measurements already described the following constants should be recorded:—

i. Temperature at which experiment was performed.
ii. Viscosity of air η corresponding to this temperature.
iii. Barometric pressure.
iv. Potential difference between the plates.
v. Density of oil.
vi. Distance d between the plates.

Specimen Result.—It is convenient to determine first the apparatus constant k given by equation (7).

i. Temperature at which the experiment was performed , , = 16·8° C.
ii. Viscosity of air η at this temperature , = 0·000179 gms./cm./sec. (Ref. 3).
iii. Barometric Pressure , = 75·68 cms. of mercury.
iv. Potential difference between the plates (see Table I).
v. Density σ of oil = 0·854 gm./c.c.
vi. Distance d between the plates. (This value is a constant supplied with the instrument, but it may be determined by dismantling the instrument and using a micrometer screw gauge. For the apparatus used in this experiment mean $d = 0{\cdot}486$ cms.).

The apparatus constant k.

$$k = 400\,\pi d\left(\frac{1}{\sigma g}\right)^{\frac{1}{2}}\left(\frac{9\,\eta}{2}\right)^{\frac{3}{2}}$$

$$= 400\,\pi\,0{\cdot}486\left[\frac{1}{0{\cdot}854\times 981}\left(\frac{9}{2}\times 0{\cdot}000179\right)^{3}\right]^{\frac{1}{2}}$$

or $\log_{10} k = \bar{4}{\cdot}68838$.

Calibration of Scale in Microscope Eyepiece.

1 division of standard = 0·01 cm.

1 ,, ,, scale $= \frac{10}{9}\times 0{\cdot}01$ cm.

TABLE I.

Time for drop to traverse 20 div. on microscope scale.

Drop No.	Under gravity alone t_1 secs.	With field applied t_2 secs.	Potential between plates. Volts.	Average t_1 secs.	Average t_2 secs.
1	80·0 79·0 81·0	134 137 134	189	80·0	135·0
2	92·0 92·0 92·0	34·0 34·5 33·5	175	92·0	34·0
3	126·0 125·0 128·0 126·0	24·5 26·5 24·5 25·0	172	126·0	25·0

TABLE II.

Columns **A** and **B** are calculated from time values (Table I) over 20 scale divisions.

Column **D** gives $\log_{10} a$ calculated from formula below derived from equation 2.

Column **F** gives $\log_{10}\left(1+\frac{b}{pa}\right)^{-\frac{3}{2}}$ the correction term for drops of small radius, where $b = 0{\cdot}000617$ and p is barometric pressure in cms. of Hg.

Column **H** gives $\log_{10} k$ for apparatus constant.

Column **G** gives $\log_{10}(V_1 + V_2)\,V_1^{\frac{1}{2}}$.

Now $e_n = k\left(1+\frac{b}{pa}\right)^{-\frac{3}{2}}\cdot\frac{(V_1+V_2)V_1^{\frac{1}{2}}}{V}$ (equation 11) where

$a = \left(\frac{9\eta V_1}{2g\sigma}\right)^{\frac{1}{2}}$ (equation 2).

Hence by adding columns **G** and **H** and subtracting **F** and $\log_{10} V$, etc., a value for e_n the charge on the drop, is obtained. This is a multiple n of e the electronic charge. The value of n is found by inspection and divided into e_n to give e in E.S.U.

A $V_1\times 10^3$ cms./sec.	**B** $V_2\times 10^3$ cms./sec.	**C** $(V_1+V_2)\times 10^3$ cms./sec.	**D** $\log_{10} a$	**E** $1+\frac{b}{pa}$	**F** $\log_{10}\left(1+\frac{b}{pa}\right)^{-\frac{3}{2}}$	**G** $\log V_1^{\frac{1}{2}}\times(V_1+V_2)$	**H** $\log_{10}(\text{const})\,k$	$e_n\times 10^{10}$ antilog $\{(G+H)-(F+\log V)\}$	n	$e\times 10^{10}$ E.S.U.
2·778	1·044	4·422	$\bar{3}{\cdot}71534$	1·16203	0·05783	$\bar{4}{\cdot}36749$	$\bar{4}{\cdot}68338$	4·750	1	4·750
5·416	6·536	9·952	$\bar{3}{\cdot}68258$	1·17380	0·06456	$\bar{4}{\cdot}64346$	,,	9·532	2	4·766
1·764	8·889	10·653	$\bar{3}{\cdot}61471$	1·20330	0·12054	$\bar{4}{\cdot}65070$	,,	9·506	2	4·753

etc., for say 10 drops.

Mean value for 3 drops taken above in this experiment $e = 4{\cdot}78\times 10^{-10}$ E.S.U.

A 89-980. The Microid Millikan Oil Drop Apparatus—*continued.*

The accuracy of the values obtained in this experiment must necessarily depend not only on manipulative skill but also on the accuracy to which the assumed constants describe the experimental conditions.

In a recent precise determination (*Nature*, 1937, **cxl.**, 29) using dry air free from foreign matter, together with other improvements the value obtained for e was $4{\cdot}806 \pm 3 \times 10^{-10}$ E.S.U.

Ref. 3.—Viscosity of Air and the Electronic Charge, (*Nature*, 1938, **cxli.**, 1016).

TABLE III.

This table of observations records measurements made on a single drop lasting over half an hour and illustrates the sudden loss of one or more charges. It will be observed from the table that the loss of a charge is indicated by an increase in the time of ascent t_2. The clock readings from which successive times of descent t_1 and ascent t_2 are evaluated, are obtained by reading the table from left to right.

88 observations lasting more than half an hour.
t_1 = time of descent under gravity alone
t_2 = time of ascent with the field on
} over distance y.
$y = 0{\cdot}234$ cms.

Field Off			Field On			
Clock Readings secs.		t_1 secs.	Clock Readings secs.		t_2 secs.	
50·0	58·8	8·8	58·8	16·2	17·4	A
16·2	24·9	8·7	24·9	42·3	17·4	
42·3	51·0	8·7	51·0	6·5	15·5?	
6·5	15·3	8·8	15·3	32·8	17·5	
32·8	41·5	8·7	41·5	58·9	17·4	
58·9	7·5	8·6	7·5	24·9	17·4	
24·9	33·5	8·6	33·5	50·8	17·3	
50·8	59·5	8·7	59·5	16·9	17·4	
16·9	25·6	8·7	25·6	43·2	17·6	
43·2	52·0	8·8	52·0	11·7	*19·7*	
11·7	20·3	8·6	20·3	41·6	21·3	B
41·6	50·1	8·5	50·1	11·5	21·4	
11·5	20·0	8·5	20·0	41·3	21·3	
41·3	50·0	8·7	50·0	11·3	21·3	
11·3	19·9	8·6	19·9	41·4	21·5	
41·4	50·1	8·7	50·1	21·2	21·3	
21·2	30·0	8·8	30·0	51·3	21·3	
51·3	0·1	8·8	0·1	21·3	21·2	
21·3	30·3	9·0	30·3	51·6	21·3	
51·6	0·4	8·8	0·4	21·7	21·3	
21·7	30·5	8·8	30·5	51·5	21·0	
51·5	0·3	8·8	0·3	21·4	21·1	
21·4	29·8	8·4	29·8	51·1	21·3	
51·5	0·3	8·8	0·3	21·6	21·3	
21·6	30·1	8·5	30·1	53·4	*23·3*	
53·4	2·4	9·0	2·4	28·1	25·7	C
28·1	36·8	8·7	36·8	2·6	25·8	
2·6	11·0	8·4	11·0	36·8	25·8	
36·8	45·2	8·4	45·2	11·0	25·8	
11·0	19·5	8·5	19·5	45·4	25·9	
45·4	54·0	8·6	54·0	19·8	25·8	
19·8	28·4	8·6	28·4	53·7	25·3	
53·7	2·5	8·8	2·5	28·1	25·6	
28·1	37·1	9·0	37·1	2·4	*44·3*	
23·4	32·3	8·9	32·3	32·0	59·7	D
32·0	41·1	9·1	41·1	40·7	58·6	
40·7	49·7	9·0	49·7	48·4	58·7	
48·4	58·3	8·9	58·3	47·3	48·9?	
47·2	56·2	9·0	56·2	56·0	59·8	
56·0	5·9	8·9	5·9	5·6	59·7	
5·6	14·4	8·8	14·4	31·7	*77·3*	
31·7	40·4	8·7	40·4	7·8	57·4	E
7·8	16·5	8·7	16·5	43·9	57·4	
43·9	52·6	8·7	52·6	30·7	58·1	

From a consideration of Equation (4), evidently the change in velocity of ascent V_2, as computed from the average times for each group, is proportional to the change in charge occurring during the time interval shown in italics. The smallest value of this difference ΔV_2 is then proportional to the unit charge and from equation (11)

$$e = k\left(1 + \frac{b}{pa}\right)^{-\frac{3}{2}} \cdot \frac{\Delta V_2 \cdot V_1^{\frac{1}{2}}}{V} \quad . \quad . \quad . \quad (12)$$

For the particular drop and apparatus to which Table III refers, the factor

$$k\left(1 + \frac{b}{pa}\right)^{-\frac{3}{2}} \frac{V_1^{\frac{1}{2}}}{V} = 4{\cdot}024 \times 10^{-7}$$

Assuming that the correct value for $e = 4{\cdot}80 \times 10^{-10}$ E.S.U. then the smallest possible change in velocity, *i.e.* that resulting from the loss of a single charge, is

$$\Delta V_2 = \frac{4{\cdot}80 \times 10^{-10}}{4{\cdot}024 \times 10^{-7}} = 0{\cdot}0012 \text{ cms./sec.}$$

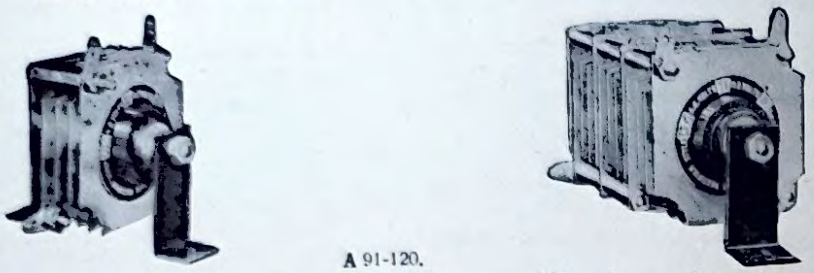
TABLE IV.

Charged state of Drop.	Vel. of Drop V_2 cms./sec.	Changes in Velocity ΔV_2	No. of charges Lost.
A	0·01346	0·00239	2
B	0·01107	0·00200	2
C	0·00907	0·00515	4
D	0·00392	0·00125	1
E	0·00267		

The changes in velocity of the drop throughout the whole observation are 0·002, 0·002, 0·005 and 0·001 cms./sec., the corresponding number of charges lost being 2, 2, 4 and 1 respectively.

Alternatively, from Table IV, the least possible change ΔV_2 in velocity, of which V_2 is a multiple n, may be deduced from the results and hence e calculated from equation (12).

Electrical Accessories



A 91-120.

A 91-120. RECTIFIERS, Westalite, Low Tension. These rectifiers have the advantages of long life, robust construction and a higher efficiency than the thermionic valve rectifier. They are provided with anchoring lugs and cooling fins and must be mounted with the spindle horizontal and be given unrestricted ventilation.

The range covers rectifiers suitable for incorporating in battery chargers, or for supplying small resistance loads. All units are bridge connected. *For suitable transformers see* **A 91-170.**

Type	Output		Overall dimensions in Inches			Nominal A.C. Input	Approximate Weight	Price
	Volts	Amps.	Width	Height	Length			£ s. d.
LT.41	12	1	2½	2½	4 3/16	22 volts	1½ lb.	1 7 0 tx
LT.42	6	1	2½	2½	4⅜	11 ,,	1½ lb.	1 1 0
LT.44	12	2	3⅜	4	4 1/16	22 ,,	2½ lb.	1 12 0
LT.45	6	4	3¾	4	7⅛	11 ,,	3¾ lb.	2 0 0



A 91-150. Open Type.



A 91-155. Enclosed Type (*with front removed*).

TRANSFORMERS, L.T., primary wound for operation on 200-230-250 volts, single phase, 50 cycles A.C., connections brought out to terminal blocks ; open and enclosed types as illustrated. Secondary tappings for special purposes can be provided.

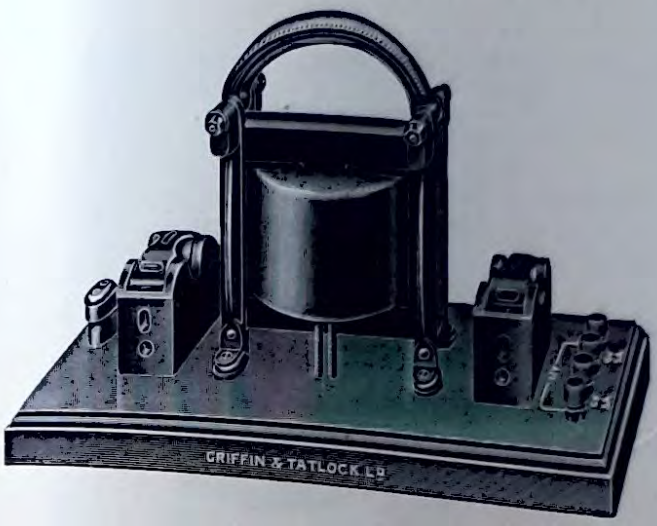
Output	4	4	4	6	6	6	*volts*
	3	5	10	3	5	10	*amps.*
A 91-150. Open Type	£ 27/-	27/-	35/-	27/-	27/-	39/6	*each*
A 91-155. Enclosed Type ..	£ 35/-	35/-	45/-	35/-	35/-	49/-	*each*
A 91-160. Secondary Tappings ..	£ 1/4	1/4	2/9	1/4	1/4	2/9	*each*

Output	7	12	12	14	14	*volts*
	5	5	10	5	10	*amps.*
A 91-150. Open Type	£ 35/-	39/6	66/-	39/6	66/-	*each*
A 91-155. Enclosed Type	£ 45/-	49/-	81/-	49/-	81/-	*each*
A 91-160. Secondary Tappings	£ 2/9	2/9	3/3	2/9	3/3	*each*

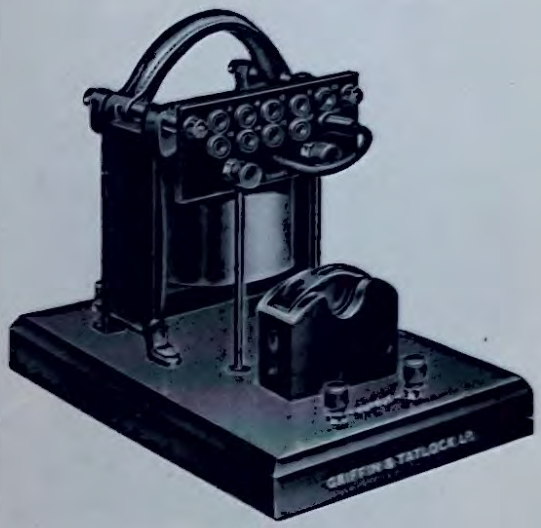
Please state voltage of secondary tappings required.

A 91-170. TRANSFORMERS, for use with L.T. Rectifiers **A 91-120.** Primary wound for operation on 200-230-250 volts, single phase, 50 cycles A.C.

For use with Rectifier					
Type No. ..	LT.41	LT.42	LT.44	LT.45	
Tappings at ..	17, 18·3, 20, 22	8·5, 10, 11	15, 16·5, 18, 20	8·5, 10, 11	*volts*
	£ 30/-	28/6	45/6	41/6	*each*



A 91-205—215.



A 91-220.

£ s. d.

A 91-205. TRANSFORMER, Portable, to supply two independent A.C. circuits of 5 amps. at 6 volts or one circuit of 5 amps. at 12 volts. Mounted on rubber feet with two fuses, four terminals, safety mains-connecting plug, and leather carrying handle. Overall dimensions $7\frac{1}{4} \times 4\frac{1}{2} \times 5$ in. high. Primary wound for any specified commercial single-phase supply (*see description below*). New model differing from that illustrated .. .. .. *p* 4 2 6

Please specify mains voltage when ordering.

A 91-210. Ditto, designed specially for the operation of the Microid Universal Projector **A 51-120** and similar apparatus. Secondary wound to supply two independent circuits of 5 amps. at 7 volts or one circuit of 5 amps. at 14 volts .. .. *p* 4 2 6

Please specify mains voltage when ordering.

A 91-215. Ditto, with secondary wound to deliver any stated low voltages in the ratio 2 : 1, provided that the secondary output does not exceed 70 V.A. (V.A. = Volts × Amps., or, watts **on non-inductive load**) .. .. *p* 4 2 6

Please specify voltages when ordering.

The primary windings of transformers **A 91-205—215** can be arranged for any commercial single-phase voltage. All fuses are placed in the secondary circuit because, in transformers of this type, heavy overloading of the secondary would cause so little variation of current in the primary that fuses placed here would afford little or no protection.

These transformers can be operated from any ordinary lamp socket. Their efficiency is 83·5 per cent., so that their consumption at 70 V.A. secondary load is about 85 watts.

The plug for connection to the mains is specially designed so that if it be withdrawn and laid on a metal surface it cannot produce an inadvertent short circuit or give an electric shock such as might occur if the ordinary 2-pin plug were employed. This plug is also arranged for simplicity of connection without a screwdriver. The plug is withdrawn and the insulated pins are unscrewed from the plug top through which the insulated flex is passed. The ends of the flex are then inserted through the holes in the washers inside the top, then well splayed and the legs screwed back again into position.

The transformers will be found very convenient for the operation of low voltage projection lamps and heating apparatus.

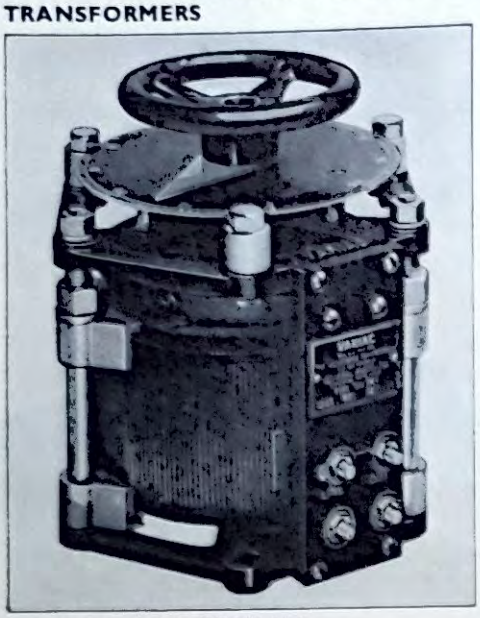
£ s. d.

A 91-220. TRANSFORMER, Portable, Tapped, to deliver A.C. 5 amps. at pressures of 2, 4, 6 up to 20 volts in 2-volt steps. Primary wound for any one standard voltage 50 to 100 cycles. An ebonite panel is fitted to the side of the transformer and carries 10 sockets, each engraved with the voltage, from which, by means of a wander plug, any of the stated voltages may be obtained. The transformer is mounted on rubber feet with two terminals for connection to the primary and two for connection to the secondary in the circuit of which a fuse is provided. A leather carrying handle is fitted. Overall dimensions $7 \times 4\frac{1}{2} \times 5$ ins. high. Transformer efficiency 87·1 per cent.

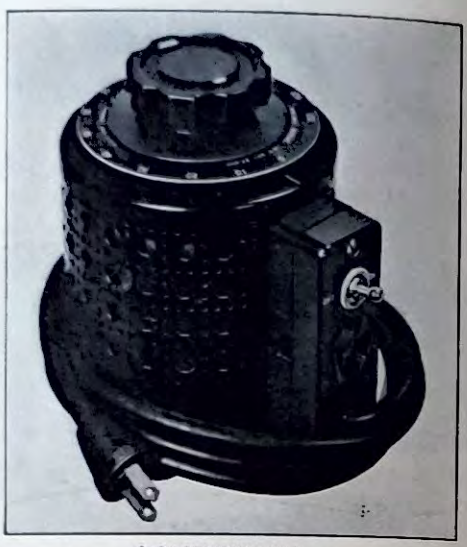
This transformer will be found invaluable for the operation of lamps such as are incorporated in the Microid Universal Projector **A 51-120**, and heating elements such as are incorporated in Searle's Conductivity Apparatus **A 44-480**, where direct current is not essential .. .. *p* 5 15 0

BELL TRANSFORMERS, see p. 296.

TRANSFORMERS



A 91-250/580 V.A.



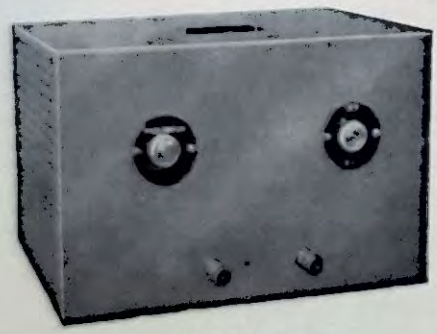
A 91-255/2000 V.A.

TRANSFORMERS, Variac, continuously adjustable secondary from zero to full output, by a 320° rotation of the central knob. Contact between the winding of the toroidally-shaped core is made through a carbon brush, operating with perfect smoothness. Output voltages are linear, substantially independent of load, and can be either equal to or 15 per cent. above input voltage. Reversible direct reading dial and suitable terminals are provided for bench or panel mounting. In protective metal case with mains lead, or "open" type for building into electrical equipment. Input 230 volts A.C.

Load rating	580	2000	V.A.
Rated current	2	9	*amps.*
Output	0–270	0–270	*volts*
No-load loss	10	25	*watts*
Overall dimensions, approx.	7 × 5 × 5½	7½ × 8 × 9	*in.*
A 91-250. Open type	*tx* **£6 7 1**	**£14 2 4**	*each*
A 91-255. Protected type	*tx* **£7 9 6**	**£14 16 1**	*each*



A 91-305.



A 91-315.



A 91-320.

A 91-305. BATTERY CHARGER, output 1 amp. at 2-12 volts, with metal rectifier, voltage and current regulator, ammeter, fuse, mains lead, shrouded output terminals; for bench or wall mounting. In metal case 7⅞ × 5½ × 5 in. .. .. £ 3 11 0

A 91-310. Ditto, output 2 amps. at 2-12 volts, as **A 91-305** but with the addition of a 12 volt 36 watt socket for operating a small projector type electric lamp from the mains .. £ 5 12 6

A 91-315. BATTERY CHARGER, output 5 amps. at 6 or 12 volts, with metal rectifier, mains switch, voltage change-over switch to give 6 or 12 volts, mains lead. In metal case 12 in. wide × 8½ in. high × 7½ in. deep .. .. £ 7 14 0

A 91-320. Ditto, output 1-3 amps. at 2-12 volts, with metal rectifier, ammeter, mains switch, fuse, two 9-position voltage and current controls giving choice of varying charging rates. In metal case 12 in. wide × 8½ in. high × 7½ in. deep .. .. £ 7 8 0

Apart from their use as battery chargers **A 91-305** to **A 91-320** provide a ready source of controllable low-voltage D.C. for experimental purposes and for operating low-voltage lamps for optical ray-track apparatus, small motors, electrolysis apparatus, etc., from A.C. mains. Larger heavy-duty chargers can be supplied, details and prices upon receipt of full particulars of requirements.

Chargers can be specially constructed for demonstration purposes with hinged sides for inspection of the interior, and all parts clearly labelled showing their particular purposes.

THE MICROID LABORATORY RECTIFIER

A convenient variable-voltage source of low tension A.C. or D.C.

This new Microid Laboratory Rectifier has been designed to make available a convenient source of low tension A.C. or D.C. for which there are many applications in both chemical and physical laboratories. It can be used for electrolysis, electrochemical analysis, battery charging, running low voltage motors or lamps, heating elements, etc. Its neat, easy-clean design, free from angularities, its louvred, well-ventilated case, and other features described in the specification below will make an immediate appeal for every class of laboratory work.



A 91-400.

SPECIFICATION

The metal case, external dimensions about 12 × 8 × 5½ in., is fitted with well-louvred sides to provide efficient ventilation. It is finished with an attractive crystalline black enamel. It contains a transformer of ample capacity tapped for 100–110 and 200–250 volt mains supplies and a Westinghouse metal rectifier. A feature of the rectifier is that it can be used to provide **simultaneous** A.C. and D.C. supplies—a feature which it is believed is not incorporated in any alternative apparatus of its type. The panel is fitted as follows:—

A.C. Output Side.—Ammeter reading 0–5 amps.; rotary switch to connect tappings on the transformer secondary output in 2-volt steps from 2–20 volts to the A.C. output terminals. Double pole fuses. Maximum A.C. output, 5 amps.

D.C. Output Side.—Ammeter reading 0–3 amps.; rotary switch giving 1, 3, 5 or 7 volts at the D.C. output terminals. When the A.C. output is simultaneously in use, the D.C. becomes 2, 4 or 6 volts at the same amperage. Double pole fuses are fitted. Maximum D.C. output 3 amps.

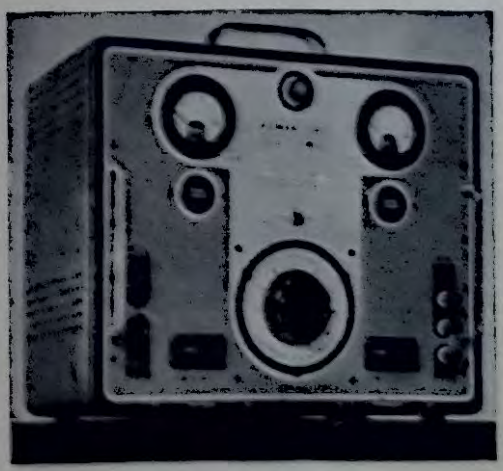
The maximum input load is about 0·14 K.V.A. and the over-all efficiency is about 85 per cent.

A 91-400. MICROID LABORATORY RECTIFIER. As described above, in case about 12 × 8 × 5½ in., weight about 14 lbs. For use on all A.C. voltages 100–110 and 200–250 — £ 16 10 0

A 91-405. Fuses for above. In glass tubes, about 1½ in. long, with metal caps; 5 amps. (for A.C. output) or 3 amps. (for D.C. output) .. .. *each* p 0 0 9

When ordering please state capacity required.

A 91-450. POWER UNIT, for use on A.C. mains supply, providing a smooth, continuously-variable D.C. voltage from 0 to approx. 1500, max. loading 500 watts, suitable for operating apparatus requiring low voltage D.C. and general laboratory experimental work. Input, 230 volts, 50/60 cycles A.C., power consumption, 650 watts at full load. Max. output voltage is maintained provided output current does not exceed 50 milliamps. 400 milliamps. can be drawn continuously at approx. 1000 volts D.C. and up to 500 milliamps. at lower voltages. Steel case 17½ × 14½ × 10 in. with carrying handle, panel with terminals, controls and two meters reading 0–1500 volts D.C. and 0–500 milliamps. D.C. .. .. .. £ 115 10 0



A 91-450.

WIRES

COPPER WIRE, Bare and Insulated. *(Please state Catalogue Number when ordering.)*

Size S.W.G.	Inch.	mm.	Approx. Yd./lb. Bare	Resistance at 60° F. Ohms per 1000 yds.	Ohms per lb.	A 91-510 Bare 4 oz.	A 91-510 Bare 8 oz.	A 91-510 Bare 1 lb.	A 91-512 Enamelled 8 oz.	A 91-512 Enamelled 1 lb.	A 91-514. Double Cotton Covered 4 oz.	A 91-514. Double Cotton Covered 8 oz.	A 91-514. Double Cotton Covered 1 lb.	A 91-516 Double Rayon Covered 8 oz.	A 91-516 Double Rayon Covered 1 lb.
12	·104	2·642	10	2·79	·0284	1/4	2/-	3/-	..	..	1/4	2/6	4/6	4/-	7/-
14	·080	2·032	17	4·71	·0811	1/4	2/-	3/-	..	..	1/4	2/6	4/6	4/-	7/-
16	·064	1·626	27	7·37	·1981	1/4	2/-	3/-	..	5/-	1/4	2/6	4/6	4/-	7/6
18	·048	1·219	48	13·10	·6261	1/6	2/6	3/6	2/9	5/-	1/6	2/9	4/6	4/6	8/6
20	·036	·914	85	23·28	1·979	1/6	2/6	3/6	2/9	5/-	1/8	3/-	5/6	5/-	9/-
22	·028	·711	140	38·5	5·407	1/8	2/9	4/-	3/-	5/6	2/-	3/6	6/-	6/-	11/-
24	·022	·559	227	62·4	14·188	1/10	2/9	4/6	3/-	5/6	2/6	4/-	7/-	6/6	12/-
26	·018	·457	340	93·2	31·659	2/-	3/-	4/9	3/6	6/6	2/6	4/9	8/-	7/-	13/-
28	·0148	·376	502	137·7	69·270	2/-	3/-	5/-	3/6	6/6	3/-	5/-	9/6	8/-	15/-
30	·0124	·315	716	196·3	140·570	2/-	3/-	5/6	3/6	6/6	3/6	6/-	10/6	9/-	17/-
32	·0108	·274	944	258·7	244·290	2/3	3/-	5/6	3/6	6/6	4/-	7/-	12/6	10/-	19/-
34	·0092	·2337	1301	356·5	463·910	2/3	3/6	6/-	4/-	7/6	4/6	8/-	14/6	11/6	22/-
36	·0076	·1930	1906	522·4	996·180	2/6	3/6	6/-	4/-	7/6	5/6	10/-	18/-	14/-	27/-
38	·0060	·1524	3059	838·2	2564	2/6	3/9	7/-	4/3	8/-	6/6	12/6	23/-	19/-	37/-
40	·0048	·1219	4800	1315	6261	3/-	4/6	7/6	5/-	9/6	9/-	17/-	33/-	25/-	48/-
42	·0040	·1016	..	1886	12982	..	..	..	5/-	9/6	..	..	..	32/-	60/-
44	·0032	·0813	..	2947	31694	..	..	..	6/6	12/-	..	..	..	44/-	85/-
46	·0024	·0610	..	5239	100171	..	..	..	8/6	16/-	..	..	..	77/6	145/-
47	·0020	·0508	..	7548	207720	..	..	..	12/6	23/-	..	..	..	97/6	180/-

CONSTANTAN RESISTANCE WIRE. Temperature coefficient of change of resistance, 0·000022 per degree Centigrade. This is a 60 Cu, 40 Ni alloy known also as Eureka. *(Please state Catalogue Number when ordering.)*

S.W.G.	Approx. Data Yards per lb.	Ohms per 1000 yards	Ohms per lb.	A 91-520 Bare 4 oz.	A 91-520 Bare 8 oz.	A 91-520 Bare 1 lb.	A 91-525 Double Rayon Covered 4 oz.	A 91-525 Double Rayon Covered 8 oz.	A 91-525 Double Rayon Covered 1 lb.
16	26·9	209·4	5·6	2/3	4/6	7/3	3/3	6/-	10/6
18	47·8	371·8	17·8	2/3	4/6	7/6	3/6	6/6	11/6
20	85·2	661·3	56·2	2/6	4/9	8/-	3/9	7/-	13/-
22	141	1157	162·7	2/9	5/-	8/6	4/3	8/-	14/6
24	228	1770	405	2/9	5/3	9/-	4/6	8/6	15/-
26	340	2645	900	3/-	5/6	9/6	5/-	9/-	16/6
28	503	3914	1970	3/-	5/9	10/-	5/9	10/6	19/6
30	717	5575	4000	3/3	6/-	10/6	6/-	11/6	21/-
32	945	7350	6850	3/6	6/9	12/-	7/6	14/6	27/-
34	1300	10129	13174	3/9	7/-	13/-	8/6	16/-	30/-
36	1800	14840	28308	4/6	8/6	15/-	10/6	20/-	38/-
38	2600	23806	72856	5/3	10/-	18/6	13/-	25/-	47/-
40	4760	37184	177744	6/6	12/-	22/-	16/6	32/-	60/-
42	6850	53564	368480	10/-	19/-	33/-	18/-	33/-	62/6
44	10750	83084	900000	12/-	23/-	41/-	18/6	36/-	65/-
46	18800	145784	2845360	16/6	32/-	57/6	30/-	57/6	105/-
47	27800	214284	5800440	22/6	44/-	75/-	50/-	97/6	180/-

A 91-540. NICKEL-CHROMIUM ALLOY RESISTANCE WIRE.

S.W.G.	Diam. in Inches	Ohms per ft. at 800° C.	Amps at 800° C.	PRICE including Reels		
				4 oz.	8 oz.	1 lb.
				p	p	p
18	·048	0·301	15	8/6	15/-	29/-
20	·036	0·534	10	9/-	16/6	32/-
22	·028	0·883	7·8	10/6	19/6	38/-
24	·022	1·43	4·8	11/6	22/-	41/-
26	·018	2·15	3·7	12/6	24/-	45/-
28	·0148	3·16	2·8	13/6	26/-	48/-
30	·0124	4·53	2·0	14/6	27/-	52/6
32	·0108	6·15	1·94	16/-	30/-	57/6
34	·0092	8·5	1·61	17/6	34/-	67/6
36	·0076	12·5	1·29	19/-	36/-	70/-
38	·0060	19·95	1·01	21/-	41/-	80/-
40	·0048	35·2	0·79	23/-	44/-	85/-

Other sizes and gauges on application.

Nickel Chromium Alloy wire is especially suitable for heating elements. Its composition is 80 per cent. nickel and 20 per cent. chromium and it is almost free from iron. It is capable of being operated up to 1100° C. if air is practically excluded, and to 900° C. if used in open air, but this quality is recommended also for all temperatures lower than these. Its specific resistance is 105 microhms per cm. cube, its temperature coefficient 0·00012, and its coefficient of expansion 0·000015. Mechanically it is soft and ductile with a tough insulating oxide surface. The current carrying capacity varies widely according to conditions, and those stated in table above are intended only as a guide. They result from tests on a small coil in the open air, free to radiate and protected from draughts, wound on a $\frac{3}{8}$ in. mandrel one inch long, the gap between the turns being equal to the diameter of the wire.

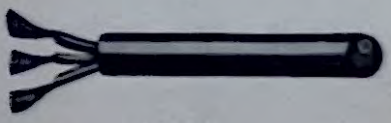
A 91-600—Single.



A 91-600—Twin.



A 91-620.



A 91-625.

A 91-600. WIRES, Bell, copper, thermoplastic insulated and sheathed, suitable for battery or transformer circuits.

	Single	Single	Twin	Twin	
Gauge	22	20	22	20	*S.W.G.*
Max. current ..	2·5	4	5	8	*amps.*
	12/-	14/6	25/-	31/-	100 *yards*
	2/-	2/6	4/6	5/6	*doz. yards*

Twin Flexible Bell Wire, ... see **A 91-660—670.**

A 91-610. WIRES, Twin, Flat Sheathed, light grade thermoplastic insulated, vulcanised rubber conductors.

Strands	14/0·0076	23/0·0076	*inch*
Max. current	2·5	4	*amps.*
	45/-	56/-	100 *yards*
	7/6	9/6	*doz. yards*

WIRES, Circular Sheathed ("Cabtyre"), vulcanised rubber insulated conductors with thermoplastic sheathing.

Strands	14/0·0076	23/0·0076	40/0·0076	70/0·0076	*inch*
Max. current ..	2·5	4	7	12	*amps.*
A 91-620. Twin	15/-	17/-	20/-	25/-	*doz. yards*
A 91-625. Three-core	16/-	18/-	25/-	30/-	*doz. yards*



A 91-660—670.



A 91-690.



A 91-710.



A 91-750.

A 91-650. WIRE, Copper, single flexible, 14 strands, No. 36 wire (1·5 amp.), insulated and red cotton braided .. .. *dozen yds.* **3/6** ; 100 *yds.* — £ 1 s. 1 d. 0

A 91-655. Ditto, black cotton braided .. .. *dozen yds.* **3/6** ; 100 *yds.* — 1 1 0

A 91-660. WIRES, Copper, twin flexible, 10 strands No. 36 wire, silk covered, for bell wiring *dozen yds.* — 0 3 0

A 91-665. WIRES, Copper, twin flexible, maroon cotton braided, insulated with two layers vulcanised rubber.

Strands	14/36	23/36	40/36	70/36	110/36	
Carrying capacity ..	1·5	3	7	10	15	*amps.*
	60/-	**70/-**	**90/-**	**120/-**	**165/-**	100 *yards*
	9/6	**10/-**	**15/-**	**20/-**	**28/-**	*doz. yards*

A 91-670. Ditto, one each red and black, 14 strands No. 36 wire (1·5 amp.), insulated and braided .. .. *dozen yds.* **9/6** ; 100 *yds.* — 3 0 0

A 91-690. SLEEVING, flexible, insulating, for covering bare wires, internal diam. 2 mm., yellow, red or black .. .. *dozen yds.* — 0 7 6

A 91-710. WIRE, Fusible, Pure Tin, in 4-oz. reels

Gauge	36	31	28	26	24	21	*S.W.G.*
Fusing current ..	1	2	3	4	5·35	9·4	*amps.*
	15/-	**10/-**	**7/-**	**6/-**	**5/-**	**5/-**	*each*

A 91-720. WIRE, Platinum. No. 28 S.W.G. is flame test wire. *Prices variable.*

Gauge	20	24	28	36	40	44	*S.W.G.*
†	£3 5 0	£2 0 0	£1 0 0	**5/-**	**3/6**	**3/4**	*foot*
†	**6/-**	**3/9**	**1/10**	—	—	—	*inch*

A 91-725. FOIL, Platinum, 2 × 1 in., thickness 0·001 in. .. .. *Price variable*, *piece* † £ 1 s. 0 d. 0

A 91-740. PARAFFIN WAX, refined white, melting points about 49°, 51°, 57° C. .. *lb.* † 0 1 4

A 91-750. INSULATING TAPE, Adhesive, prepared both sides, in rolls 25 yds.

Width	½	¾	1	*inch*
	1/6	**2/6**	**3/-**	*roll*

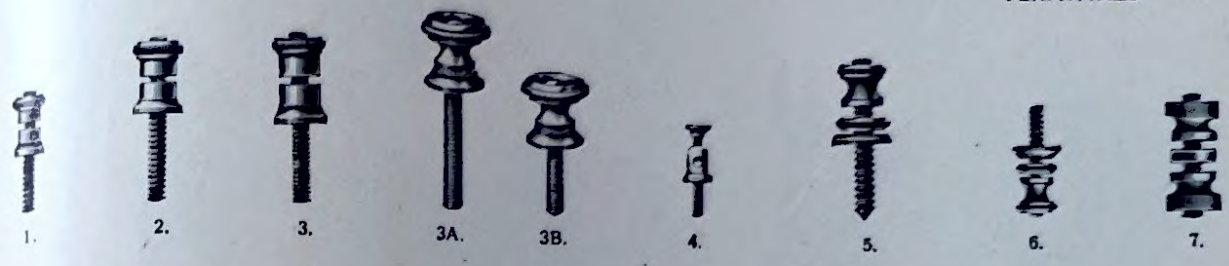
A 91-755. RUBBER STRIP, ½, ¾ or 1 in. wide .. .. 100 *yd. roll* — 0 7 6

A 91-765. RUBBER SOLUTION, in collapsible tube .. .. ¼ *lb.* † 0 1 1

A 91-775. CHATTERTON'S COMPOUND, flexible and rich in rubber. In 4 oz. sticks *stick* **2/-** ; *lb.* — 0 5 6

A 91-780. SOLDER, thin wire, for electrical purposes .. .. *lb.* — 0 3 6

A 91-785. Ditto, resin cored .. .. ¼ *lb.* † 0 1 3



A 91-820.—*Illustrations half size.*

A 91-820. TERMINALS and CLAMPS, Brass.

Nos.	1	2	3	3A	3B	4	5	6	7	
Shank Thread B.A.	4	2	2	2	2	4	2	4	—	
	2/6	3/3	3/3	4/6	4/3	2/6	3/-	2/6	5/-	*dozen*
	3d.	4d.	4d.	5d.	5d.	3d.	4d.	3d.	6d.	*each*

Nos.	8	11	12	13	14	14A	15	21	
	6/-	4/6	3/-	2/6	3/6	4/-	4/6	10/-	*dozen*
	7d.	5d.	4d.	3d.	4d.	5d.	5d.	11d.	*each*



A 91-830. A 91-835. A 91-870. A 91-880.

	£	s.	d.
A 91-830. TERMINALS, with milled, moulded, captive head; shank threaded 2 B.A., with two nuts and washer. Drilled transversely so that terminals will take loop or pin connections .. .. *each* 1/2; *dozen*	0	14	0
A 91-835. Ditto, larger, shank threaded 0 B.A. .. .. *each* 2/10; *dozen*	1	14	0

NUTS and WASHERS, brass, hexagon nuts, stamped round washers.

	0	1	2	3	4	5	6	B.A.
A 91-850. Nuts	9d.	9d.	6d.	6d.	6d.	6d.	4d.	*dozen*
A 91-855. Washers ..	3d.	3d.	3d.	3d.	3d.	3d.	3d.	*dozen*

A 91-870. SPRING CONNECTORS, Phosphor Bronze, to hold wires up to 14 S.W.G. *each* 4d.; *dozen*	0	3	6
A 91-880. BANANA PLUG AND SOCKET, plugs of three prong construction. Socket self-bushing, eliminates soldering and will not twist or become loose in its bush *each* 9d.; *dozen*	0	8	0



A 91-910.



A 91-915.



A 91-920.



A 91-930.



A 91-940—945.

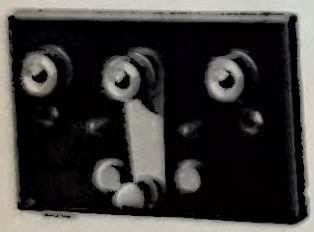
	£	s.	d.
A 91-910. SPADE TERMINALS, improved pattern embodying a positive cone grip. Acid cannot reach the wire at the point of contact .. .. *each p* 4d. ; *dozen*	0	2	9
A 91-915. SPADE TAGS, for attaching to flexible wires .. .. *dozen*	0	1	0
A 91-920. WANDER PLUGS, self locking, all metal .. .. .. *each t* 1/6 ; *dozen*	0	16	0
A 91-930. CROCODILE CLIPS, plated, with spring, connecting screw and tubular extension through which the wire is passed before fixing beneath the screw *each p* 5d. ; *dozen*	0	4	6

A 91-940. BATTERY CLIPS, cadmium plated, with toothed jaws and strong spring ; useful for battery charging and testing, and for instrument leads, etc.

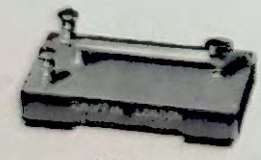
To carry	5	25 *amps.*
	8d.	11d. *each*

A 91-945. Rubber Sleeve Insulators for above, with hole at end for wire.

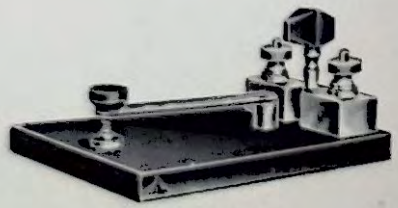
For Clip	5	25 *amps.*
	8d.	1/- *each*



A 92-110.



A 92-120.



A 92-125.



A 92-140, 1-way.

A 92-110. CONTACT SWITCHES, on square **ebonite bases**, with nickel-plated fittings.

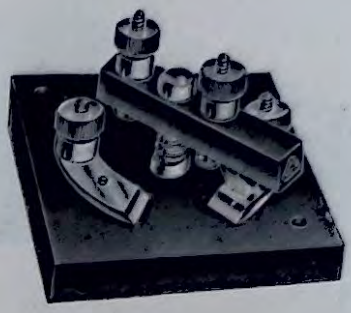
Type	1-way	3-way	3-way	£	s.	d.
	5/-	6/6	7/6 *each*			
A 92-120. CONTACT KEY, on wood base, gold-silver contacts				0	10	6
A 92-125. CONTACT KEY AND PLUG KEY, Combined, on wood base with gold-silver contacts				1	0	0

A 92-140. PLUG SWITCHES, on ebonite bases, with accurately fitting plugs, lacquered brass blocks and terminals.

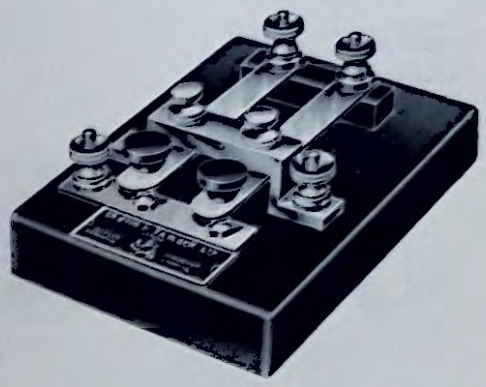
Type	1-way	2-way
	12/6	£1 0 0 *each*



A 92-145.



A 92-160.

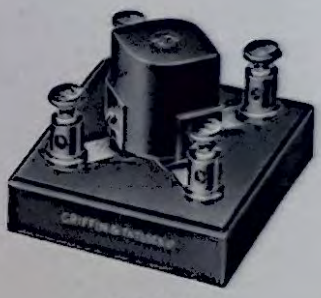


A 92-170.

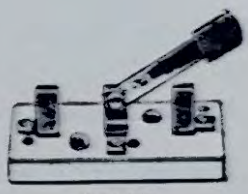
	£	s.	d.
A 92-145. **REVERSING PLUG KEY,** with four quadrants and two plugs, on ebonite base ..	1	17	6
A 92-160. **REVERSING KEY,** ebonite base, with terminals and contact plates, ebonite bar with terminals and laminated contacts	1	2	6
A 92-170. **REVERSING KEY, Universal double form,** on polished wood base about 5 × 4½ in. Two tapping keys are provided, with gold-silver contacts. Fittings of heavy brass ..	1	10	0



A 92-180.



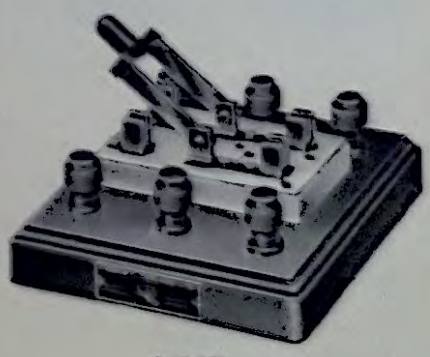
A 92-190.



A 92-220.

	£	s.	d.
A 92-180. **COMMUTATOR, Pohl,** or **Reversing Switch,** on mahogany base about 3 in. square with 6 terminals and mercury cups, two of which are metal-lined. The contact arms are of stout copper with amalgamated ends and an ebonite handle is provided. Base fitted with four rubber feet.	0	17	6
A 92-190. **COMMUTATOR,** on wood base 2½ in. square. Four holes are sunk in the base, to contain mercury, connection being permanently made to the four terminals by copper strips. The current is reversed by lifting the handle, which is not removable, and turning it through 90°. The copper strips attached to it then connect the next pair of terminals	0	8	6
A 92-220. **DOUBLE THROW KNIFE SWITCH, single pole,** on porcelain base	0	2	3
A 92-225. **Ditto, double pole**	0	3	9

	£	s.	d.
A 92-240. **DOUBLE POLE DOUBLE THROW SWITCH,** for potentiometric work. A porcelain base with four contacts and a knife blade switch mounted on a polished wood block 5½ in. square. 6 terminals, with Bakelite-shrouded heads are provided ..	1	0	0



A 92-240.



A 92-315.



A 92-315 + 320.



A 92-340.



A 92-360—365.



A 92-380

A 92-315. FUSES, Cartridge type, enclosed in glass tubes, about 1¼ in. long, with metal end contacts, and indelibly colour coded.

Capacity	60	100	150	250	500	750	*milliamps.*
t	6d.	6d.	6d.	6d.	6d.	6d.	*each*

Capacity ..	1	1·5	2	3	5	10	15	*amps.*
t	6d.	6d.	6d.	6d.	6d.	6d.	6d.	*each*

		£	s.	d.
A 92-320. Holders, for above, moulded base with spring clip contacts and soldering lugs	*each t*	0	1	0
A 92-340. FUSE, Lighting type, vitreous porcelain, 2 × 1 in., to carry up to 15 amps.	*complete t*	0	1	11
A 92-360. SWITCH, Tumbler, Bakelite cover, porcelain base, 2 in. diam., one way, rapid make and break, for use on 5 amp. circuits up to 250 volts	*each t* 2/5 ; *dozen*	1	6	0
A 92-365. Ditto, 15 amp.	*each t* 6/3 ; *dozen*	3	6	8
A 92-380. SWITCH, Suspension, 2 amp. midget type, for controlling single lamps, etc. Through-cord type, Bakelite, 2¼ × ⅝ in.	*each t*	0	4	0



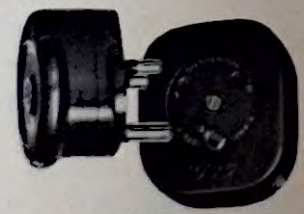
A 92-405.



A 92-420. 2 pin 5 amp.



A 92-420. 2 pin 15 amp.



A 92-420. 3 pin 5 amp.

A 92-405. SWITCHES, Three-heat type, vitreous porcelain bases, Bakelite covers lettered in white—"High," "Med.," "Low," "Off," pointer type white porcelain handles.

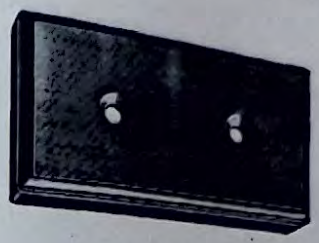
Capacity	5	7·5	10	15	20	*amps.*
Diam.	2¼	2½	2¾	3	3	*in.*
t	10/9	12/8	13/6	16/2	19/3	*each*

A 92-420. SOCKET OUTLETS AND PLUGS, Bakelite covered porcelain sockets, Bakelite plugs, 5 amp. size with flat top plugs, 15 amp. size with handshield type plugs.

To carry	5	15	5	15	*amps.*
No. of pins	2	2	3	3	
Complete .. .. *t*	4/-	7/3	6/1	8/6	*each*
A 92-425. Extra Plugs .. .. *t*	1/7	4/1	2/9	4/-	*each*



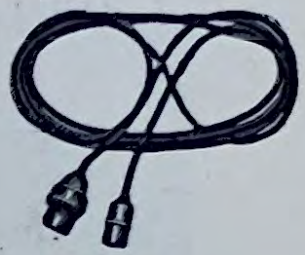
A 92-455.



A 92-455.



A 92-470.



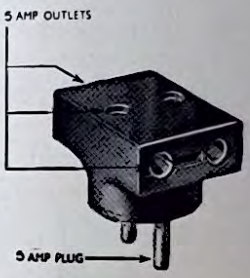
A 92-480.

A 92-455. **BLOCKS, Wood,** for mounting switches, batten type lamp holders, etc. Polished imitation walnut. Dimensions .. .. 3 × 3 × 1 | 6 × 3 × 1 *in.*

t 10/- | 16/8 *dozen*

A 92-470. **CONNECTORS, Extension,** for flexible wires, 2-pin, Bakelite .. .. .. *each* £ *t* 0 3 3

A 92-480. **FLEXIBLE EXTENSION,** 3 yards circular braided flexible wire, with Bakelite B.C. lampholder and Bakelite adaptor 0 5 6



A 92-490.



A 92-530.



A 92-535.



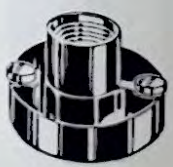
A 92-540.

A 92-490. **PLUG, triple socket,** parallel wired, to plug into a wall socket to enable three leads to be taken from it. Standard pins, 5 amps. The total loading should not exceed the capacity of the socket in which the plug is used .. .. £ *t* 0 3 4

A 92-530. **ADAPTORS,** B.C., Bakelite, for taking leads from lampholders *each t* 8d.; *dozen* 0 6 8

A 92-535. **ADAPTOR,** 2-pin to B.C., Bakelite, in two parts, with braided cord to prevent loss, allows lead to be plugged into 2-pin socket or lampholder; 5 amp. .. .. .. *t* 0 1 10

A 92-540. **ADAPTOR, Two-way,** with push through switch. Bakelite body with B.C. lampholder at bottom and side lampholder at 45° approx. for plugging-in adaptor **A 92-530** *t* 0 6 0



A 92-560.



A 92-570—575.



A 92-585—590.



A 92-595



A 92-600.

£ s. d.

A 92-560. **LAMPHOLDER, Bakelite,** miniature screw, for flash lamp bulbs .. .. .. *p* 0 0 6

A 92-570. **LAMPHOLDERS, cord grip, S.B.C.** (small bayonet cap), Bakelite *each t* 1 4; *dozen* 0 14 0

A 92-575. **Ditto, B.C.** (bayonet cap), suitable for ordinary lighting lamps *each t* 1 2; *dozen* 0 12 0

A 92-580. **Ditto,** with bar switch .. .. *each t* 4 -; *dozen* 2 4 0

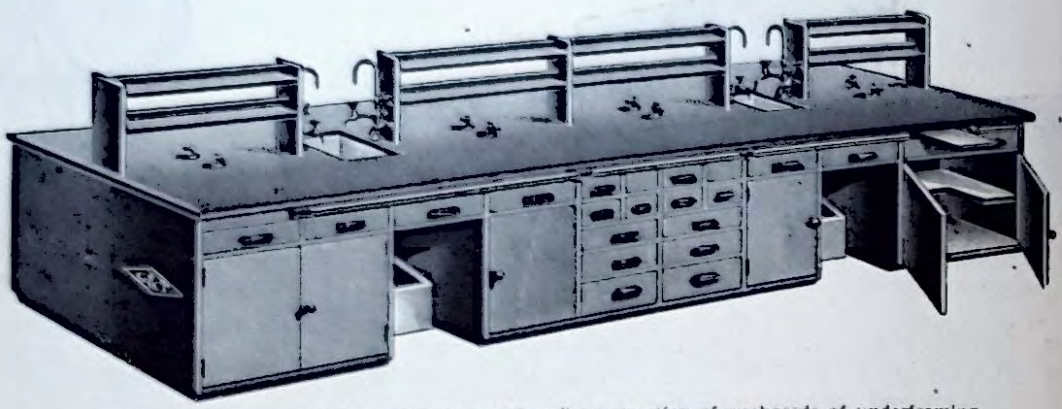
A 92-585. **LAMPHOLDERS, batten, S.B.C.** (small bayonet cap), Bakelite, with backplate 2 in. diam., two fixing holes .. .. *each t* 1 7; *dozen* 0 16 8

A 92-590. **Ditto, B.C.** (bayonet cap), backplate 2¼ in. diam. .. .. *each t* 1 8; *dozen* 0 18 0

A 92-595. **LAMPHOLDERS, E.S. Edison Screw, cord grip pattern,** Bakelite, suitable for projector type lamps having E.S. caps .. .. *each t* 0 4 0

A 92-600. **Ditto, with backplate,** 2¼ in. diam., with two fixing holes .. .. .. *each t* 0 4 0

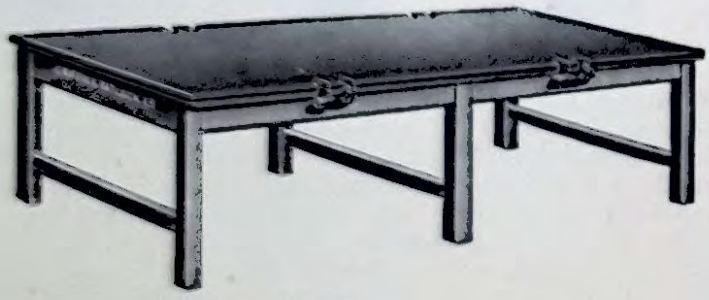
Laboratory Furniture and Fittings



B 10-255.—This illustration shows flush "easy-clean" construction of cupboards of underframing.

B 10-255. BENCH, Chemistry. 15 ft. × 4 ft. 6 in. × 3 ft. high, accommodating 4 students. Consisting of:— Two double cupboards, two single cupboards, 18 graded-depth drawers and two long drawers for glass tubing, burettes, etc., on each side of bench. Pull-out writing flap and waste box in knee space for each student. Access door to services at one end of bench. Double sided 2-tier reagent shelves along centre of bench top. Two white-glazed earthenware sinks, external size 20 × 12 × 6 in. with two 3-way water taps over each sink. Eight gas leads with front controls fitted.

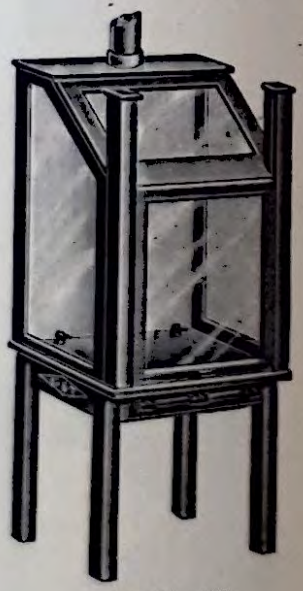
Price on application.



B 10-410.

B 10-410. PHYSICS TABLE. 8 ft. × 4 ft. × 3 ft. high, accommodating four students. Supported on strong polished framing, with rails and stretcher. Can be fitted with four single-way gas taps **B 11-185** and four 15-amp. electric plugs (or terminal blocks if desired), all on rail under bench top with slots in edge of top specially designed to avoid kinking of rubber tubing; the bench top is therefore quite unobstructed

Price on application.



B 10-545—546.

B 10-545. FUME CUPBOARD. 5 ft. × 2 ft. × 7 ft. 1 in. high overall. Base of 1 in. natural grade Sindanyo supported at height of 3 ft. on timber framing. Upper part with glazed top and sides and glazed, counterpoised sliding front. Sheet asbestos back. Two gas leads and one draught burner to flue for natural draught, each operated by front controls. Uralstone piping to requirements extra

Price on application.

Only a selection of our range of Laboratory Furniture is included in this Catalogue. Fully descriptive Catalogue 15 B—LF on application.



B 10-670.



B 10-675.

B 10-670. LABORATORY BENCH SINKS of enamelled fireclay, white-glazed inside and outside. Outlet in centre of bottom at one end with integral overflow. Outlet 2½ in. flange, 2 in. bore suitable for use with waste fittings **B 10-805**. External dimensions not including flange.

Dimensions ..	10 × 8	12 × 10	12 × 12	16 × 11	17 × 13	*in.*
Depth	6	6	6	6	6	*in.*
tx	£1 3 8	£1 7 3	£1 8 3	£1 9 1	£2 13 8	*each*

Dimensions ..	20 × 12	20 × 12	23 × 14	23 × 14	*in.*
Depth	6	8	6	8	*in.*
tx	£2 13 8	£2 13 8	£3 3 8	£3 3 8	*each*

B 10-675. **Ditto, as B 10-670** but without overflow. *(For waste fittings see* **B 10-815**.)

Dimensions ..	12 × 10	12 × 12	16 × 11	17 × 13	*in.*
Depth	6	6	6	6	*in.*
tx	£1 2 5	£1 3 11	£1 4 11	£1 10 7	*each*

Dimensions ..	20 × 12	20 × 12	23 × 14	23 × 14	*in.*
Depth	6	8	6	8	*in.*
tx	£2 1 11	£2 13 8	£2 11 3	£3 3 8	*each*



B 10-680—10½ × 6 × 6 in.



B 10-680—16 × 10 × 8 in.



B 10-685.

B 10-680. LABORATORY SINKS of enamelled fireclay, half-round for use on end of bench. White glazed inside and outside with screw holes for fixing. With outlet 2½ in. flange 2 in. bore for use with waste fittings **B 10-815**.

Overall size	10½ × 6 × 6	16 × 10 × 8 *in.*
tx	£1 11 7	£3 0 2 *each*

B 10-685. LABORATORY SINK of enamelled fireclay, white glazed inside and outside. With 6 in. anti-splash back skirting, rolled edge and outlet 2½ in. flange 2 in. bore for use with waste fittings **B 10-815**. External dimensions not including flange, 17 × 14 × 6 in. *tx* £ s. d. 2 17 0

SINKS

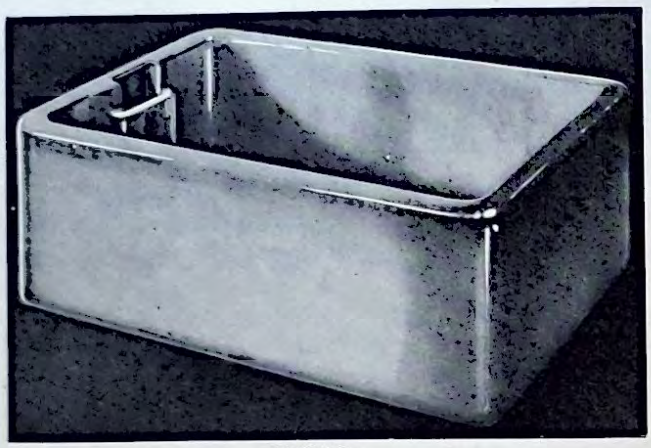


B 10-695.

B 10-695. SLATTED RACKS, or Duckboards, strongly made of oiled teak, for placing at bottom of sink to reduce breakages or for use as a duckboard.

Size ..	15 × 12	21 × 15	27 × 15	*in.*
To fit sink	18 × 15 × 8	24 × 18 × 10	30 × 18 × 10	*in.*
	t £1 6 0	£1 10 0	£1 17 6	*each*

Other sizes to order.



B 10-705.

LABORATORY WASH-UP SINKS with integral weir overflow, in strong heavy fireclay, glazed all round, permitting use with waste at either end. Outlet in centre of bottom at one end. Outlet 3½ in. flange 2⅝ in. bore.

B 10-705. White glazed inside and outside.

External Dimensions.		£	s.	d.
18 × 15 × 8 in. ..	*each tx*	2	8	9
21 × 16 × 8 in. ..	*each tx*	2	17	10
24 × 16 × 8 in. ..	*each tx*	2	17	10
30 × 18 × 8 in. ..	*each tx*	4	6	6
24 × 16 × 10 in. ..	*each tx*	3	8	5
24 × 18 × 10 in. ..	*each tx*	3	11	0
27 × 18 × 10 in. ..	*each tx*	4	16	2
30 × 18 × 10 in. ..	*each tx*	5	6	10

External Dimensions.		£	s.	d.
30 × 20 × 10 in. ..	*each tx*	7	2	7
36 × 18 × 10 in. ..	*each tx*	7	15	3
36 × 20 × 10 in. ..	*each tx*	8	10	8
42 × 24 × 10 in. ..	*each tx*	12	3	3
42 × 24 × 12 in. ..	*each tx*	14	11	3
48 × 24 × 10 in. ..	*each tx*	13	18	0
48 × 24 × 12 in. ..	*each tx*	16	11	11

For waste fittings for above sinks see **B 10-810.**



B 10-715.



B 10-725.

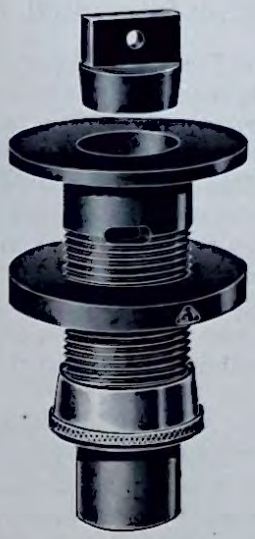
B 10-715. LABORATORY RECEIVERS, of enamelled fireclay, white glazed inside and out, with outside rim at top. With bent outlet at end, not fitted with syphon. External dimensions not including flange.

Dimensions	12 × 8	15 × 10	*in.*
Depth	7	8	*in.*
	tx £1 17 5	£2 8 4	*each*

B 10-725. LABORATORY ACID TRAP OR RECEIVER, in enamelled fireclay white glazed inside and outside, with plain edge. Syphon outlet with rubber bung in tubulure in bend of syphon for inspection and cleaning. External size 13 × 13 × 13 in. .. .. .. *tx* £ 3 5 6



B 10-805.



B 10-810.

£ s. d

B 10-805. OUTLET, Vulcanite, 2½ in. diam. flange, slotted below flange to connect to sink overflow, with screwed vulcanite fly-ring, perforated vulcanite removable grid and vulcanite plug. Fitted with lead tail-piece flanged to fit flush against bottom of vulcanite tube, secured by brass milled edge union-nut to prevent breakage liable to occur when spanner is used with hexagon nut usually supplied. Waste from sink only comes into contact with vulcanite or lead pipes. For use with sink **B 10-670** .. .. £ 1 7 6

B 10-810. Ditto, with 3½ in. diam. flange. For use with sinks **B 10-705.** .. .. .. £ 1 12 6



B 10-815.

B 10-815. STANDING WASTE, Vulcanite, 2½ in. diam. flange, with screwed vulcanite fly-ring and removable perforated vulcanite grid and vulcanite standing waste with perforations near top at height to suit sink. Fitted with lead tail-piece flanged to fit flush against bottom of vulcanite tube, secured by brass milled edge union-nut as supplied with **B 10-805.** For use with sinks **B 10-675, B 10-680, B 10-685** .. .. £ s. d. £ 1 12 6



B 10-820.

£ s. d.

B 10-820. DRIP WASTE, Vulcanite, funnel shaped, 3 in. diam. at top, with screwed vulcanite fly-ring and removable perforated vulcanite grid. Fitted with lead tail-piece flanged to fit flush against bottom of tube, secured by brass milled edge union-nut. For fixing in bench top or in fume cupboard under water taps .. .. £ 1 12 6

New easy-clean improved patterns designed specially for laboratory use

Laboratory Water Taps are used under very exacting conditions of arduous service and corrosive atmospheres, and must therefore be designed to give trouble-free operation over prolonged periods.

The new G & T water taps listed here have all been specially designed for laboratory use, particular attention having been given to those minute details of design which make them ideal for their purpose.

The selection of taps adequately covers all normal laboratory needs ; but if special taps are required for installation in any position in which standard patterns are unsuitable, we shall be pleased to quote upon receipt of details.

G & T water taps are acceptable to, and, if so ordered, can be examined and stamped by any water authority, at the appropriate extra cost.

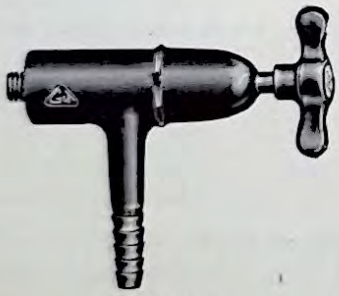
G & T water taps are of easy-clean design with all fillets, ridges and mouldings eliminated to produce robust, neat smooth taps, easy to keep clean. An important feature of the easy-clean covers, is the introduction of an unobtrusive, octagonal spanner seating which enables the covers to be removed without damage to the cap by distortion or score marks.

G & T water taps for bench mounting all use the latest and best method of fixing by screws inserted into the bench top through countersunk holes in the flanged base of the standard. This method carries with it a number of advantages, chief among which are that the tap can be firmly and rigidly mounted and that screwed iron service pipe connections can be made to the tap itself. Taps constructed to be fixed by a back nut are difficult to mount rigidly, particularly where, as is usually the case, little space is available in which a spanner can be manipulated. The G & T method eliminates all the troubles associated with this type of design.

All the water taps listed are durable, black, oxidised finish, believed to be the best for general laboratory use. It will give excellent service if wiped periodically with a damp cloth. Chromium plated taps can be supplied if desired, but are not recommended for use except in a non-corrosive atmosphere.



B 11-015.



B 11-020.



B 11-025.

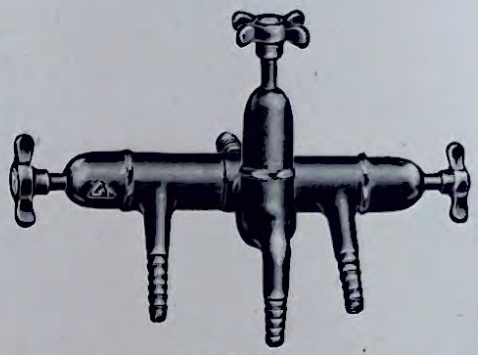
B 11-015. WATER TAPS, G & T Easy-clean bib-cock pattern. Screw-down capstan head valve, for high pressure water, special buttress-riffled nozzle, firmly holding rubber tubing. Oxidised finish. Screwed for iron pipe.

Inlet screwed	$\frac{3}{8}$	$\frac{1}{2}$	*in.*
	p 17/6	£1 0 0	*each*

£ s. d.

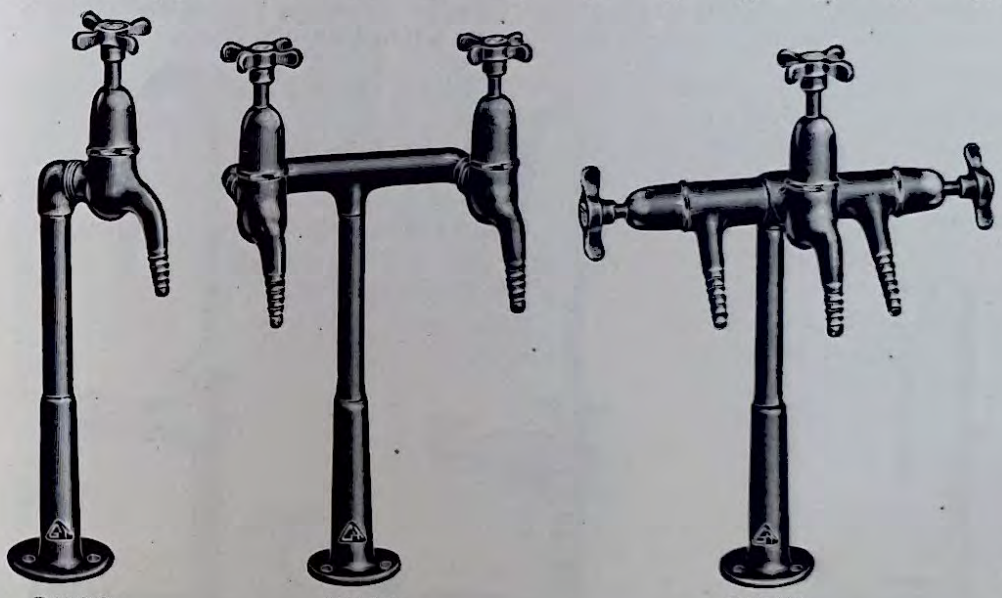
B 11-020. WATER TAP, G & T Easy-clean pet-cock pattern. For condensers, pumps, etc. Fixture enables nozzles to be directed to any convenient angle. Screw-down valve for high pressure water, special buttress-riffled nozzles, firmly holding rubber tubing. Oxidised finish. Screwed for $\frac{1}{2}$ in. iron pipe .. .. *p* 0 17 6

B 11-025. WATER TAP, G & T Easy-clean straight pattern. Suitable for screwing direct into iron pipe running above channel in the bench top. Screw-down capstan head valve for high pressure water. Special buttress-riffled nozzle firmly holding rubber tubing. Oxidised finish. Screwed for $\frac{1}{2}$ in. iron pipe .. .. *p* 0 17 6



B 11-030.

B 11-030. **WATER TAP, G & T Easy-clean pattern.** Bib-cock **B 11-015** and two adjustable angle pet-cocks **B 11-020.** Screw-down valves for high pressure water. Special buttress-riffled nozzles, firmly holding rubber tubing. Oxidised finish. Screwed for connection to $\frac{3}{8}$ in. iron pipe .. .. *p* £ 2 10 0



B 11-050. B 11-055. B 11-060.

B 11-050. **WATER TAPS, G & T Easy-clean pattern.** Single bib-cock **B 11-015** on large flanged standard giving rigid support for bench mounting, with screw-down capstan head valve for high pressure water, special buttress-riffled nozzle firmly holding rubber tubing. Oxidised finish. Flange screwed for $\frac{1}{2}$ in. iron pipe.

Height from flange to nozzle ..	8	11	*in.*
p	£2 0 0	£2 2 0	*each*

B 11-055. **WATER TAPS, G & T Easy-clean pattern.** Two bib-cocks **B 11-015** on large flanged standard giving rigid support for bench mounting. Screw-down capstan head valve, for high pressure water, special buttress-riffled nozzles firmly holding rubber tubing. Oxidised finish. Flange screwed for $\frac{1}{2}$ in. iron pipe.

Height from flange to nozzle ..	8	11	*in.*
p	£3 0 0	£3 5 0	*each*

B 11-060. **WATER TAPS, G & T Easy-clean pattern.** Bib-cock **B 11-015** with two side pet-cocks **B 11-020** on large flanged standard giving rigid support for bench mounting. Suitable for condensers, pumps, etc. Screw-down valves for high pressure water. Oxidised finish. Flange screwed for $\frac{1}{2}$ in. iron pipe.

Height from flange to nozzle ..	8	11	*in.*
p	£3 10 0	£3 15 0	*each*

Griffin and Tatlock Limited are makers of Complete Laboratory Equipment, including furniture, fittings and apparatus.



B 11-062.



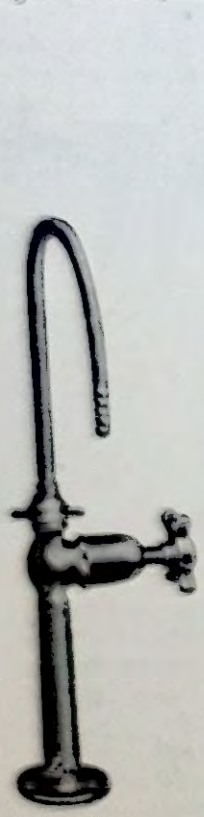
B 11-063.

£ s. d.

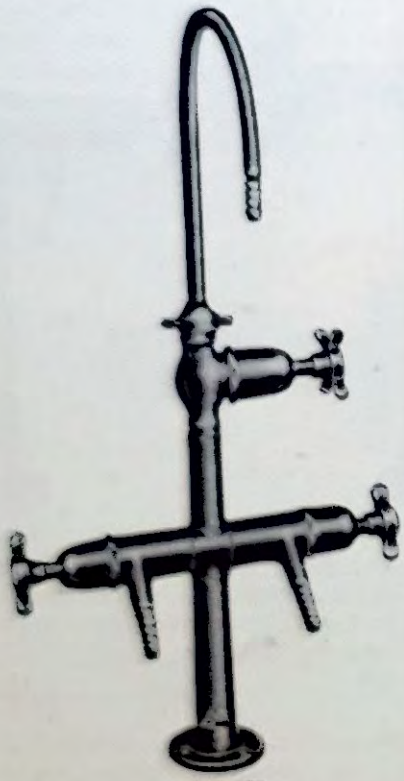
B 11-062. Ferrules, Brass, for connecting to lead supply pipes, taps which are screwed for iron pipe.

Screwed for taps	$\frac{3}{8}$	$\frac{1}{2}$ *in.*
p	1/-	1/- *each*

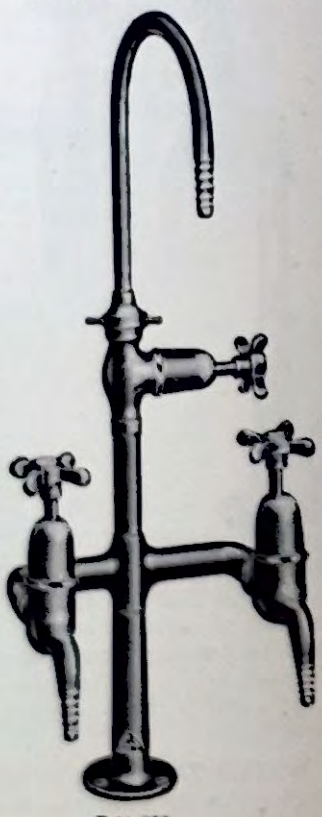
B 11-063. Union, Brass. Complete with extension piece, for connecting to lead supply pipes, flanged-standard, bench-mounting taps which are screwed for iron pipe .. .. *p* 0 4 6



B 11-065.



B 11-070.



B 11-075.

£ s. d.

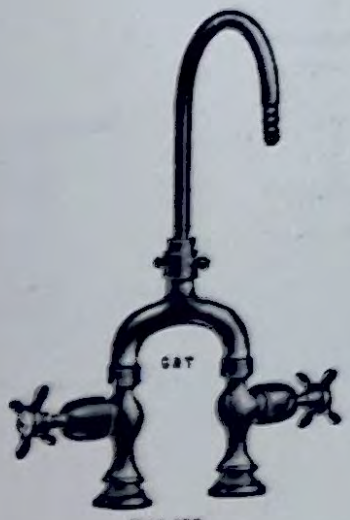
B 11-065. WATER TAP, C & T Easy-clean pattern. Screw-down capstan head valve for high pressure water, with swan neck and swivel joint on large flanged standard, giving rigid support for bench mounting. Oxidised finish. Flange screwed for ½ in. iron pipe. Height from flange to nozzle, 10 in. .. .. *p* 2 0 0

B 11-070. WATER TAP, C & T Easy-clean pattern. As B 11-065 but with two pet-cocks B 11-020, suitable for supplying condensers, pumps, etc. Oxidised finish. Flange screwed for ½ in. iron pipe. Height from flange to nozzle of side taps, 3½ in. Height from flange to nozzle of swan neck, 15 in. .. .. *p* 4 15 0

B 11-075. WATER TAP, C & T Easy-clean pattern. Two bib-cocks B 11-015, with screw-down capstan head valves, swan neck with swivel joint and separate valve control, on large flanged standard giving rigid support for bench mounting. Oxidised finish. Flange screwed for ½ in. iron pipe. Height from flange to nozzle of side taps, 3½ in. Height from flange to nozzle of swan neck, 15 in. .. .. *p* 4 15 0



B 11-090.



B 11-095.

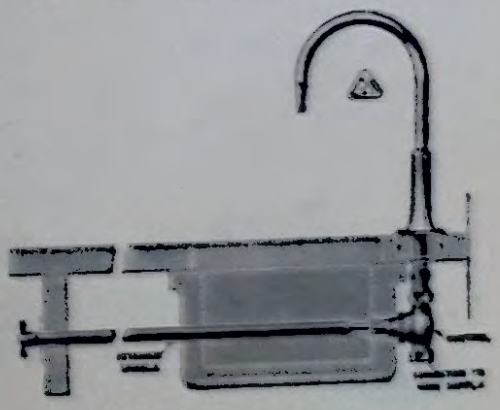
£ s. d.

B 11-090. WATER TAP, G & T Easy-clean folding pattern, to fold into sink when not in use, with swivel joint swan neck, special buttress-riffled nozzle firmly holding rubber tubing, screw-down capstan head valve, for high pressure water. Oxidised finish. Screwed for ⅜ in. iron pipe .. .. *p* 2 15 0

B 11-095. WATER MIXER, G & T Easy-clean pattern. To deliver, from hot and from cold water supplies, a constant stream of water at any temperature between that of the cold supply and that of the hot supply. Pipe lines 4½ in. apart. Delivery nozzle 12 in. from bench top. Screw-down valves with capstan heads for high-pressure water, special buttress-riffled nozzle firmly holding rubber tubing. Oxidised finish. Inlets screwed for ½ in. iron pipe .. .. *p* 3 0 0



B 11-106.



B 11-105 + 107.—Method of installation.

£ s. d.

B 11-105. WATER TAP, G & T. Front control, for use with water bend B 11-107. This is a convenient and improved type of control when apparatus set up on the bench renders it difficult to reach the ordinary type of water tap installed at the back of the bench, and also in fume cupboards, where it is desirable to control the water without raising the sash.

Standard length of front control spindle, 10 in. Complete with flanged, front-fixing plate and capstan head. Oxidised finish. Inlets screwed for ½ in. iron pipe .. *p* 1 6 0

Other spindle lengths made to order.

B 11-107. WATER BEND, G & T Easy-clean pattern, for use with front control B 11-105. Large flanged standard giving rigid support for bench mounting.

Height from flange to nozzle, 9 in. Oxidised finish. Flange screwed for ½ in. iron pipe. *(See diagram for method of installation)* .. .. *p* 0 19 0

GAS TAPS



B 11-150.



B 11-152.



B 11-155.



B 11-157.

	£	s.	d.
B 11-150. **T-PIECE,** 3-way, brass, riffled ends, without taps	0	4	0
B 11-152. **Ditto,** with two taps	0	10	0
B 11-155. **DISTRIBUTION TUBE,** 4-way, brass, riffled ends, without taps	0	5	0
B 11-157. **Ditto,** with three taps	0	13	6



B 11-175.



B 11-178.

B 11-175. GAS TAPS, single-way, brass, black bronzed with lever handles. To screw into gas pipe. The larger sizes are of exceptionally robust construction, and are designed specially for the control of furnaces and of gas-operated apparatus having a high gas consumption.

Screwed for	¼	½	¾	1	*in. gas pipe.*
p	6/6	7/6	10/-	12/-	*each.*

B 11-178. Ditto, two-way.

Screwed for	¼	½	¾	*in. gas pipe.*
Bore of taps	¼	⅜	½	*in.*
p	10/-	14/-	17/6	*each.*



B 11-185.



B 11-190.



B 11-195.

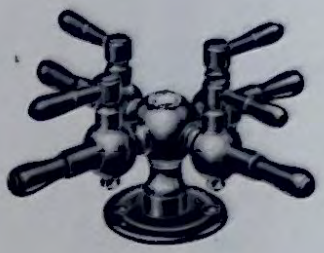
B 11-185. GAS TAPS, single-way, brass, black bronzed, with lever handles. Fitted with flanged base to screw to bench. The larger sizes are of exceptionally robust construction, and are designed specially for the control of furnaces and of gas-operated apparatus having a high gas consumption.

Screwed for	⅛	¼	⅜	½	*in. gas pipe.*
p	11/-	12/6	14/-	17/6	*each.*

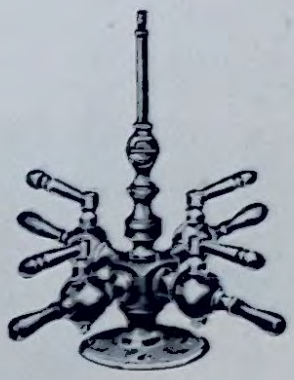
	£	s.	d.
B 11-190. GAS TAP, two-way, with taps set at 90°, brass, black bronzed, with lever handles, and with flanged base to screw to bench. Screwed for ¼ in. gas pipe .. .. *p*	0	17	6
B 11-195. Ditto, with taps set at 180°. Screwed for ¼ in. gas pipe .. .. *p*	0	17	6



B 11-200.



B 11-205.



B 11-210.

£ s. d.

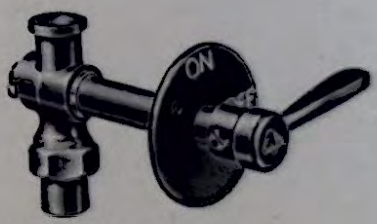
B 11-200. GAS TAP, three-way, with taps set at 120°, brass, black bronzed, with lever handles, and with flanged base to screw to bench. Screwed for ½ in. gas pipe .. .. *p* 1 0 0

B 11-205. GAS TAP, four-way, brass, black bronzed, with lever handles, and flanged base to screw to bench top. Screwed for ½ in. gas pipe .. .. *p* 1 5 0

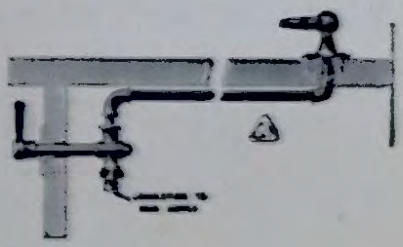
B 11-210. Ditto, as **B 11-205,** but fitted in centre with extra tap and tube with luminous flat flame burner, to act as pilot light or for bending glass. Screwed for ½ in. gas pipe *p* 1 10 0



B 11-215.



B 11-220.



B 11-215 & 220. Method of installation.

£ s. d.

B 11-215. GAS LEADS, single-way, brass, black bronzed, with flanged base to screw to bench top. For use with gas taps **B 11-220.** Screwed for ½ in. gas pipe. .. *each* *p* 0 7 6

B 11-220. GAS TAPS, Front control, new design, enabling all gas connections to be run inside bench or fume cupboard, thus producing a neat, tidy, laboratory with no exposed piping, and yet providing a convenient front control not subject to the disadvantages of other types. Black oxidised finish. Diagram shows method of installation with gas lead **B 11-215** used for delivery and connected in any desired position. Screwed for ½ in. gas pipe .. .. *each* *p* 0 15 0

Griffin and Tatlock Limited are complete Laboratory outfitters and design and manufacture Laboratory Furniture and Apparatus of the most varied character.

General Apparatus



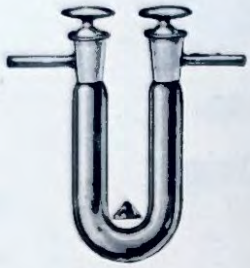
B 11-600.



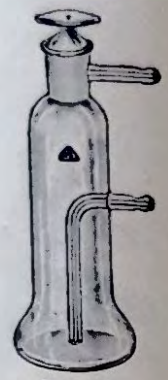
B 11-610.



B 11-615.



B 11-660.



B 11-678.

B 11-600. ABSORPTION TUBES, calcium chloride (*B.L.W.A. Standard T.C.D. No.* 109), straight, with one bulb.

Length × Diam. ..	100 × 12	150 × 20	200 × 25	*mm.*
	5/-	6/-	8/6	*dozen*
	6d.	7d.	10d.	*each*

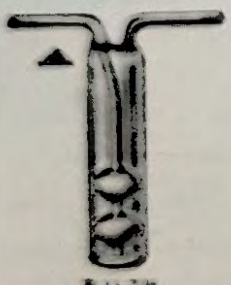
ABSORPTION TUBES, calcium chloride, U-form. Plain U-tube *B.L.W.A. Standard T.C.D. No.* 110. **With** two side arms, *B.L.W.A. Standard T.C.D. No.* 112.

Length×Diam. ..	100×12	125×15	150×20	200×25	*mm.*
B 11-610. Plain U-tube	10/-	13/-	14/6	20/-	*dozen*
	11d.	1/3	1/4	1/10	*each*
B 11-615. Ditto, with side arms	14/6	18/-	25/-	33/-	*dozen*
	1/4	1/8	2/6	3/-	*each*

B 11-660. ABSORPTION TUBES, calcium chloride (*B.L.W.A. Standard T.C.D. No.* 113), with drilled, ground-in stoppers, allowing sealing by partial rotation of stopper. Very convenient for suspending from balance stirrup for weighing.

Length × Diam. ..	100 × 12	125 × 15	150 × 20	*mm.*
	5/-	6/-	6/6	*each*

B 11-678. ABSORPTION TUBE, Midvale (*B.L.W.A. Standard T.C.D. No.* 120), height to shoulder 4½ in., diam. 1¾ in., with capillary inlet tube, and outlet tube fitted to ground-in stopper permitting it to be sealed by partial rotation of stopper. Capacity approx. 75 ml. .. £ s. d. 0 12 6



B 11-725.



B 11-790.

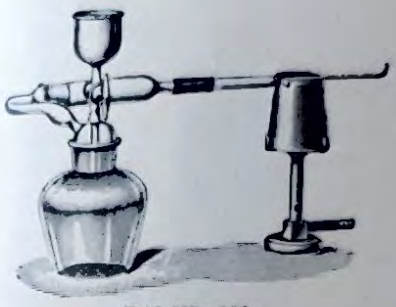


B 11-792.

B 11-725. ABSORPTION TUBE, Arnold (*B.L.W.A. Standard T.C.D. No.* 117), with two bulbs, 5 in. high 0 3 6

B 11-790. ABSORPTION (POTASH) BULB, Liebig (*B.L.W.A. Standard T.C.D. No.* 116), 3¾ in. high, in card case 0 3 6

B 11-792. ABSORPTION (POTASH) BULB, Mohr (*B.L.W.A. Standard T.C.D. No.* 114), 4½ in. high, in card case 0 6 0



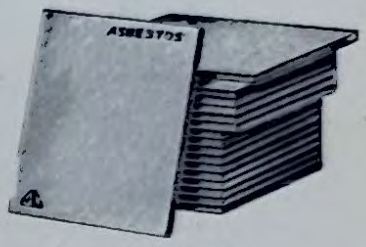
B 12-035—036.



B 12-065.



B 12-078.



B 12-146—148.

B 12-035. ARSENIC APPARATUS, Inland Revenue standard pattern (*Report Arsenic Committee appointed by Commissioners of Inland Revenue*, 1903). Glass body with tap funnel and ground-on calcium chloride tube. With special hard glass arsenic tube and small pattern Bunsen burner with copper chimney .. .. £ 1 13 6

B 12-036. Ditto, glass parts only 0 18 0

B 12-065. ARSENIC TUBES, Standard Inland Revenue pattern, for use with **B 12-035**. Hard combustion tubing specially selected for arsenic testing, giving clear brown stains with freedom from double mirrors. Made with sharp shoulder, as requested by prominent workers .. .. *each* 9d.; *dozen* 0 8 0

B 12-078. ARSENIC APPARATUS, Lindsey, Gutzeit Test (*Analyst*, 1930, **55**, 303), conical flask, 150 ml. capacity, rubber stopper, glass tube with lower end constricted to about 2 mm. diam., hole in side 2 mm. diam., and ground flanges at top, with hole 6·5 mm. diam., in accordance with B.P. 1932. A disc of mercuric chloride paper is held between the two ground flanges by a rubber band passing around the specially-shaped lugs 0 9 6

B 12-080. TEST STRIPS, Arsenic, Whatman No. 130. Unsensitised paper, approx. 120 × 2·5 mm. .. .. *packet* 1000 *strips* £ 0 3 11

B 12-140. ASBESTOS CORD, $\frac{1}{8}$, $\frac{3}{16}$, $\frac{1}{4}$ in. diam., for lagging and making gaskets, etc. *lb.* 0 4 0

B 12-142. ASBESTOS PAPER, flexible. Best quality for use in fireproofing, heat insulation of distillation apparatus, fractionating columns, etc. (approx. 12 sq. ft. per lb.) .. *lb.* 0 3 0

B 12-144. ASBESTOS CLOTH, finest quality. For making fireproof aprons, etc. (approx. 3 sq. ft. per lb.) .. .. *lb.* 0 5 0

B 12-146. ASBESTOS MILLBOARD, SQUARES, soft. Heat resistant, for use under Bunsen burners, etc. ..

Dimensions ..	4 × 4	5 × 5	6 × 6	9 × 9	12 × 12 in.
$\frac{1}{16}$ in. thick ..	11d.	1/4	1/9	4/-	7/- *dozen*
$\frac{1}{8}$ in. thick ..	1/9	2/9	3/6	7/-	13/6 *dozen*

B 12-148. ASBESTOS CEMENT, SQUARES, hard. Heat resistant, for placing beneath Bunsen burners. Protects bench top from damage by containers of heated substances.

Dimensions ..	4 × 4	5 × 5	9 × 9	9 × 9	12 × 12 in.
Thickness ..	$\frac{1}{16}$	$\frac{1}{8}$	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{4}$ in.
	5/-	9/-	11/-	21/-	30/- *dozen*



B 12-162.



B 12-200.



B 12-202.



B 12-207.

B 12-160. ASPIRATORS, Stoneware, plain top, with tubulure at base, for distilled water, etc.

Capacity	2	4	5	6	8	10	*gallons*
p	11/6	27/6	32/6	40/-	70/-	85/-	*each*

B 12-162. Ditto, with ground-in stoneware stop-cock .. .. .. *p* 51/6 67/6 72/6 85/- 120/- 135/- *each*

B 12-200. ASPIRATORS, Glass, with tubulure. Up to 5 litres, necks and tubulures are ground to approximately the undermentioned B.S. interchangeable joint sizes.

Capacity ..	¼	½	1	2	3	5	10	15	20	*litres*
Neck ..	B19	B24	B29	B29	B29	A40	—	—	—	
Tubulure ..	C14	B19	B19	B24	B24	B29	—	—	—	
tx	3/3	4/3	5/6	7/-	9/-	13/6	30/-	48/-	84/-	*each*

B 12-202. ASPIRATORS, Glass, with side tube riffled at end for rubber tubing. For use as a levelling bottle, with Orsat apparatus, etc.

Capacity ..	125	250	500	*ml.*	1	2	3	5	*litres*
tx	2/9	3/9	4/6	*each*	6/6	9/-	13/6	18/-	*each*

B 12-205. ASPIRATORS, Glass, with tubulure and ground-in glass stopcock.

Capacity	½	1	2	3	5	6	8	10	15	20	*litres*
tx	15/-	17/-	20/-	24/-	31/-	35/-	41/-	54/-	78/-	123/-	*each*

B 12-207. ASPIRATORS, Glass, with both ground-in stopper with vent hole, and stopcock.

Capacity	½	1	2	3	5	6	8	10	15	20	*litres*
tx	16/6	19/-	22/6	27/-	36/-	42/-	48/-	62/-	87/-	133/-	*each*

Please use our Catalogue Numbers in your requisitions and orders. They are a complete specification of your requirements.

BALANCES.—Modern manufacturing methods have resulted in the production of balances capable of standing up to severe operating conditions without sacrifice of accuracy and consistency.

Attention is drawn to balances employing the principle of a sliding rider traversing the length of the beam. The Monorider and Duorider Balances, **B 12-635, B 12-650, B 12-720**, are of this type. The Microid Chaindial Balances, **B 12-660, B 12-725**, are worthy of note. These balances are not only direct reading, but the use of fractional weights is eliminated, thereby considerably reducing the time taken in weighing operations. Such balances are now standard equipment in many educational laboratories. Likewise, increasing numbers of these balances are being supplied to industrial laboratories, particularly for accurate routine weighings.

The Microid Lever Balance (**B 12-600**) in its present greatly improved design, is an instrument of great utility; the action is simple and rapid, the pointer comes to rest without oscillating and it is direct reading. It is a general-purpose balance for rough weighings in the chemical, physical or biological laboratory, and particularly useful in the preparation room. It is recommended for use in general Science courses.

We believe that all usual educational, and many industrial laboratory requirements are covered by the range of balances, weights and accessories listed on the following pages. We shall be pleased to advise on the selection of balances, or the solution of any particular weighing problems.

The Fitting-up of Balances.—In unpacking Balances, the greatest care should be taken to avoid chipping the knife-edges. If they be damaged in any way, they must be replaced.

When assembling, follow carefully the instruction sheet sent with each Balance. Parts are not interchangeable and it is advisable to complete the fitting up of one Balance before another is unpacked.

The knife-edges and planes may be freed from dust by a gentle rubbing with a fine-grain chamois-leather. This leather should be kept specially for dusting the weights or the knife-edges, and should not be allowed to become dirty or greasy.

When moving a balance from one bench to another, the pans and bows should be removed so as to avoid any jarring which might damage the knife-edges.

Manipulation and Care of Balances.—Balances should be kept free from acid fumes, and a desiccator containing Silica Gel or granulated calcium chloride placed in the balance case, the drying agent being occasionally renewed. The Microid Balance Desiccator **B 13-480** is particularly recommended.

Vibration, extremes of temperature and direct sunlight should be avoided.

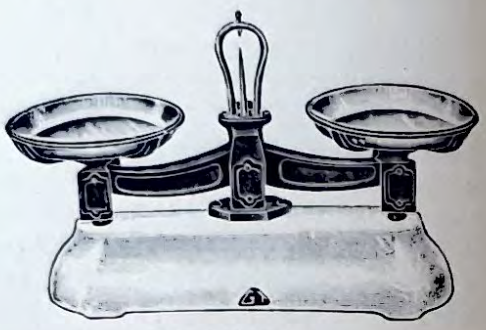
The following points should be noted:—

1. Removable riders, when out of use, should be kept on the rider-slide, and not left on the beam.
2. The equilibrium of the balance should be tested before and after using.
3. The motion of the beam should be arrested only when the pointer is at zero.
4. Substances to be weighed should not be placed directly on the scale-pan, but weighed in vessels of glass, porcelain, or platinum.
5. Deliquescent substances should be weighed in closed vessels.
6. Substances should not be weighed when warm.
7. Under no circumstances should anything be removed from the pans while the beam is swinging.

If the apparatus you require is not found in this catalogue, please write to us for quotations and specifications.



B 12-510.



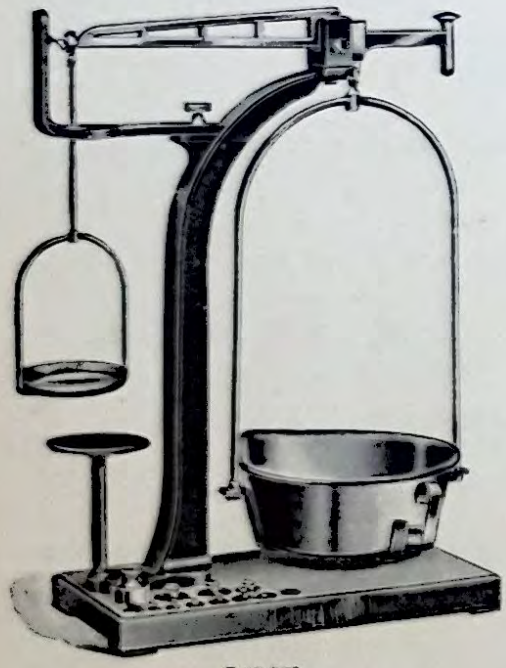
B 12-516.

B 12-510. COUNTER SCALES, light pattern, on bronzed iron stand, with two removable flat brass pans. To carry .. 1 2 5 10 *kilos.*

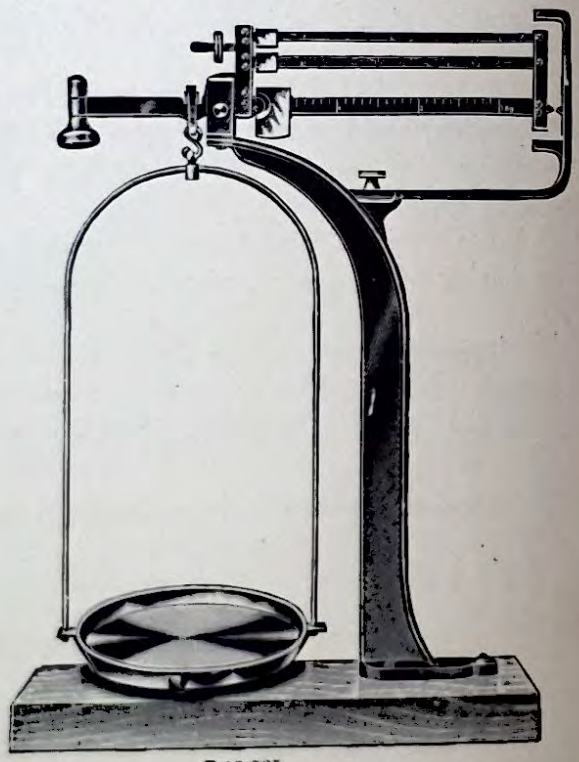
t £3 5 0 £4 7 6 £6 0 0 £9 0 0 *each*

B 12-516. SCALES, Counter, best quality, British manufacture, mounted on cast-iron base, vitreous enamelled, diecast beam and superior quality knife edges and self-aligning bearings. Indicator point and needle to show equilibrium position; with two circular heavy chromium-plated brass pans. To carry .. 2 4 *lbs.*

t £3 5 0 £3 10 0 *each.*



B 12-532.



B 12-535.

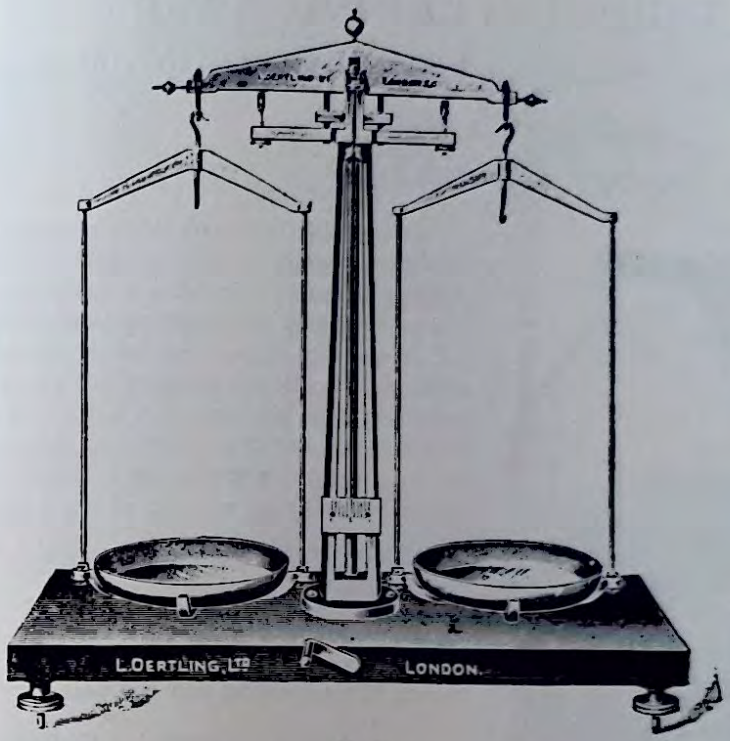
B 12-532. DECIMAL BALANCES. The two arms of the beam of the balance are in the ratio of 10 : 1. The counterpoising weight is therefore 1/10 the weight of the article being weighed. Mounted on polished wood base into which a complete set of weights 1—500 gms. or 1—1000 gms. is fitted. Lacquered brass beam and removable shallow pan. Sensitivity 0·1 gm. (*The deep form pan illustrated is supplied only to order.*)

To carry .. .. 5 10 *kilos.*

t £19 0 0 £20 0 0 *each*

B 12-535. TECHNICAL SCALES for direct weighing without weights, sensitive to 0·5 gram, with three graduated arms, each of which is fitted with a suitable rider, not removable, so that readings in steps of 100 grams can be taken with the largest rider up to the capacity of the balance. The other two riders read up to 100 grams × 5 grams and up to 10 grams × 0·5 gram respectively. The beam and pans are brass and the pillar is black enamelled iron. To carry 5 kilos. Diam. of pan 22 cms. .. .. *each* *t* 23 10 0

£ s. d.



B 12-540.

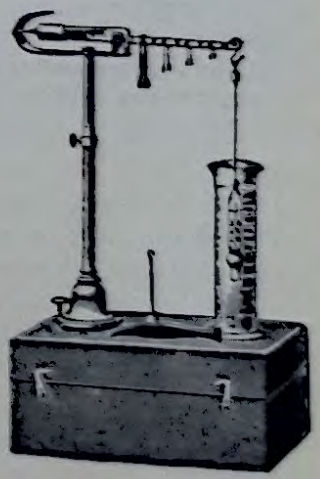
B 12-540. BALANCES, Oertling, constructed generally of lacquered gunmetal, brass beam. Mounted on polished mahogany base with plummet and levelling screws. Index reads 5 divisions each side of centre zero.

To carry ..	2	5	5	*kilos.*
Sensitivity ..	5	20	20	*mg.*
Beam, length	10	14	18	*in.*
Pans, diam. ..	6	7½	10	*in.*
Knife edges and bearings ..	Agate	Steel	Steel	
tx	£22 10 0	£25 0 0	£29 0 0	*each*



B 12-545.

B 12-545. BALANCE, Specific Gravity, Jolly (Yarwood: *Inter. Pract. Physics*, p. 14). Stainless steel rod 36 × ⅜ in. mounted on tripod with levelling screws. A silvered glass scale 60 cm. long divided in mm., supported in clips is adjustable for height on the steel rod. A spring is supported from a clamp at the top of the rod and is fitted at its lower end with a ring to support a metal pan for weighing in air, a glass pan for immersion in liquid, and a pointer to indicate the length of the spring on the scale. Complete with beaker, adjustable metal table, and 3 springs of different lengths £ 14 0 0



B 12-555.

B 12-555. BALANCE, Westphal (Findlay: *Pract. Phys. Chem., 7th Edn.*, p. 61; Fryer and Weston: *Oils, Fats and Waxes*, Vol. II, p. 32), **for determining specific gravity of all liquids** up to a maximum density of 2·0999 to the fourth place of decimals. Consisting of lacquered balance support and notched beam fitted **with non-rusting gilt steel knife edges** to give lasting service without breaking or chipping; set of 5 riders, forceps, plummet enclosing thermometer, and solution jar. Complete in polished wood case, with instructions for use £ 12 10 0

B 12-557. Thermometer Plummet, Reimann, for **B 12-555,** for determining the specific gravity of liquids; weighing 15 grams and displacing 5 grams of distilled water at 15° C. £ 2 7 6

THE MICROID LEVER BALANCE

Automatic self-indicating oil-damped balance reading to 200 grams sensitivity 0·5 gram

Registered Design Nos. 838738, 843750.



B 12-600.

This new Microid Lever Balance marks a radical advance in balances designed for rough or preliminary weighing in works', research and school laboratories. It is an automatic, self-indicating balance—that is to say, it does not require the use of weights. The weight of an article not exceeding 200 grams is found by placing it on the scale pan, and the oil-damped pointer swings smoothly and without oscillation over the scale, coming rapidly to rest in a position which can be read with an accuracy of 0·5 gram.

Simplicity is the keynote in design of the Microid Lever Balance.

Its initial accuracy and sensitivity are not impaired by use, because it has no knife edges to become blunted and has only one main pivot bearing.

Its accuracy is independent of the position of the load on the pan, because the pan is " suspended." In certain types of balances in which the pan is placed vertically above the lever mechanism, the accuracy of the readings is affected by the position of the load.

Its action is rapid. The weighing of five objects was found to take an aggregate time of 30 seconds.

The Microid Lever Balance is the first instrument which incorporates all these valuable features. The first design, introduced some years ago, won widespread approval. The instrument has now been completely redesigned for large scale production. The sector-type scale is inclined and therefore easier to read; the oil dash-pot is removeable; the base is more conveniently-shaped and stable; and the pillar and beam support are a rigid, non-ferrous casting in place of the earlier sheet metal construction. A counterbalance weight, equal to the weight of pan and bows, is now available for use in school specific gravity work.

SPECIFICATION

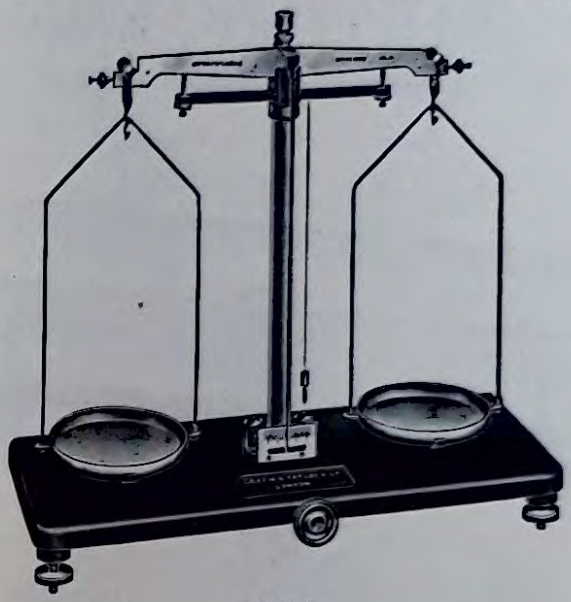
A black enamelled base is provided with rubber feet, and a levelling screw for use in adjusting the zero setting. Formed with the base is a dash-pot, to which is attached the pillar casting, carrying the pivoted beam, which is mounted in a box-type bearing with a single hardened steel pivot fitted with anti-friction end plates. The beam is fitted at one end with a counterweight and pointer and at the other end with a hardened steel pivot supporting a double-hooked stirrup from which the bows, and a pan about 4 in. diam., depend. From one side of the beam a link is connected to a rod fitted with a vane moving in oil in the dash-pot.

The scale is of triangular section, with one face inclined to the user, for ease in reading and for the elimination of parallax. It is divided black on silver, 200 × 1 grams. The scale can be read by interpolation to 0·5 gram. Overall height, 13 in.; overall width, 14½ in.; weight about 8 lb.

	£ s. d.
B 12-600. MICROID LEVER BALANCE, New Model (*Regd. Design Nos.* 838738, 843750), on enamelled base, with scale engraved 200 × 1 gram, as described above. Complete with a charge of oil and instructions for use	7 0 0
B 12-601. Counterbalance weight, for above, to enable specific gravity work to be carried out. Plated brass weight, fitted above and below with hooks, for suspension from beam in place of bows. Weight equals weight of normal pan and bows	0 3 6

THE MICRO-MINOR BALANCE

A reliable Model for the School Laboratory



B 12-620.

This is a new **all-agate** bearing model which closely follows the general lines of our extremely successful " Microid " type. The base is made of **Bakelite** which will not warp or shrink. Our object in producing this model has been to provide a balance which is not only low in price, but is robust, accurate, sensitive and reliable. This has been achieved by increased production and without sacrifice of any essential feature.

SPECIFICATION

All knife edges, planes and vees are of **agate** and all metal parts are of brass, strongly made and well finished.

The **Balance** is assembled on a **Bakelite base** 15 × 6 in., supported by levelling screws, a plummet being provided for levelling.

The pillar is secured to the base by two knurled screws. The releasing mechanism, which is of the usual eccentric type, is operated at the front of the base by a large milled disc, which permits of smooth release.

The lifting mechanism carries two agate planes on which the beam is supported when swinging. When lowered, the beam rests on two adjustable screws projecting from the beam support and in this position the centre agate is relieved of the weight of the beam.

The beam is solid, 9 in. long and is fitted with three agate knife edges of ample size. At each end is provided a screwed extension carrying a circular nut for zero adjustment. Since these extensions are provided with heads, the nuts are prevented from being screwed off and the risk of loss is thus eliminated—a very useful feature.

The pointer is of light, yet rigid, construction and reads on a scale boldly marked in black on a white background.

The stirrups are fitted with V-grooved agates and with double hooks which enable specific gravity determinations to be made.

The bows are 9 × 4½ in. and carry pans 4 in. diameter. Removable fittings (stirrups, bows and pans) and the ends of the beam are marked with one or two dots to denote left and right hand respectively.

The capacity of the balance is 250 grams in each pan and its sensitivity when fully loaded is 2 mg.

Simple instructions for erection accompany each balance.

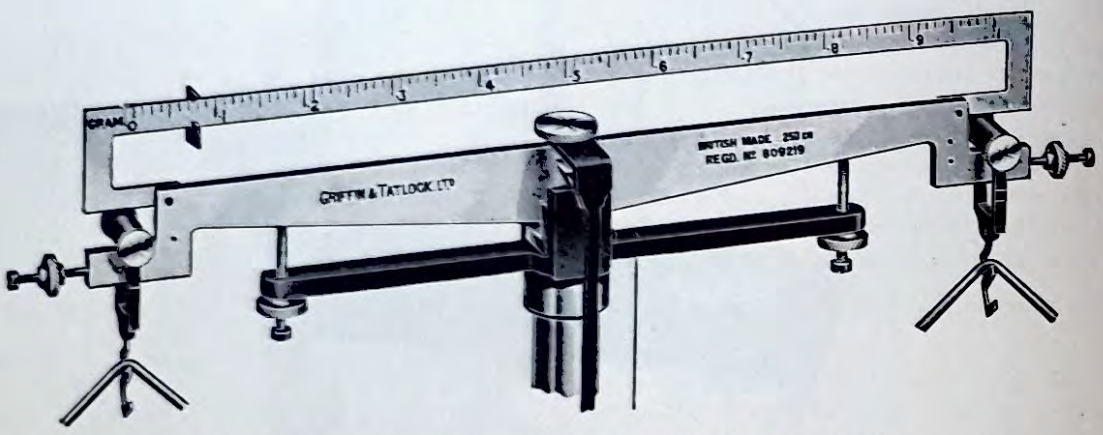
	£ s. d.
B 12-620. MICRO-MINOR BALANCE on Bakelite base, with levelling screws, brass pillar and stainless steel pans, solid beam and **all agate bearings**, capacity 250 grams in each pan, sensitivity 2 mg.	7 4 15 0
B 12-625. MICRO-MAJOR BALANCE, built on same lines as the **Micro-Minor** (**B 12-620**), but capacity 500 grams, sensitivity 5 mg.; mahogany base 17½ × 7 × ½ in.; bows 11½ × 5½ in.; brass pans 5 in. diam.; beam 10½ in. long	7 6 0 0

BAKELITE PANS FOR MICRO-MINOR BALANCES, see B13-520.
BALANCE CASES FOR STUDENTS' BALANCES, see B13-120–125.

THE MONORIDER BALANCE

Direct and rapid reading to 1 gram in 5 milligram steps by means of non-detachable rider

Registered Design No. 809219



B 12-635.—Showing beam, rider scale, and non-detachable rider reading 0·075 gm.

The outstanding feature of this balance, which in general construction is similar to the Micro-Minor (**B 12-620**), is the rider scale attached to the beam. This scale has been specially constructed to be direct-reading to 1 gram. All fractional weights are eliminated.

The scale is divided into 100 parts over a length equal to the distance between the two outer knife edges. Each tenth division is numbered, ·1, ·2, ·3, . . . 1 gram. The rider is of unique design, non-removable and can clearly be read against the engraved scale. It weighs 500 mg. The balance is adjusted, when the pans are unladen, to be in equilibrium with the rider in the zero position above the left hand knife edge. A movement of the rider along the scale from zero to its extreme right hand position above the right hand knife edge thus corresponds to an addition of 1 gram in the right hand pan and each division on the graduated beam is therefore equivalent to 10 milligrams. Since it is practicable to locate the rider accurately to at least one half a division, the balance is direct-reading to 5 milligrams.

The convenience of this arrangement will readily be appreciated. The operation of weighing consists merely in obtaining equilibrium to the nearest integral number of grams below the true weight of the object by placing gram weights on the right hand pan, and then in sliding the rider along the beam until equilibrium is obtained. All fractional weights are thus eliminated and the weighing carried out with great rapidity.

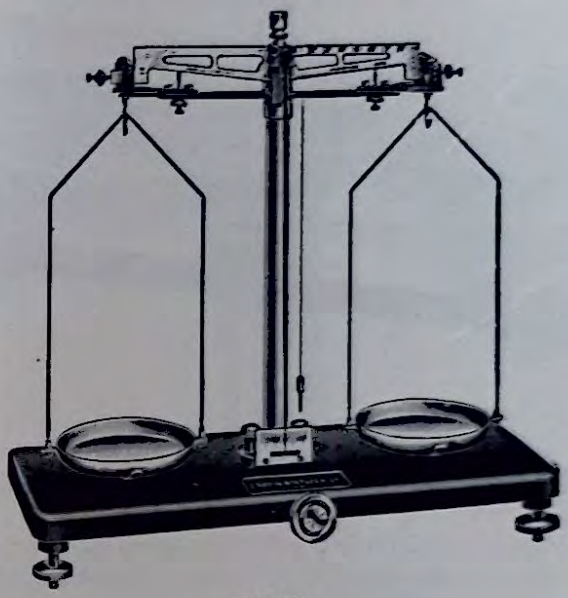
	£ s. d.
B 12-635. MONORIDER BALANCE, on Bakelite base. Agate knife edges and planes throughout. Complete with stainless steel pans and beam attachment divided into 100 parts. Non-detachable rider of total range 1 gm. in steps of 10 mg. and by interpolation to at least 5 mg. Capacity 250 gms. Sensitivity when fully loaded 5 mg.	5 5 0

THE MONORIDER BALANCE IN CASE, see B12-720.
THE DUORIDER BALANCE, see B12-650.

THE MICROID BALANCE

THE STANDARD MODEL

Robust and reliable for education or industry



B 12-640.

The remarkable success of our original model of Microid Balance, thousands of which are in successful use, has made it possible for us to offer at the same price a design incorporating several improvements, including particularly the provision of **stainless steel pans** and **Bakelite base** which does not warp or shrink.

This new British Model is offered at a very low price, made possible only by quantity production and the use of the latest mechanical and testing devices.

The Microid design incorporates all the features necessary for accurate and reliable service. Though inexpensive it is definitely a high-grade instrument and users are strongly recommended to adopt the Microid Model as standard, since it combines efficiency, robustness and economy in the highest degree.

SPECIFICATION

The pillar is of brass secured to a **Bakelite base** (about 15 × 6 in.) by two strong, knurled screws. A plummet and substantial levelling screws are provided. The pointer is well-balanced and the scale clearly divided on a white ground.

The brass beam is of the open type, of strong and rigid construction, graduated on the right hand side for rider. It carries non-removable adjusting nuts at each end. The stirrups are fitted with double hooks. The knife edges and planes are all of agate.

The beam is raised by means of a large milled head at the front of the base, which gives a smooth and even movement. When arrested it is supported on two adjustable pins and the stirrups are carried on brackets so that there is no contact between either the central or the lateral agate bearings, which are consequently relieved of all weight.

Removable bows carry substantial pans of stainless steel, 4 in. diameter. Each stirrup, bow and pan is marked with one or with two dots to denote left and right hand respectively.

The Balance carries 250 grams in each pan and is sensitive to 2 mg.

Simple instructions for erection accompany each balance.

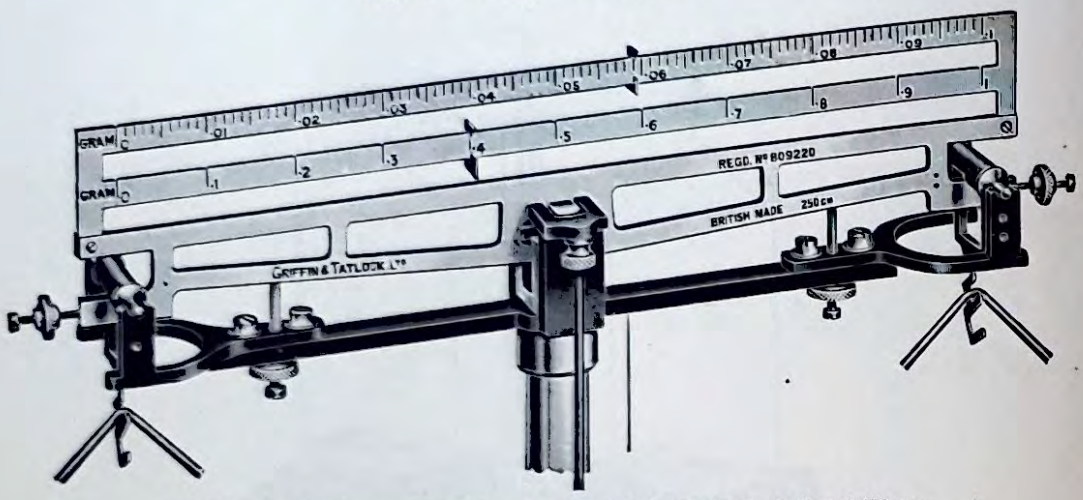
£ s. d.

B 12-640. MICROID BALANCE, on Bakelite base with stainless steel pans, agate knife edges and planes, beam divided one side, with levelling screws, to carry 250 grams and sensitive to 2 mg. 6 0 0

THE DUORIDER BALANCE

Direct and rapid reading to 1 gram in 1 milligram steps by means of dual non-detachable rider system

Registered Design No. 809220



B 12-650.—Showing beam, rider scales, and non-detachable riders reading 0·459 gm.

In general construction this balance follows lines exactly similar to the well-known and thoroughly approved standard model of Microid balance fully described on p. 401. It retains all the features which have made the Microid the standard balance for school equipment—agate knife edges and planes, Bakelite base, stainless steel pans, etc.

It is, however, a unique balance. The beam is fitted with two graduated scales, by means of which weighings accurate to 1 mg. may speedily be obtained.

The lower scale is divided into ten equal divisions over a length equal to the distance between the outer knife edges. The divisions are numbered ·1, ·2, ·3, . . . 1 gram. The scale is provided at each division with a shallow notch which locates precisely a 500 mg. non-detachable rider. A complete movement of the rider along the scale from its zero position above the left hand knife edge to its extreme position above the right hand knife edge is thus equivalent to the addition of 1 gram to the right hand pan ; and the distance between consecutive notches is consequently equivalent to 100 mg. giving the first decimal (decigram) place.

The upper scale is divided over the same distance into 100 equal parts. Each tenth division is numbered ·01, ·02, ·03, . . . ·1 gram. The rider is non-detachable and weighs 50 mg. A complete movement of the rider is thus equivalent to 100 mg. and each division on the upper scale therefore equals 1 mg.

To weigh an object in the left hand pan, the riders are set in their zero positions and gram weights are placed in the right hand pan until equilibrium is obtained to the nearest gram below the weight of the object.

The lower rider is then moved to the right along the beam until equilibrium is obtained to the nearest 0·1 gram below the weight of the object. The upper rider is then brought into operation and is moved along the beam until equilibrium is obtained. This upper rider should always be placed on one of the graduations on its beam and no attempt should be made to increase by interpolation the apparent accuracy of the weighing.

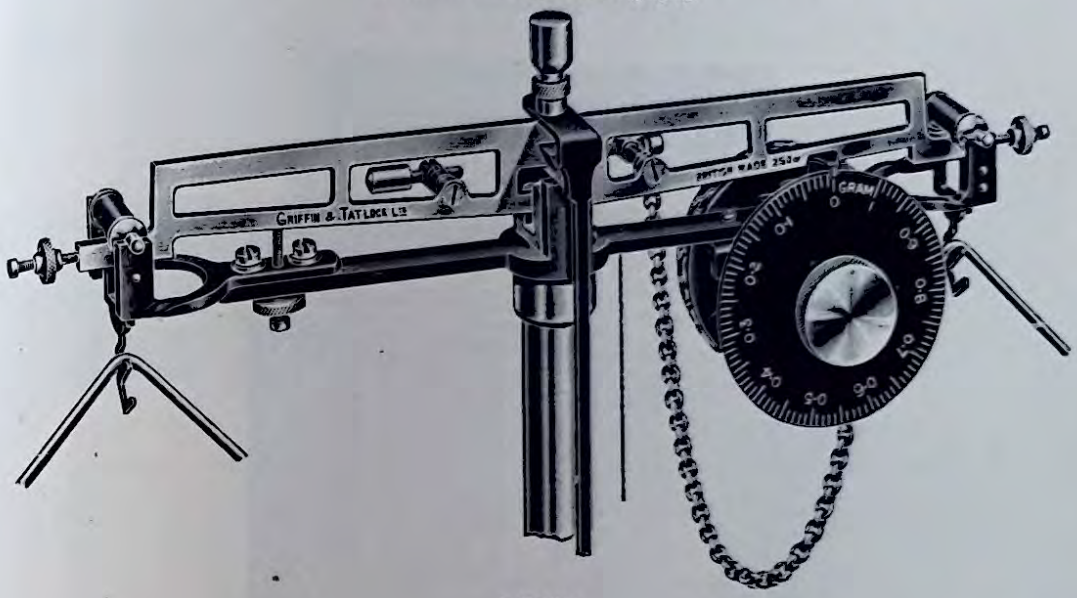
	£	s.	d.
B 12-650. DUORIDER BALANCE, on Bakelite base. Agate knife edges and planes throughout. Complete with stainless steel pans, dual beam attachment with non-detachable riders of total combined range 1 gram in steps of 1 mg. directly and without interpolation. Capacity 250 grams. Sensitivity when fully loaded 1 mg.	7	0	0

WEIGHTS FOR DUORIDER BALANCES, see B 13-255.

THE MICROID CHAINDIAL BALANCE

Accurate chain model sensitive to 5 mgm. and reading to 1 gram on dial operable *while beam is swinging*

Registered Design No. 830303



B 12-660.

The general construction of the Microid Chaindial Balance exactly follows that of the Microid Balance fully described on p. 401. All the distinctive features which have won for the Microid its well-deserved reputation are incorporated in the Chaindial Balance. They include:—acid- and stain-proof moulded Bakelite base, stainless steel pans, non-removable zero-adjustment nuts, agate knife edges and planes of generous size, relief of bearings when the balance is arrested, etc.

The chain principle has been successfully applied for many years to balances of analytical accuracy, and its use is now extended in the new Microid Chaindial Balance to balances of the student type. A chain has many advantages. It not only abolishes fractional weights, but, since the chain can be manipulated to add weight to the balance **while the beam is swinging**, its use results in a great saving, both of time in weighing and wear on knife edges.

The Microid Chaindial Balance is especially convenient in use, as it incorporates full-scale visibility and comes to the user with its integral Chaindial ready for immediate service.

Construction.—A bracket, fixed to the right-hand beam support, carries a horizontal spindle, bearing two coaxial discs which are frictionally held against unintentional rotation by a cupped spring washer of special design. Around the periphery of the rear disc is provided a groove in which one end of the chain is anchored and the remainder wound during weighing. The chain is a specially selected heavily-gilded link pattern. Its free end is suspended by a knife-edged link from the grooved head of an adjustable screw supported by a short pillar secured to a lug integral with the beam. A chain-support counterpoise of similar construction is provided on the left-hand side of the beam.

The front dial, 63 mm. diam., has a jet-black finish engraved with bold, white-filled, radial divisions, each equivalent to 10 mg. and covering the range 0–1 gram. It is rotated by a large milled head. The reading is taken against a white-filled engraved line on a stationary index. Each 10 mg. division occupies about 1·8 mm. at the circumference of the dial, which can therefore with ease be **read by interpolation to 5 mg.** Closer reading than this is not advised.

Operation.—The object to be weighed is placed in the left-hand pan and weights added to the right-hand pan to the nearest gram below the weight of the object. With the **balance released** the dial is rotated in a clockwise direction until equilibrium is established. The sum of the weights on the pan and the reading on the dial indicates the weight of the object.

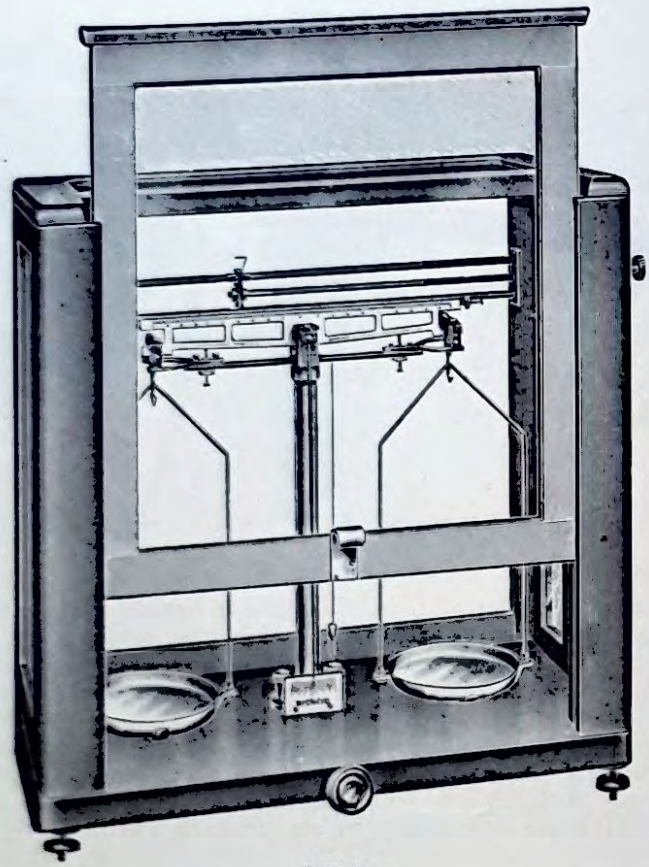
No cheaper, simpler and more accurate and rapid means is at present available for determining the weight of objects from 0–250 gram to an accuracy of 5 mg.

	£	s.	d.
B 12-660. MICROID CHAINDIAL BALANCE, on Bakelite base. With stainless steel pans, agate knife edges and planes throughout. Capacity 250 grams, with integral chain and dial, range up to 1 gram in increments of 10 mg. and readable by interpolation to 5 mg.	8	5	0

THE MICROID CHAINDIAL BALANCE, In Case, see B 12-725.

THE MICROID BALANCE IN CASE

New model with rider of 100 milligram range and improved rider mechanism



B 12-710.

The Microid balance in case is similar in construction to the Microid balance **B 12-640.** It is produced to satisfy the requirements of those who appreciate the greater convenience and added rigidity which result from mounting the balance to form an integral part of the case.

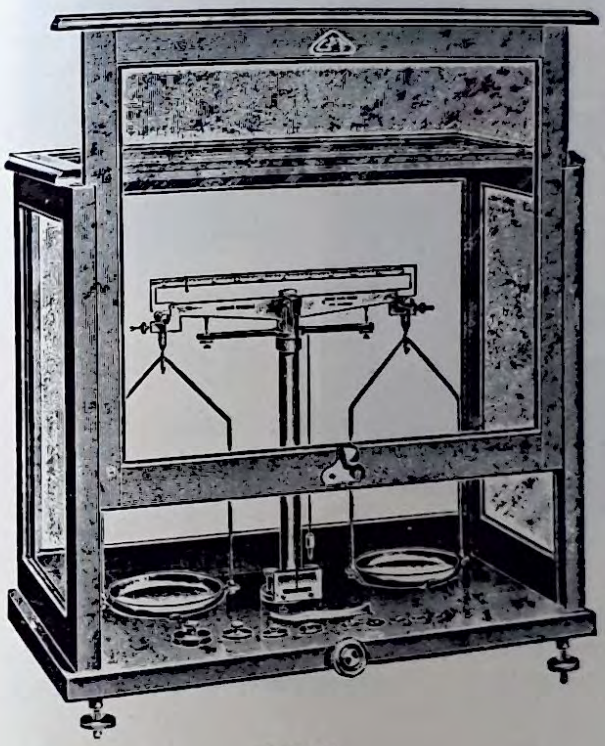
The beam of this balance is, however, of slightly different design from that of the Microid balance. The pointer is attached to the beam in such a manner that the upper portion of the beam is unobstructed to the free passage of a rider. The beam is graduated from left to right over its whole length into 100 parts numbered at each 10 divisions ·01, ·02, ·03, . . . 0·1 gram. A removable rider, of conventional design and weighing 50 mg., is placed on the beam which is consequently direct reading to 1 mg. over a 100 mg. range. It is operated by a rider mechanism which is spring controlled with an upward bias. It is thus impossible, as in some types of balance, for the rider mechanism inadvertently to be left in its lowered position, which is one of the most frequent causes of damage to agate knife edges.

The case of the balance is soundly constructed of well-seasoned, polished mahogany. It has a counterpoised front slide and glazed top and sides and is provided with levelling screws. The top corners and edges of the case are neatly rounded, giving a shape which is easy to clean and smooth to handle.

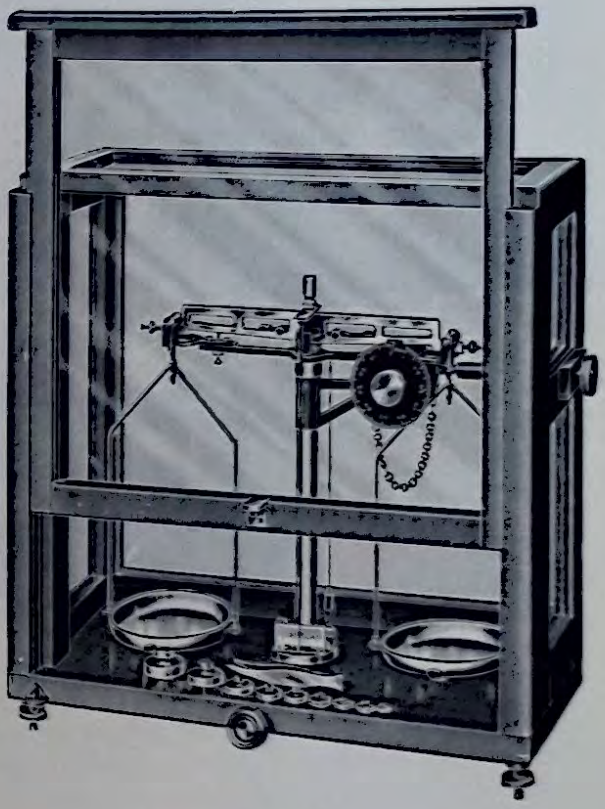
	£ s. d.
B 12-710. MICROID BALANCE IN CASE, with counterpoised sliding front, glazed top, back and sides. Agate planes and knife edges throughout, stainless steel pans, spring-controlled rider mechanism. Beam divided to give range of 100 mg. in increments of 1 mg. by means of 50 mg. rider. Capacity 250 grams, sensitivity 1 mg.	12 10 0

THE MONORIDER AND MICROID CHAINDIAL BALANCES IN CASES

With built-in weights to avoid loss and to facilitate checking



B 12-720.



B 12-725.

The distinctive feature of these balances is that weights are incorporated in the base. No set of weights needs to be used outside the balance case. The science master can, therefore, easily check by rapid inspection at the end of a science period whether any weights are missing. No fractional weights are required with either balance.

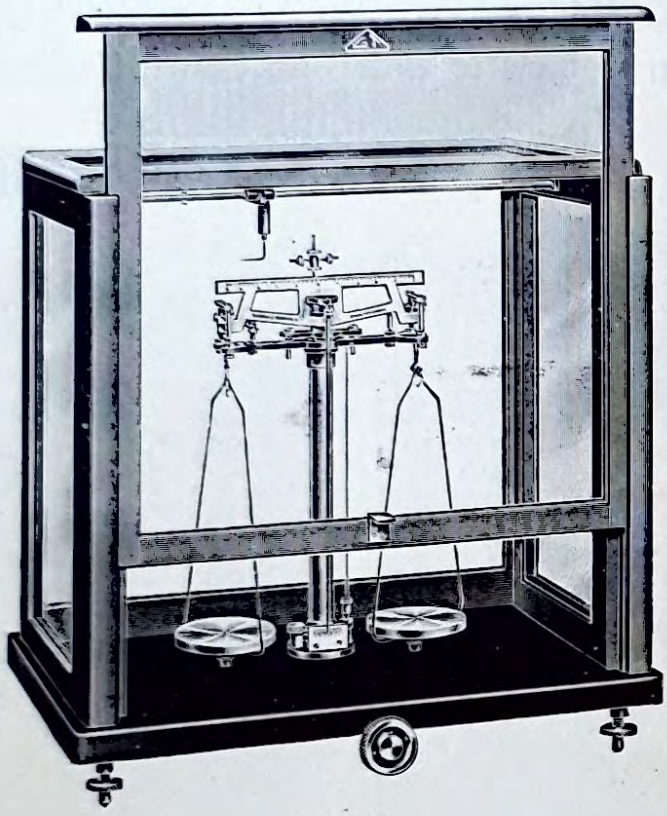
The weights provided range from 1 gm. to 100 gms. Forceps are included and accommodated in a groove alongside the weights. Cases are of polished oak, glazed on top and on all sides, and fitted with sliding front and levelling screws.

	£	s.	d.
B 12-720. MONORIDER BALANCE, in case, with sliding front and built-in weights, complete as described above. (*For Balance specification see* **B 12-635.**) With stainless steel pans	10	0	0
B 12-725. MICROID CHAINDIAL BALANCE, in case, with counterpoised sliding front and built-in weights, complete as described above. (*For Balance specification see* **B 12-660.**) With stainless steel pans	14	10	0

THE MONORIDER BALANCE, without case, see B 12-635.
THE MICROID CHAINDIAL BALANCE, without case, see B 12-660.

THE MICROID ANALYTICAL BALANCE

A new inexpensive model sensitive to 0·1 mg. with a load of 200 gm.



B 12-735.

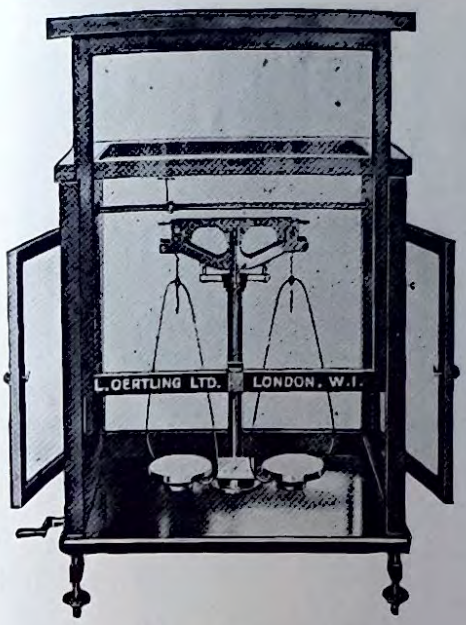
This new addition to the MICROID series is an Analytical Balance weighing to 0·1 milligram. It has a short period, is reliable and accurate, soundly constructed and well finished, and recommended for use by advanced students and for routine analytical work.

Many thousands of Microid Balances are in daily use in all parts of the world. Many years of experience in building balances ensures a reliable product. Tests have shown this new Analytical model to be thoroughly dependable.

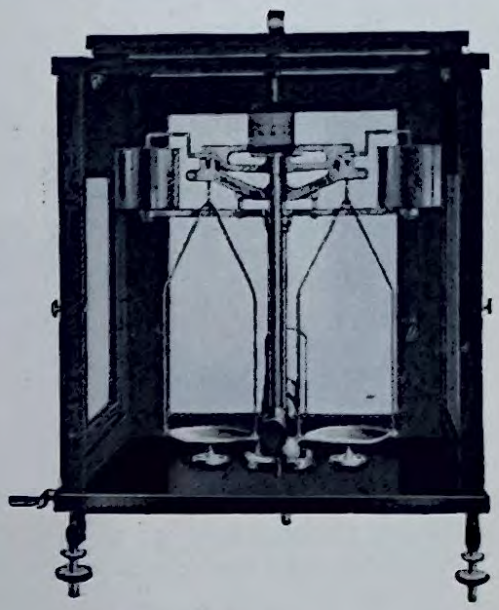
	£	s.	d.
B 12-735. MICROID ANALYTICAL BALANCE, with agate knife edges and planes. As specified below	22	10	0

Capacity	200 grams.
Sensitivity	0·1 mg.
Beam	Short armed, of special hard polished brass, 15 cm. long, with rapid swing (about 20 seconds unladen). Upper edge divided into 100 parts, with left-hand zero. Using a 5 mg. rider, each division represents 0·1 mg. All parts heavily lacquered.
Knife Edges and Bearings	Finest agate.
Rider adjustment	Parallel action smoothly operating.
Arrestment	Circular type, front action.
Pans	Polished stainless steel, slightly concave, 75 mm. diam.
Bows	11 cm. wide at base by 19 cm. high.
Pointer Scale	White scale graduated in 12 divisions on each side of a central zero.
Case	Polished mahogany, with counterpoised sliding front, levelling screws and plummet. Unbreakable base of special black reinforced Bakelite, acid, heat and stain proof.

ANALYTICAL WEIGHTS, see B 13-140.



B 12-762.



B 12-830.

£ s. d.

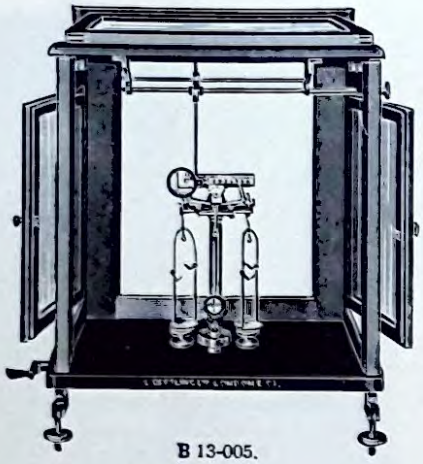
B 12-762. ANALYTICAL BALANCE, Oertling 48, for use in industrial and advanced educational laboratories. As specified below, capacity 100 grams .. .. *tx* 31 10 0

B 12-765. Ditto, capacity 200 grams .. .. *tx* 32 10 0

Sensitivity . . 0·1 mg.
Beam . . Gun-metal, 5 in. long, with upper edge graduated in 100 divisions from 0 on left to 10 on right, and adjusted with a 5 mg. rider at zero.
Knife Edges and Bearings . Agate.
Rider Slide . Single type.
Arrestment . At left-hand side.
Pans . . Chromium-plated, flat, 2¼ in. diam. Distance between bows 4¼ in. Adjustable pan supports.
Pointer Scale . White scale, with 10 divisions each side of central zero.
Case . . . Polished mahogany with two side doors, counterpoised sliding front, levelling screws, plummet, and black plate-glass base.

B 12-830. APERIODIC ANALYTICAL BALANCE, Projection Reading, Oertling 52/FM, with illuminated scale, projected and read on ground glass screen situated at eye level near the top of the balance case. Eliminates the handling of riders and of weights below 0·1 gram. Saves time and greatly reduces risk of error. With transformer for A.C., or resistance for D.C., 9 feet insulated flex and adapter for plugging into lighting circuit. As specified below. (*Please state voltage and whether A.C. or D.C. when ordering*) £ s. d. .. *tx* 65 0 0

Capacity . . 100 grams.
Sensitivity . . 0·2 mg., can be read by interpolation to 0·1 mg.
Beam . . 5 in. long, gun-metal.
Knife Edges and Planes . . Agate.
Arrestment . At left-hand side.
Illumination . A 12-volt projector lamp.
Damping Device . Air-damping cylinders attached to each end of the beam.
Pans . . Flat aluminium plates; 3½ inches between bows.
Pointer Scale . Finely divided graticule attached to pointer. Magnified image of graduations shows zero on left, 1000 on right and 500 intermediate divisions each corresponding to 0·2 mg. Can be read by interpolation to 0·1 mg.
Case . . . Polished mahogany; side doors; counterpoised front slide; heavy plate glass base, levelling screws and plummet.



B 13-005.



B 13-090 with microbalance in position.

B 13-005. MICRO-CHEMICAL BALANCE, Oertling 63, a highly satisfactory British made micro-balance for routine work. As specified below. Capacity 10 grams .. .. ..*tx* £85 0 0

Sensitivity . . 0·01 mg. directly, and by estimation to 0·001 mg.
Beam . . Hard-rolled brass, platinised, 3 in. long. The upper edge is serrated into 100 divisions from 0 on left to 10 on right.
Knife Edges and Bearings . Agate.
Rider Slide . Vertical type with lens attachment to facilitate reading of rider scale.
Arrestment . At left-hand side.
Pans . . Circular, concave, distance between bows 1½ in.
Pointer Scale . Scale graduated in 10 divisions each side of central zero, fitted with magnifying reader device.
Case . . . Polished mahogany with two side doors, counter-poised sliding front, black plate-glass base, plummet and levelling screws.

£ s. d.

B 13-090. BALANCE TABLE, Anti-Vibration, G & T, a new support to enable balances and other sensitive instruments, such as galvanometers and electrometers, to be placed where conditions of vibration would otherwise make their use impracticable. Absorbs severe or mild vibrations, of high or low frequency, intermittent or continuous. Polished oak case 25 × 21 × about 7 in. deep, fitted inside with pockets to act as retainers for four sets of four special solid rubber spheres arranged tetrahedrally. On these spheres rest two very heavy iron plates separated by a layer of compressed cork. The balance stands on a sheet of armoured plate glass 18 × 14 in., beneath which is placed a rectangle of black felt. Frictional means are provided for damping the system .. .. ..*r* 17 10 0

B 13-092. Ditto, Stand model, similar to above, but mounted on a framed leg stand, bench height .. ..*r* 20 10 0

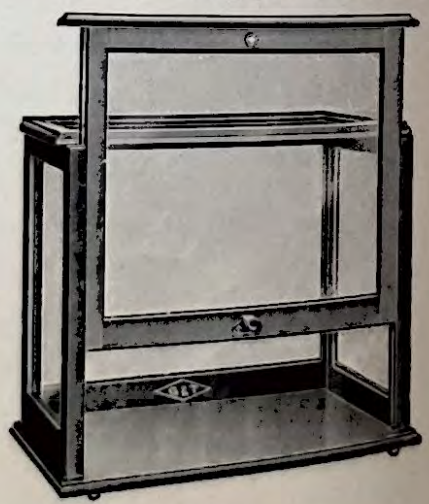
B 13-094. Spheres, rubber, spare, for replacement when the "permanent set" assumed by the spheres under load allows the glass plate to drop below the level of the surrounding case
set of four *r* 0 15 0

£ s. d.

B 13-120. BALANCE CASE, Oak, stained and polished, suitable for **Micro-Minor, Monorider, and Microid** balances. Inside dimensions, 16 × 7½ × 14½ in. high. With special springs for holding sliding front at any opened height .. .. ..*r* 2 10 0

B 13-122. Ditto, suitable for **Micro-Major, Duorider and Chaindial** balances. Inside dimensions, 18 × 8½ × 18 in. high .. ..*r* 3 5 0

B 13-125. BALANCE CASE, Oak, with counterpoised sliding front. Highly recommended as giving a smooth, even action. Suitable for use with all balances stated under **B 13-120.** Inside dimensions, 16 × 7½ × 14½ in. high .. .. *r* 3 15 0



B 13-120.

MICROID STAINLESS STEEL ANALYTICAL WEIGHTS TALL FORM

Incorrodibility confers permanence of surface with resultant constancy of mass



B 13-140—145.

The most notable adv ..ce of recent years in analytical weights was made when our stainless steel weights were introduced in 1932. That the claim of incorrodibility, conferring permanence of surface and therefore constancy of mass, was not ill-founded, is established by the fact that the many thousands of sets sold during this period have given every satisfaction in use.

The weights have been much improved by alteration of their shape to the conventional tall form associated with analytical work. They are otherwise unchanged in all the characteristics which have popularised their predecessors. The stainless steel used in their manufacture is made by a special process and is particularly suited to laboratory use use on account of its corrosion resistance and its non-magnetic properties. They are enclosed in a neat and attractive Bakelite case having a velvet-lined lid and provided with rubber feet.

The weights are made to satisfy standards of tolerance specified in the table below as Adjustment I (equivalent to Class A of the National Physical Laboratory). The table shows the permissible limit of error on weights of each denomination. Each set of weights is accompanied by a works certificate.

The sets contain weights of 50 or 100 grams to 10 milligrams with the twos and twenties duplicated. The fractions, of stainless steel, and the riders, are protected by a Perspex cover. A pair of ivory-tipped stainless steel forceps is supplied with each set.

B 13-140. MICROID ANALYTICAL WEIGHTS, TALL FORM, Adjustment I, stainless steel in Bakelite case. Fractions in stainless steel, 10 mg. and 1 mg. riders and ivory-tipped forceps. Works certificate supplied with each set.

10 mg. to	50	100	*grams*
	r £3 15 0	£4 5 0	*set*

B 13-143. N.P.L. Certificate for above .. .. *Prices on application.*

B 13-145. Bakelite Boxes only, for **B 13-140** .. .. r 7/- 7/- *each*

Spare Weights and Fractions for above, see pp. 411, 412.

ADJUSTMENT TOLERANCES FOR B 13-140.

Denomination	10 mg.	20 mg.	50 mg.	100 mg.	200 mg.	500 mg.	1 gm.	2 gm.	5 gm.	10 gm.	20 gm.	50 gm.	100 gm.
Tolerance, Adjustment I ± mg. . .	·03	·03	·05	0·1	0·1	0·1	0·1	0·1	0·1	0·1	0·2	0·5	1·0

MICROID BRASS WEIGHTS

Weights of high quality and finish in Bakelite case



B 13-250—252.

Microid Brass Weights represent the finest value obtainable in weights of their class. They have been widely adopted, both at home and abroad, for students' use, for which Adjustment IV is usually specified. Adjustment II, however, as applied to brass weights, is now introduced for use where higher standards of accuracy are desired. It is equivalent to the Class B adjustment of the National Physical Laboratory.

Microid Brass Weights are accurately made, finely finished and are adjusted to definite tolerances shown in the table below. They are supplied in a neat and attractive Bakelite case having a strongly-hinged velvet-lined lid, designed to withstand rough usage in the hands of students. The lid when closed is held by means of a snap spring catch fitted to the front. As Bakelite will neither warp nor shrink, its use for this purpose has proved to be generally popular.

The sets contain 50 grams or 100 grams to 5 milligrams with the twos or tens duplicated.

The fractions are of stainless steel and aluminium and are protected by a Perspex cover.

B 13-250. MICROID WEIGHTS, Adjustment IV, brass, in Bakelite case, fractions of stainless steel and aluminium under Perspex cover, with forceps.

5 mg. to	50	100	*grams*
	r £1 1 0	£1 7 6	*set*
B 13-252. Ditto, Adjustment II	*r* £1 6 0	£1 9 0	*set*

B 13-255. MICROID WEIGHTS, Adjustment IV, as **B 13-250,** but without fractions and Perspex cover, for use with Monorider, Duorider and Chaindial Balances.

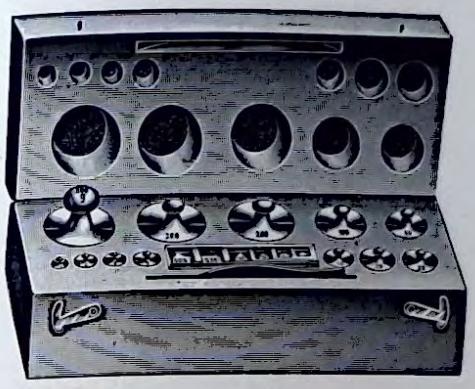
1 gram to	50	100	*grams*
	r 16/6	18/6	*set*
B 13-262. Bakelite Boxes only, for **B 13-250—255**	*r* 7/-	7/-	*each*

Spare Weights and Fractions for above, see pp. 411, 412.

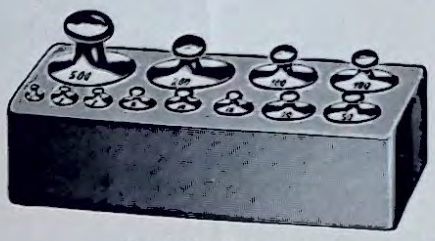
ADJUSTMENT TOLERANCES FOR B 13-250—255.

Denomination	5 mg.	10 mg.	20 mg.	50 mg.	100 mg.	200 mg.	500 mg.	1 gm.	2 gm.	5 gm.	10 gm.	20 gm.	50 gm.	100 gm.
Tolerance, Adjustment II ± mg. .	0·2	0·2	0·2	0·2	0·5	0·5	0·5	0·5	0·5	0·5	0·5	1·0	2·0	5·0
Tolerance, Adjustment IV ± mg. .	0·25	0·3	0·4	0·5	0·6	0·8	1·0	2·0	3·0	4·0	6·0	10	15	20

Thousands of sets of MICROID Metric Brass Weights are in use all over the world. They have been accepted as the standard weights of their class because they are carefully adjusted to definite limits.



B 13-272.



B 13-280. 500 grams.

£ s. d.

B 13-270. WEIGHTS, Set, brass, 5 mg. to 200 grams, in reinforced plastic case, with brass forceps, stainless steel and aluminium fractions under Perspex cover. (*Adjustment IV accuracy, see p. 410.*) 2 5 0

B 13-272. WEIGHTS, Set, brass, 5 mg. to 500 grams, in polished wood block case, with brass forceps, stainless steel and aluminium fractions under Perspex cover. (*Adjustment IV accuracy, see p. 410.*) 3 5 0

B 13-280. WEIGHTS, Sets, brass, in reinforced plastic block, without lid. (*Adjustment IV accuracy, see p. 410.*)

1 gram to	500 *grams*	1	2 *kilos.*
p	£2 5 0	£3 5 0	£4 15 0 *set*



B 13-310.



B 13-315—324.

£ s. d.

B 13-310. FRACTIONAL WEIGHTS, set of nine, 5 to 500 mg., in small metal box. (*Adjustment IV accuracy, see p. 410.*) 0 2 9

FRACTIONAL WEIGHTS, students' quality. Weight 5 mg. is of aluminium, and 10–500 mg. of stainless steel.

Cat. No.	Type	Milligrams						
		5	10	20	50	100	200	500
B 13-315.	Microid Adjustment IV . . *each*	4d.	4d.	4d.	4d.	4d.	4d.	4d.
		dozen 3/6; *gross* 38/-						
B 13-320	Ditto, Adjustment II . . *each*	8d.	8d.	8d.	8d.	1/3	1/3	1/3

B 13-324. FRACTIONAL WEIGHTS. Analytical, Microid, of stainless steel. (*Adjustment I accuracy, see p. 409.*)

Weight	10	20	50	100	200	500 *mg.*
r	1/3	1/3	1/6	1/9	1/9	2/- *each*



B 13-345—350.



B 13-355—357.

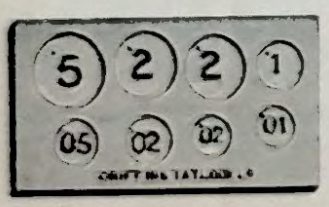
BRASS WEIGHTS, students' quality, loose, flat form.

Cat. No.	TYPE	Grams								
		1	2	5	10	20	50	100	200	500
B 13-345	**Microid** Adjustment IV . *each* Suitable for sets **B 13-250, B 13-255, B 13-270—280.**	r 1/-	r 1/6	r 1/6	r 1/9	r 2/-	r 2/3	r 2/6	r 7/-	r 9/-
B 13-347	**Ditto,** Adjustment II . *each* Suitable for set **B 13-252.**	r 1/9	r 1/9	r 2/-	r 2/3	r 2/6	r 2/9	r 3/6	—	—
B 13-350	**Ditto,** Adjustment IV . . Suitable for sets **B 13-280.** *each*	1 Kilo				2 Kilos				
		r 25/-				r 30/-				

	£	s.	d.
B 13-355. RIDERS, Aluminium, Adjustment I, 10 milligram ; 5 milligram ; 1 milligram *each p*	0	0	9
B 13-357. Ditto, Gold, Adjustment I, 10 milligram ; 5 milligram ; 1 milligram .. *each t*	0	1	6

B 13-365. WEIGHTS, Analytical, Microid, stainless steel, Adjustment I, loose, tall form.

Weight	1	2	5	10	20	50	100 *gm.*
	r 4/-	4/6	5/6	6/6	7/6	10/-	12/6 *each*



B 13-420.



B 13-430.



B 13-435. Curved.



B 13-435. Straight.



B 13-440.

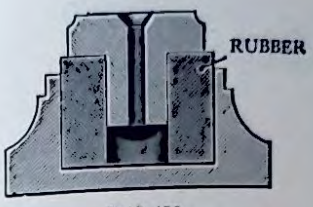
B 13-420. PLATE FOR FRACTIONS, opal glass, approximately 80 mm. long, 45 mm. wide, with eight circular cavities, each figured in black. Very useful for placing in balance case so that weights are easily accessible and those on pan can be readily checked by inspection of the number of empty spaces .. .. £ 0 6 6

B 13-430. COVERS, Glass, for fractional weights, $3\frac{1}{4} \times \frac{3}{4}$ in. .. .. *each* 0 0 9

B 13-435. FORCEPS, nickel-plated brass, 9 cm. long, either curved or straight *pair (a)* 0 2 0

Curved forceps will be supplied if type required is not specified on order.

B 13-440. FORCEPS, stainless steel, curved, 9 cm. long, real ivory tipped, for use in analytical weight boxes .. .. *pair (a) p* 0 11 0



B 13-450



B 13-455.

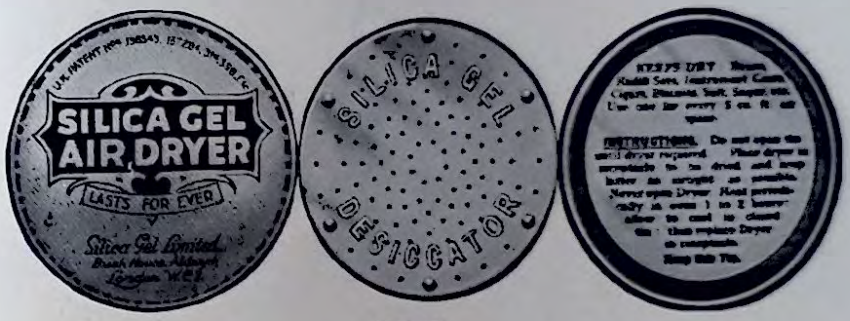


B 13-457.

B 13-450. **SHOCK ABSORBERS,** for balance feet. A rubber buffer with flanged brass insert, supported in a metal base .. .. *set of* 3 — £ 1 5 0

B 13-455. **SPIRIT LEVELS, T-pattern,** 1 × 1⅛ in., with two bubbles .. .. .. *each* — £ 0 5 6

B 13-457. **Ditto, Round,** brass mount, 1 in. over flange .. .. *each* — £ 0 5 6



B 13-470.



B 13-480.

B 13-470. DESICCATOR, Silica Gel .. .. — £ 0 1 6

Can be easily regenerated and lasts indefinitely. The perforated aluminium container, 2½ in. diam. × ¾ in. deep, contains a charge of active silica gel which absorbs and holds 40 per cent. of its own weight in moisture. Odourless and having no chemical action or injurious properties, silica gel remains perfectly dry externally even when saturated. A unique device, which changes colour, indicates when the dryer is spent and the necessity for heating the dryer to drive off absorbed moisture arises. Suitable for cases containing balances, optical lenses, instruments, etc. One desiccator is suitable for a volume of five cubic feet.

B 13-480. BALANCE DESICCATOR, Microid, Glass (*Regd. Design No.* 839907), for use inside balance and instrument cases. Two part, calcium chloride receptacle at top with perforated base, nesting into moulded liquid receiver with foot. Overall height about 7 cm. .. .. *each* 7 6; *dozen* — £ 3 0 0

The Microid Balance Desiccator fits neatly into the corner of the balance case, occupying no more room than the conventional prismatic type. It has a heavy moulded base to give stability. In two sections, the lower is a heavy moulded glass liquid receiver; the upper nests into the lower and has a conical base perforated with a single hole through which the saturated calcium chloride solution can drip into the receiver below. The maximum surface area of the calcium chloride is always exposed for drying. Cleaning is easy, and disappearance of the last lump of solid immediately indicates when recharging is necessary.

B 13-505. LAMP HOUSE for illumination of a balance. Excellent for use where balances are placed in dimly illuminated positions. Gives adequate illumination and does not fatigue the eyes. To accommodate a 40 watt lamp and to stand on the top window of the balance case. Size 10 × 4½ × 4½ in. Finished black outside and white inside. With two yards of flex and lamp adapter. **Without** lamp .. .. — £ 1 2 6



B 13-505.



B 13-520.



B 13-525.

B 13-520. BALANCE PANS, Bakelite, 10 cm. diameter, accurately adjusted, equipoised. Intended for use in addition to the pans supplied with certain Microid and other balances .. .. *pair* **0 3 0**

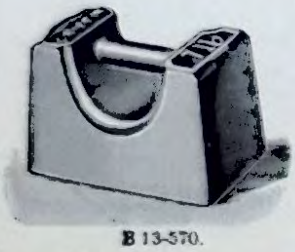
B 13-521. Ditto, brass .. .. *pair* **0 4 6**

B 13-522. Ditto, stainless steel .. .. *pair* **0 9 6**

B 13-525. SPECIFIC GRAVITY STOOLS, suitable for Microid and other balances. *each* **0 2 3**



B 13-560—568



B 13-570.



B 13-575.



B 13-577—580.

B 13-560. WEIGHTS, Brass, Round, Flat. Each size nesting in size larger.

¼ *oz.*	½ *oz.*	1 *oz.*	2 *oz.*	4 *oz.*	8 *oz.*	1 *lb.*	2 *lb.*	4 *lb.*	7 *lb.*	
6/-	8/6	12/6	17/-	25/-	42/-	80/-	165/-	280/-	—	*dozen*
8d.	10d.	1/2	1/8	2/6	4/-	7/-	14/-	26/-	47/6	*each*

B 13-562. WEIGHTS, Iron, Round, Flat, as above.

4 *oz.*	8 *oz.*	1 *lb.*	2 *lb.*	4 *lb.*	7 *lb.*	
6/-	9/6	14/-	£1 4 0	£2 4 0	£4 2 6	*dozen*
8d.	1/-	1/4	2/6	4/3	7/6	*each*

B 13-564. SETS OF WEIGHTS, Brass, Round, Flat.

From ¼ oz. to .. .. 1 2 4 7 *lb.*

p 16/6 £1 10 0 £2 15 0 £4 17 6 *set*

B 13-568. SETS OF WEIGHTS, Iron, Round, Flat, with the exception of ¼, ½, 1 and 2 oz., which are brass.

From ¼ oz. to .. .. 1 2 4 7 *lb.*

7/- 9/6 13/- 20/- *set*

B 13-570. WEIGHTS, Iron Bar.

¼	½	1	2	4	7	14	28	56	*lb.*
1/2	1/4	1/8	3/-	4/6	6/6	10/-	18/6	33/-	*each*

B 13-575. WEIGHTS, Iron, Square, with Rings.

¼	½	1	2	4	7	14	28	56	*lb.*
1/4	1/6	2/6	3/6	5/6	8/-	13/-	23/-	39/-	*each*

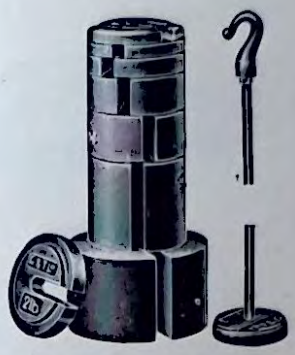
B 13-577. WEIGHTS, Iron, Hexagonal, with Rings.

50	100	200	500 *grams*	1	2	5	10	*kilos.*
p 1/2	1/4	1/8	2/9 *each*	*p* 4/-	6/6	13/-	23/-	*each*

B 13-580. SETS OF WEIGHTS, Iron, Hexagonal, with Rings.

From 50 grams to .. 1 2 5 *kilos.*

11/- 16/6 30/- *set*



B 13-582—592.
B 13-604—614.



B 13-594—596.
B 13-616—617.



B 13-600—602.

B 13-582. WEIGHTS, Imperial, Slotted, large form, iron, interlocking.

Weight ..	0·1	0·2	0·5	1	2	5	10	20	*lb.*
	1/3	1/4	2/-	3/6	5/6	8/-	17/6	28/-	*each*

B 13-584. Hangers, iron, for B 13-582.

			lb.
Weight	1	2	*lb.*
Size, approx.	12 × ¾	18 × ½	*in.*
	6/-	8/-	*each*

WEIGHTS, Imperial, Slotted, in Sets. Weights B 13-582:—

Cat. No.	Total	Hanger	0·1	0·2	0·5	1	2	5	10	20 *lb.*	Price
			No. of weights in set								£ s. d.
B 13-586	Set 7 lb.	1 *lb.*	1	2	1	1	2	—	—	—	1 4 0
B 13-588	Set 12 lb.	1 *lb.*	1	2	1	1	2	1	—	—	1 12 0
B 13-590	Set 23 lb.	2 *lb.*	1	2	1	1	2	1	1	—	2 10 0
B 13-592	Set 43 lb.	2 *lb.*	1	2	1	1	2	1	1	1	3 17 6

B 13-594. WEIGHTS, Imperial, Slotted, small form, brass, interlocking

Weight	0·01	0·02	0·05	0·1	*lb.*
	10/6	14/-	16/-	19/-	*dozen*
	1/-	1/4	1/6	1/9	*each*

B 13-596. Hangers, brass, for B 13-594, 0·1 lb. .. .. *each* 3/-; *dozen* 1 12 0

B 13-600. WEIGHTS, Imperial, Slotted, small form, iron, 0·1 lb. Weights cannot slip sideways off hanger and are removed by sliding up hanger stem .. .. *each* 1/3; *dozen* 0 13 0

B 13-602. Hangers, iron, for B 13-600, 0·1 lb. .. .. *each* 2/9; *dozen* 1 10 0

B 13-604. WEIGHTS, Metric, Slotted, large form, iron, interlocking.

Weight ..	100	200	500 *grams*	1	2	5	10	*kilos.*
	2/-	2/6	3/6 *each*	5/6	8/-	17/6	28/-	*each*

B 13-606. Hangers, iron, for B 13-604.

			kilo.
Weight	0·5	1	*kilo.*
Size, approx.	12 × ¾	18 × ¾	*in.*
	6/-	8/-	*each*

WEIGHTS, Metric, Slotted, in Sets. Weights B 13-604.

Cat. No.	Total	Hanger	Grams 100	200	500	Kilos 1	2	5	Price
			No. of weights in set						£ s. d.
B 13-608	Set 1 Kilo	500 gm.	1	2	—	—	—	—	0 12 0
B 13-610	Set 2 Kilo	1 Kilo	1	2	1	—	—	—	0 17 6
B 13-612	Set 5 Kilo	1 Kilo	1	2	1	1	1	—	1 10 0
B 13-614	Set 10 Kilo	1 Kilo	1	2	1	1	1	1	2 7 6

B 13-616. WEIGHTS, Metric, Slotted, small form, brass, interlocking

Weight	5	10	20	50 *grams*
	10/6	14/-	16/-	19/- *dozen*
	1/-	1/4	1/6	1/9 *each*

B 13-617. Hangers, brass, for B 13-616, 50 grams .. .. *each* 2/9; *dozen* 1 10 0


B 13-620.


B 13-628.


B 13-630.


B 13-650.


B 13-660.

B 13-620. SPRING BALANCES, Imperial, flat brass scale, with hook.

To weigh	6	8	10	25	50	100	*lb.*
Graduated to ..	$\frac{1}{10}$	$\frac{1}{10}$	$\frac{1}{10}$	$\frac{1}{2}$	1	1	*lb.*
	Prices on application.			**2/6**	**4/5**	—	*each*

B 13-628. SPRING BALANCES, Imperial, Tubular, brass, with hook.

To weigh	4	8	10	20	20	30	*lb.*
Graduated to ..	$\frac{1}{2}$	1	4	4	8	8	*oz.*
	12/2	**13/3**	**6/4**	**11/6**	**6/4**	**8/-**	*each*
To weigh		5		10		20	*lb.*
Graduated to		$\frac{1}{10}$		$\frac{1}{10}$		$\frac{1}{8}$	*lb.*
		10/-		**17/6**		**17/6**	*each*

B 13-630. SPRING BALANCES, Imperial, Tubular, with adjustable zero, in which any small preliminary tension put on the spring may be compensated by pushing down the sleeve with the milled ring.

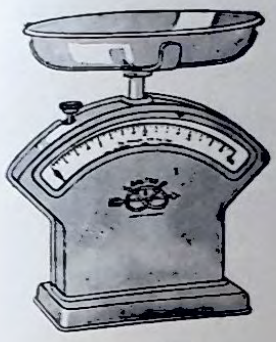
To weigh	4	11	16	*lb.*
Graduated to	1	4	4	*oz.*
	9/6	**9/-**	**9/-**	*each*

B 13-650. SPRING BALANCES, Imperial, circular, brass dial, with hook.

To weigh	10	20	30 *lb.*
Graduated to	$\frac{1}{2}$	1	1 *oz.*
Diam. of dial	6	6	8 *in.*
	Prices on application.		

B 13-660. SPRING BALANCES, Imperial, Compression, with round tin scale pan 9½" diam., white enamelled dial 7 in. diam., with screw for adjusting zero.

To weigh	10	22	*lb.*
Graduated to	$\frac{1}{4}$	1	*oz.*
	(*a*) **£1 9 1**	**£1 10 4**	*each*


B 13-670—675.



B 13-685.


B 13-687.



B 13-690.



B 13-745.

B 13-670. SPRING BALANCES, Imperial, Compression, with round pan, cream enamelled case with protected scale, screw for adjusting zero.

To weigh	1		5	*lb.*
Graduated to	½		1	*oz.*
Diam. of Pan	7		7	*in.*
	(*a*) £1 14 1		£1 6 7	*each*

B 13-675. Ditto, Metric, to weigh 2 kilos., graduated to 20 grams., with aluminium pan 5 in. diam. .. .. £ s. d. 1 1 6

B 13-685. SPRING BALANCES, Metric, flat brass scale, with hook.

To weigh ..	50	100	200	500	1000	*grams.*	12	25	*kilos.*
Graduated to	½	1	2	5	10	*grams.*	¼	½	*kilos.*
	5/11	5/11	5/11	5/11	5/11		2/1	4/9	*each*

B 13-687. SPRING BALANCES, Metric, flat scale, with light scale pan and hook underneath as recommended in Board of Education pamphlet No. 89, "*Science in Senior Schools.*"

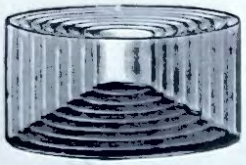
To weigh	100	200	250	500	1000	*grams.*
Graduated to ..	1	2	5	5	10	*grams.*
	10/-	10/-	8/6	10/-	10/-	*each*

B 13-690. SPRING BALANCES, Metric, Tubular, brass, with hook.

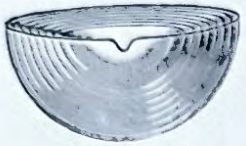
To weigh ..	100	200	1000	*grams.*	5	10	20	*kilos.*
Graduated to	1	5	10	*grams.*	⅛	¼	½	*kilos.*
	13/7	8/3	13/7		7/3	7/3	13/7	*each*

B 13-745. SPRING BALANCES, Metric, Compression, with round tin scale pan, white enamelled dial; with screw for adjusting zero.

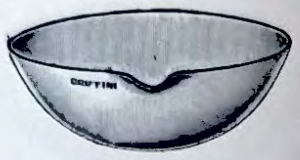
To weigh	5	10	15	25	*kilos.*
Graduated to ..	20	30	50	100	*grams.*
Diam. of Dial ..	5	5	6½	7½	*in.*
Diam. of Pan ..	9½	9½	10	12	*in.*
	£1 3 6	£1 4 6	£1 5 6	£2 4 6	*each*



B 14-350—352.



B 14-370—374.



B 14-385—400.

BASINS, Crystallising, Glass, flat bottom, unspouted.

		Diam. ..	4	6	8	10	12·5	15	19	*cm.*
B 14-350. Monax ..	..	*tx*	12/-	14/-	18/2	23/7	—	—	53/8	*dozen*
		tx	1/3	1/5	1/10	2/3	—	—	5/-	*each*
B 14-352. Pyrex ..	..	*tx*	—	—	16/10	21/-	31/6	42/-	54/8	*dozen*
		tx	—	—	1/8	2/-	2/10	3/11	4/11	*each*

BASINS, Evaporating, Glass, hemispherical form with spout, **round bottom.**

		Diam. ..	4	5	6	7	8	9	10	11	12	*cm.*
B 14-370. Chance's Hysil		*tx*	—	16/11	16/11	—	20/3	21/11	—	—	—	*dozen*
		tx	—	1/8	1/8	—	1/11	2/1	—	—	—	*each*
B 14-372. Monax ..	..	*tx*	13/3	14/6	15/4	16/6	18/7	19/10	23/2	26/5	31/5	*dozen*
		tx	1/3	1/5	1/7	1/7	1/10	1/11	2/3	2/6	2/11	*each*
B 14-374. Pyrex ..	..	*tx*	—	—	17/6	—	17/11	19/3	—	—	30/2	*dozen*
		tx	—	—	1/8	—	1/8	1/11	—	—	2/10	*each*

B 14-376. BASINS, Evaporating, Glass, hemispherical form with spout, **flat bottom, Pyrex.**

	Diam. ..	6	8	9	10·5	12·5	15	20	*cm.*
	tx	15/5	15/5	16/10	18/3	28/-	35/-	45/6	*dozen*
	tx	1/7	1/5	1/8	1/9	2/7	3/2	4/3	*each*

B 14-385. BASINS, Evaporating, Sillax British Porcelain, round bottom with spout. For average educational and routine use. Nos. 000 to 5 glazed inside and out, larger sizes glazed halfway down outside.

	No.	000	00	0	1	2	3	4	
	Diam. ..	60	75	85	90	95	105	115	*mm.*
	Capacity ..	42	75	85	125	140	210	250	*ml.*
	tx	15/-	18/-	23/6	25/6	33/6	41/6	50/-	*dozen*
	tx	1/6	1/8	2/2	2/4	3/2	3/10	4/8	*each*

	No.	5	6	6B	7	8	8A	9	
	Diam. ..	127	157	178	200	220	245	280	*mm.*
	Capacity ..	350	475	850	1000	1600	1900	3000	*ml.*
	tx	58/-	82/-	92/-	104/-	144/-	172/-	200/-	*dozen*
	tx	5/4	7/8	8/6	9/8	13/4	15/10	18/4	*each*

B 14-400. BASINS, Evaporating, Royal Worcester Porcelain, round bottom, with spout. Nos. 000 to 5 glazed inside and out; larger sizes glazed inside and halfway down outside.

	No. .. 000	00	0	1	2	3	4	5	6	
	Diam. 60	75	85	90	95	109	115	127	157	*mm.*
	Capacity 42	75	85	125	140	225	250	375	525	*ml.*
	tx 18/-	22/6	27/-	34/6	40/6	48/-	54/-	66/-	90/-	*dozen*
	tx 1/8	2/2	2/6	3/2	3/8	4/6	5/-	6/-	8/6	*each*

	No.	6B	7	8	8A	9	10	11	12	
	Diam. ..	178	200	225	245	280	330	370	420	*mm.*
	Capacity ..	850	1000	1600	1900	3000	5000	7500	12000	*ml.*
	tx	11/-	12/-	15/-	18/6	22/-	37/-	52/-	110/-	*each*



B 14-420—425.



B 14-430—440.



B 14-445—447.

BASINS, Evaporating, silica, glazed, **round bottom with spout.**

Diam.	51	70	83	89	95	108	*mm.*
Height	21	25	30	33	35	45	*mm.*
Capacity	20	45	70	85	100	200	*ml.*
B 14-420. **Translucent** .. *tx*	3/4	3/9	4/2	5/-	5/5	6/3	*each*
B 14-422. **Transparent** .. *tx*	7/1	11/11	17/3	18/9	19/7	27/6	*each*

B 14-425. **BASINS, Evaporating, silica,** smooth inside only, translucent, **round bottom with spout.**

Diam.	137	130	152	152	178	178	203	203	229	229	*mm.*
Height	57	64	64	76	70	95	83	108	89	121	*mm.*
Capacity	400	500	600	700	800	1200	1400	1800	1800	2500	*ml.*
tx	9/7	10/-	10/5	11/8	12/6	12/7	13/7	16/8	18/9	20/10	*each*

B 14-430. **BASINS, Evaporating, Sillax British Porcelain,** flat, unglazed bottom, with spout.

Size	1	2	2B	3	4	5	
Diam.	70	82	90	95	100	120	*mm.*
Capacity	38	56	100	115	150	290	*ml.*
tx	23/6	25/6	33/6	41/6	50/-	60/-	*dozen*
tx	2/2	2/4	3/2	3/10	4/8	5/6	*each*

B 14-440. **BASINS, Evaporating, Royal Worcester Porcelain,** flat unglazed bottom with spout.

No.	00	0	1	2	3	4	5	6	7	8	
Diam.	40	60	75	82	100	109	125	147	177	225	*mm.*
Capacity	10	25	50	75	115	150	290	400	750	1500	*ml.*
tx	19/6	22/6	27/-	34/6	52/6	58/6	73/6	90/-	121/6	162/-	*dozen*
tx	1/10	2/2	2/6	3/2	4/10	5/6	6/8	8/2	11/-	15/-	*each*

BASINS, Evaporating, silica, flat form, glazed, with spout.

Diam.	64	73	89	95	127	*mm.*
Capacity	20	25	60	75	125	*ml.*
B 14-445. **Translucent** .. .. *tx*	3/9	4/2	4/7	4/7	6/3	*each*
B 14-447. **Transparent** .. .. *tx*	11/10	15/8	16/6	23/6	31/3	*each*

BATHS, Sand.

Diam.	13	16·5	20	24	*cm.*	
B 14-625. **Tinned iron** ..	(*a*)	2/6	3/6	—	14/-	*dozen*
	(*a*)	3d.	3d.	—	1/4	*each*
B 14-630. **Ditto, stout sheet iron**	*p*	12/-	15/-	17/-	23/-	*dozen*
	p	1/2	1/5	1/7	2/3	*each*
B 14-635. **Ditto, copper** ..	*p*	2/9	3/3	5/6	7/6	*each*



B 14-625—635



B 14-640

B 14-640. **BATHS, Sand,** tinned iron, deep pattern, diam 13 cm. s. s. d.
each (*a*) 10d.; *dozen* (*a*) 0 8 6



B 14-670.



B 14-685.

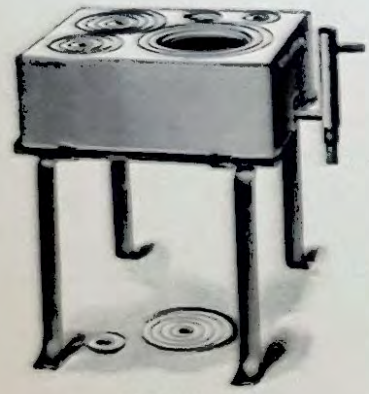


B 14-690—692.

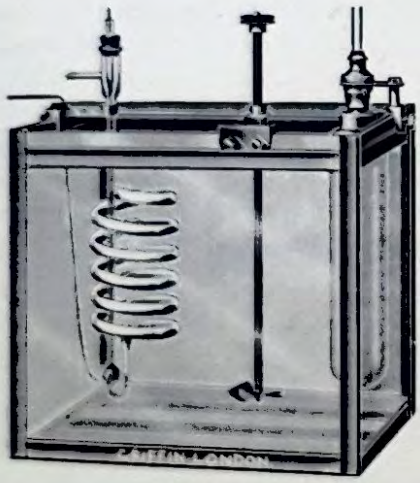
B 14-670. BATH, Water, stout enamelled iron, with two handles and copper rings, 15 cm. diam. An efficient bath for student use .. .. (*a*) *p* £ 0 17 0

BATHS, Water, stout spun copper, hemispherical, with copper rings and two handles.

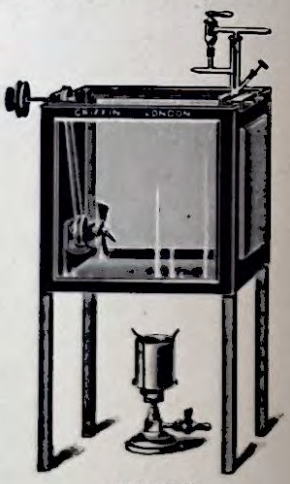
Diam.		12·5	15	18	20	23	*cm.*
B 14-685. Without constant level	*p*	13/-	18/-	£1 2 0	£1 5 0	£1 14 0	*each*
B 14-687. Iron Stands for B 14-685	*p*	3/9	3/9	5/6	5/6	5/6	*each*
B 14-690. With constant level ..	*p*	£1 14 0	£1 19 0	£2 3 0	£2 9 0	£3 2 6	*each*
B 14-692. Iron Stands for B 14-690.	*p*	6/6	7/-	6/6	8/6	9/6	*each*



B 14-770—772.



B 14-840.



B 14-870.

B 14-770. BATH, Water, copper, 25 × 21 × 9 cm., having five openings of different diams., rings and constant level; on stand .. .. *r* £ 4 10 0

B 14-772. Ditto, fitted with a porcelain cover and rings instead of copper .. .. .. *r* £ 6 10 0

B 14-840. BATH, Thermostatic, electrically heated, of stout glass in strong non-rusting metal frame 10 × 10 × 12 in. high, with metal sheathed heating element, loading 250 watts, lampholder with clamp to affix to side of bath and stirring gear with pulley which may be clamped in any desired position along the sides of the bath. **Without** thermo-regulator .. .. *p* £ 13 10 0

When ordering please state voltage.

B 14-870. BATHS, Thermostatic, gas heated, with front and back walls of glass and the others of nickel-plated copper, mounted on iron stand. Complete with removable stirrer and pulley wheels, thermo-regulator, and Argand burner.

Size	A	B	
Length × breadth × depth ..	26 × 17 × 26	32 × 20 × 32	cm.
	r £17 5 0	£19 10 0	*each*

The squat spouted beaker, known throughout the world as the "Griffin" Beaker, was first introduced by the late John Joseph Griffin, one of the founders of this firm.



B 14-946—954

B 14-946. BEAKERS, Griffin form, squat with spout, British resistance glass.

Nominal capacity	100	150	250	400	600	900	*ml.*
tx	11/10	12/9	14/7	18/2	22/9	30/-	*dozen*
tx	1/3	1/3	1/5	1/10	2/-	2/9	*each*

BEAKERS, Griffin form, squat with spout, resistance glass.

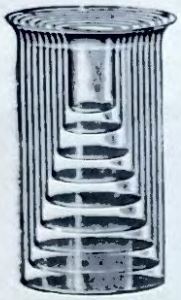
Cat. No. →	B 14-950. Chance's Hysil		B 14-952. Monax		B 14-954. Pyrex		
Nominal capacity ml.	*each*	*dozen*	*each*	*dozen*	*each*	*dozen*	Standard cases contain
↓	*tx*	*tx*	*tx*	*tx*	*tx*	*tx*	
25	1/5	14/1	1/3	12/10	—	—	—
30	1/5	14/6	—	—	1/4	13/4	144
40	1/5	14/6	1/3	13/3	—	—	—
50	1/5	14/6	—	—	1/4	13/4	144
60	1/5	14/6	1/3	13/3	—	—	—
100	1/7	15/4	1/5	14/6	1/5	14/9	120
150	1/7	15/8	1/7	15/8	1/7	15/9	84
200	1/8	17/4	1/8	17/4	1/8	17/6	84
250	1/10	18/7	1/10	18/7	1/9	18/11	84
300	1/11	20/8	—	—	1/11	19/8	72
400	2/1	22/4	2/1	22/4	2/1	22/5	60
500	2/3	23/11	2/3	23/11	2/4	24/6	60
600	2/8	27/8	2/8	27/8	2/6	26/8	60
800	3/1	33/-	3/1	33/-	2/10	30/6	48
900	3/6	37/2	3/6	37/2	—	—	—
1000	3/9	40/1	3/9	40/1	3/11	41/-	36
1300	4/4	46/3	4/4	46/3	4/7	49/5	24
1500	4/7	48/8	4/7	48/8	5/2	56/-	24
2000	5/10	62/9	5/10	62/9	6/4	68/8	12
3000	7/5	80/11	7/5	80/11	9/2	98/-	12
4000	9/11	107/3	9/11	107/3	11/7	126/-	10
5000	11/2	122/2	11/2	122/2	13/7	147/-	6
6000	—	—	14/1	148/8	—	—	—

Chance's Hysil Glass.—On orders of not less than 3 gross of Beakers and Flasks of any sizes, to be delivered in one consignment, a discount of 10 % is allowed. On orders of not less than half a gross of one item a discount of 5 % is allowed.

Monax Glass.—On orders of not less than 3 gross of Beakers and Flasks of any sizes, to be delivered in one consignment, a discount of 10 % is allowed. On orders of not less than half a gross of one item a discount of 5 % is allowed. Can be supplied in **heavy weight** at above prices plus 33⅓ % on sizes up to and including 1000 ml. and plus 50 % above 1000 ml.

Pyrex Glass.—Where available in standard cases and delivered in one consignment the following discounts are allowed.

No. of standard cases	1	10	20	30	40
	10 %	10 % & 2½ %	10 % & 5 %	10 % & 7½ %	10 % & 10 %



B 14-961—968.

B 14-961. BEAKERS, tall form without spout, British resistance glass.

Nominal capacity	100	150	250	400	600	1000 *ml.*
tx	11/10	12/9	14/7	18/2	22/9	30/- *dozen*
tx	1/3	1/3	1/5	1/10	2/-	2/9 *each*

BEAKERS, tall form without spout, resistance glass.

Cat. No. →	B 14-964. Chance's Hysil		B 14-966. Monax		B 14-968. Pyrex		
Nominal capacity ml.	*each*	*dozen*	*each*	*dozen*	*each*	*dozen*	Standard cases contain
↓	*tx*	*tx*	*tx*	*tx*	*tx*	*tx*	
25	—	—	1/3	12/10	—	—	—
30	1/5	14/6	—	—	1/4	13/4	144
40	—	—	1/3	13/3	—	—	—
50	1/5	14/6	—	—	1/4	13/4	144
60	—	—	1/3	13/3	—	—	—
100	1/7	15/4	1/5	14/6	1/5	14/9	96
150	1/7	15/8	1/7	15/8	1/7	15/9	84
200	1/8	17/4	1/8	17/4	1/8	17/6	84
250	1/10	18/7	1/10	18/7	1/9	18/11	72
300	1/11	20/8	—	—	1/11	19/8	72
400	2/1	22/4	2/1	22/4	2/2	22/5	72
500	2/3	23/11	2/3	23/11	2/4	24/6	60
600	2/8	27/8	2/8	27/8	2/6	26/8	60
800	3/1	33/-	3/1	33/-	2/10	30/6	48
900	3/6	37/2	3/6	37/2	—	—	—
1000	3/9	40/1	3/9	40/1	3/11	41/-	36
1300	—	—	4/4	46/3	—	—	—
1500	4/7	48/8	4/7	48/8	5/2	56/-	24
2000	5/10	62/9	5/10	62/9	6/4	68/8	12
3000	7/5	80/11	7/5	80/11	9/2	98/-	10
4000	9/11	107/3	9/11	107/3	—	—	—
5000	—	—	11/2	122/2	—	—	—
6000	—	—	14/1	148/8	—	—	—

These Beakers supplied to order with spout at same prices. Quote Nos.:—
B 14-965 **B 14-967** **B 14-969**

Chance's Hysil Glass.—On orders of not less than 3 gross of Beakers and Flasks of any sizes, to be delivered in one consignment, a discount of 10 % is allowed. On orders of not less than half a gross of one item a discount of 5 % is allowed.

Monax Glass.—On orders of not less than 3 gross of Beakers and Flasks of any sizes, to be delivered in one consignment, a discount of 10 % is allowed. On orders of not less than half a gross of one item a discount of 5 % is allowed. Can be supplied in **heavy weight** at above prices plus 33⅓ % on sizes up to and including 1000 ml. and plus 50 % above 1000 ml.

Pyrex Glass.—Where available in standard cases and delivered in one consignment the following discounts are allowed.

No. of standard cases	1	10	20	30	40
	10 %	10 % & 2½ %	10 % & 5 %	10 % & 7½ %	10 % & 10 %



B 14-974—976.



B 14-984—988.



B 14-994.



B 14-996—998.



B 15-015.

BEAKERS, Conical (Phillips), narrow mouth, spouted, resistance glass.

Capacity	125	175	200	250	300	400	500	600	1000	2000	*ml.*
B 14-974. Chance's Hysil .. *tx*	—	—	17/4	—	—	—	—	—	—	—	*dozen*
tx	—	—	1/8	—	—	—	—	—	—	—	*each*
B 14-976. Monax .. .. *tx*	14/11	16/6	—	18/7	19/10	22/4	23/11	27/8	40/1	46/3	*dozen*
tx	1/5	1/7	—	1/10	1/11	2/1	2/3	2/8	3/9	5/10	*each*

BEAKERS, Conical (Phillips), wide mouth, spouted, resistance glass.

Capacity	125	150	175	200	250	300	350	400	450	500	600	650	800	1000	*ml.*
B 14-984. Chance's Hysil.															
tx	—	—	16/6	17/4	18/7	19/10	—	22/4	23/11	23/11	27/8	—	33/-	40/1	*dozen*
tx	—	—	1/7	1/8	1/10	1/11	—	2/1	2/3	2/3	2/8	—	2/7	3/9	*each*
B 14-986. Monax.															
tx	—	16/6	—	—	—	19/10	—	—	23/11	—	27/8	—	33/-	40/1	*dozen*
tx	—	1/7	—	—	—	1/11	—	—	2/3	—	2/8	—	2/7	3/9	*each*
B 14-988. Pyrex.															
tx	14/5	—	—	17/6	17/11	18/11	20/-	21/-	22/1	23/6	—	25/11	28/-	39/7	*dozen*
tx	1/5	—	—	1/8	1/8	1/9	1/11	2/-	2/2	2/3	—	2/6	2/7	3/9	*each*

BEAKER FLASKS, resistance glass.

Capacity ..	50	75	100	150	200	250	300	400	450	500	600	800	1000	*ml.*
B 14-994. Chance's Hysil.														
tx	16/1	16/11	17/4	17/9	18/7	—	20/8	23/2	24/9	—	28/11	—	40/1	*dozen*
tx	1/8	1/8	1/8	1/8	1/10	—	1/11	2/3	2/4	—	2/9	—	3/9	*each*
B 14-996. Monax.														
tx	14/11	—	16/1	—	18/7	19/5	—	23/2	—	—	28/11	34/8	40/1	*dozen*
tx	1/5	—	1/8	—	1/10	1/10	—	2/3	—	—	2/9	3/2	3/9	*each*
B 14-998. Pyrex.														
tx	—	—	15/9	—	18/11	—	21/-	23/10	—	26/8	29/5	—	45/6	*dozen*
tx	—	—	1/7	—	1/9	—	2/-	2/3	—	2/6	2/10	—	4/3	*each*

B 15-015. BEAKERS, Stirring (Lixiviating Jars), heavy glass, with spout. Suitable for use in decantations, etc. Precipitates can be stirred vigorously without fear of breaking beaker. Not suitable for heating.

Capacity ..	100	250	500	800	1000	1500	2000	3000	4000	*ml.*
tx	1/4	1/8	2/1	2/8	3/2	4/1	5/-	6/10	8/11	*each*

THE GRIFFIN BEAKER-CLIP

Registered Design No. 792756



Fig. 2.



B 16-105.

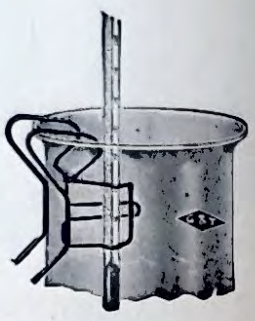


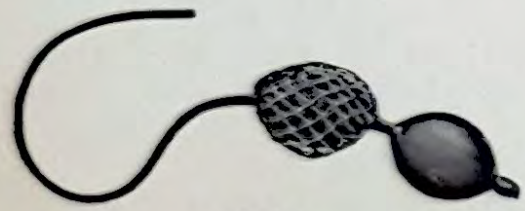
Fig. 3.

The Griffin Beaker-Clip has been designed to overcome the inconvenience of funnel or retort stands with their associated bossheads and clamps. By its use, the vessel and the object supported can be moved as one integral unit taking up no more space than the vessel itself.

The clip is made in polished stainless steel and is therefore resistant to corrosion and may be used without fear of contaminating filtrates or solutions undergoing examination. Fig 2 shows the clip supporting a funnel in a beaker. It is readily slipped on to the side of a beaker and, the upper part being specially shaped to clear the curved lip of the beaker, it may be placed so that the object supported is either inside or outside the beaker.

The clip may similarly be used for supporting a thermometer in a beaker, calorimeter, freezing bath, thermostatic bath, sulphuric acid bath for melting points, etc. Fig 3 shows it in use supporting a thermometer in a beaker It will grip rods from $\frac{5}{16}$ to $\frac{8}{8}$ in. diam. quite firmly and is adaptable to vessels of widely-varying curvature. The specific heat of the metal of the clip is 0·117.

	£	s.	d.
B 16-105. GRIFFIN BEAKER-CLIP, polished stainless steel, non-corrodible, to fit beakers, calorimeters, etc., and to support articles with stems between $\frac{3}{16}$ and $\frac{3}{8}$ in. diam. *each* 11d. ; *dozen*	0	10	0
B 16-115. BEAKER MATS of compressed filter paper, on which to stand hot flasks, beakers, etc., 11 cm. × 4 mm. thick. Porous—may also be used for drying crystals .. 100	0	12	6



B 16-125

B 16-125. BELLOWS, Rubber, Double, of best black rubber with silk cord protection net to constant pressure reservoir.

No.	1	2	3	4	5	
Diam. of net	5	6	8	9	10	*cm.*
p	5/-	5/6	6/-	6/-	7/6	*each*

B 16-142. BELLOWS, Foot, for use with gas blowpipes, etc. Give a steady, powerful blast, the pressure of which may be increased by the addition of rubber discs to the air reservoir. Bellows of stout leather. Mounted on rigid iron tripod. With one rubber disc and string net.

Size	3	5	
Bellows dimensions	11 × 8 × 6½	13 × 10 × 7	*in.*
f	£3 10 0	£4 0 0	*each*



B 16-142—144

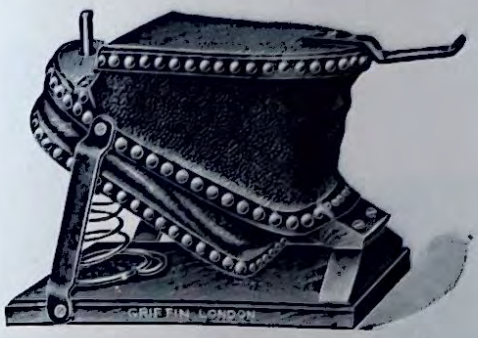
B 16-144. DISCS, Rubber, for foot bellows.

Size ..	3 (10 in.)	5 (12 in.)	
	2/9	3/6	*each*

	£	s.	d.
B 16-146. Wires for foot bellows, 39 in. long, for securing rubber discs .. .. *dozen*	0	4	0

B 16-148. Nets, String, for foot bellows, complete with wire.

Size ..	3	5	
	3/-	3/3	*each*



B 16-155.



B 16-160.



B 16-170.

B 16-155. BELLOWS, Foot, with double bellows of stout leather with a metal spring, obviating use of rubber discs. Mounted on strong wood stand. Will stand very rough usage.

Top	8	10 *in. wide*
	r £3 0 0	£3 12 6 *each*

B 16-160. BENCH POLISH, Laboratory, antiseptic and preservative. Specially prepared for laboratory and hospital use and on any woodwork where a resistant, lasting and non-smearing wax surface is required. In tins ready for use .. .. .. ½ *lb. tin* £ 0 s. 1 d. 6

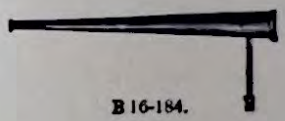
B 16-170. BLOCKS, Wood, Set of 6, of varying thicknesses, for supporting glass apparatus, etc., 4 in. diam., ⅛, ¼, ½, 1, 2, and 4 in. thick .. .. *p* 0 6 6



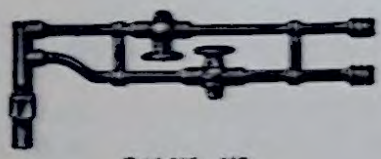
B 16-180—181.



B 16-182.



B 16-184.



B 16-205—207.

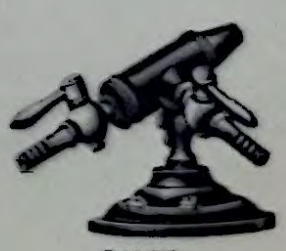
		£	s.	d.
B 16-180. BLOWPIPE, Mouth, brass, nickel-plated, 8½ in.	*each* 1,2 ; *dozen*	0	12	0
B 16-181. Ditto, brass, nickel-plated, tinned at end for mouth	*each* 1,4 ; *dozen*	0	14	0
B 16-182. Ditto, brass, nickel-plated, 8½ in., with bone mouthpiece ..	*each* 1 9 ; *dozen*	0	19	0
B 16-184. BLOWPIPE, Mouth, Black's, japanned tin	*each* 9d. ; *dozen*	0	8	6

B 16-205. BLOWPIPE, Gas, Hand, Bornkessel, improved type. A popular burner having many applications in a variety of industries. Independent gas and air supply tubes, each fitted with control taps permitting extremely fine adjustment of flame. Fitted with by-pass which promotes gas economy and ready re-ignition when required for further use. The difficulty of adjustment and risk of breakage experienced with glass jets in the old type is obviated by the use of metal jets. Three types of interchangeable jets available. Fine usually supplied. Length about 7½ in. .. .. *each* 1 0 19 1

B 16-207. Spare Jets for above, fine, medium or large .. .. *each* 1 0 4 7

Please state type of jet required when ordering.

B 16-235. BLOWPIPE, Gas, with swivel joint giving up-and-down movements, and locking screw for fixing in any desired position, mounted on heavy circular iron base bored with three holes to permit screwing to bench. Fitted with two lever stopcocks for air and gas control and adjustable outer tube. All exposed parts, except base, nickel-plated. With three interchangeable brass jets and three glass jets .. £ 1 s. 15 d. 0



B 16-235.



B 16-304.



B 16-310.



B 16-330.



B 16-430.



B 16-437.

BOATS, Combustion, Battersea, Fireclay.

B 16-304. Pattern A, with one end rounded and the other flat. Length 3¼ in., width ½ in., depth ⅜ in. .. .. *dozen* r 0 2 6

B 16-306. Pattern B, as Pattern A. Length 4 in., width ⅝ in., depth 13/32 in. .. .. *dozen* r 0 2 6

B 16-308. Pattern C, as Pattern A. Length 4⅛ in., width 9/16 in., depth 7/16 in. .. *dozen* r 0 2 6

B 16-310. Pattern D, with both ends rounded. Length 5 in., width ⅝ in., depth ⅜ in. *dozen* r 0 3 9

B 16-330. BOATS, Combustion, Sillax Porcelain.

Length ..	60	70	75	75	100	115	*mm.*
Width ..	10	6	11	15	18	13	*mm.*
Depth ..	6	6	6	9	12	11	*mm.*
tx	12/6	12/6	12/6	15/-	16/-	16/-	*dozen*
tx	1/2	1/2	1/2	1/6	1/6	1/6	*each*

B 16-430. BOTTLES, Reagent, wide mouth, white flint glass, **fitted with black polished Korkalite screw caps lined with a waxed disc.** The cork is replaced by a neat moulded black composition cap which screws easily on to the neck. The inside of the cap is fitted with a waxed card disc which effectually seals the interior during storage. The caps of bottles of similar size are interchangeable, obviating the trouble involved in obtaining corks to fit. The bottles may be used for all purposes for which corked wide mouth bottles were formerly employed. They are ideal for the transmission of dry samples. Used as stock bottles their uniformity enhances the appearance of the laboratory.

Capacity	½	1	2	3	4	6	8	*oz.*
	£1 18 0	£2 2 0	£2 6 0	£2 10 0	£2 15 0	£2 17 6	£3 10 0	*gross*
	3/6	4/-	4/3	4/6	5/-	5/6	6/6	*dozen*
	4d.	5d.	5d.	5d.	6d.	7d.	8d.	*each*

Capacity	12	16	20	24	32	40	*oz.*
	£2 17 6	£4 10 0	£5 0 0	£5 10 0	£7 10 0	£9 5 0	*gross*
	7/-	8/6	9/6	10/-	13/6	17/-	*dozen*
	9d.	10d.	11d.	11d.	1/3	1/7	*each*

B 16-437. BOTTLES, Winchester pattern, narrow mouth, white flint glass. **Fitted with black polished Korkalite screw caps.**

Capacity ..	2	4	6	10	16	20	*oz.*
	5/3	5/6	6/-	8/-	9/6	10/-	*dozen*
	7d.	7d.	7d.	9d.	11d.	11d.	*each*


B 16-450.


B 16-455.


B 16-460.


B 16-465.


B 16-470.

BOTTLES, Reagent, Stoppered, for laboratory purposes. Best quality white glass. Lips so shaped that liquid contents may be poured out easily and smoothly or very slowly drop by drop. Bottles **B 16-470** may be used as killing bottles for biological specimens.

Please state Catalogue Number when ordering.

Cat. No. →	B 16-450		B 16-455		B 16-460		B 16-465		B 16-470		
	Flat stoppered				Dust-proof stoppered				Flat stoppered		
Nominal Capacity oz. ↓	ml.	Narrow mouth each	Narrow mouth dozen	Wide mouth each	Wide mouth dozen	Narrow mouth each	Narrow mouth dozen	Wide mouth each	Wide mouth dozen	Extra wide mouth body size	each	dozen
										Ht. to shoulder × diam.	—	—
½	15	8d.	6/6	9d.	8/-	10d.	9/-	1/-	10/-		—	—
1	30	9d.	7/6	10d.	8/6	10d.	9/-	1/-	10/-		—	—
2	60	10d.	8/6	1/1	11/6	1/-	10/-	1/3	13/6		—	—
4	125	11d.	9/6	1/3	13/6	1/2	12/-	1/6	16/-	5 × 6·2 cm.	1/3	13/-
6	175	1/1	11/-	1/4	14/-	1/3	13/6	1/8	17/6		—	—
8	250	1/2	12/6	1/6	15/6	1/5	15/-	1/9	19/-	6·7 × 7·3 cm.	1/6	16/-
10	300	1/4	14/-	1/9	18/6	1/6	16/-	2/3	24/-		—	—
12	350	1/6	16/-	1/10	20/-	1/9	19/-	2/3	25/-		—	—
16	500	1/10	19/6	2/-	22/-	2/3	24/-	2/6	27/-	8 × 9 cm.	2/1	22/6
20	625	2/-	22/-	2/3	25/-	2/6	26/-	2/9	30/-	11·7 × 10·7 cm.	3/-	32/6
24	750	2/3	25/-	2/9	30/-	2/9	30/-	3/3	35/-		—	—
32	1000	2/9	28/-	3/3	35/-	3/3	33/-	4/-	42/-		—	—
40	1250	3/9	39/-	4/6	52/6	4/-	44/-	4/9	52/6		—	—
48	1500	3/9	40/-	4/9	52/6	4/9	50/-	6/-	65/-		—	—
64	2000	5/-	55/-	6/-	62/6	5/6	60/-	7/-	72/6	15·4 × 12·4 cm.	5/9	62/6
100	3000	8/-	87/6	8/6	100/-	9/-	97/6	9/6	110/-		—	—
160	5000	—	—	—	—	13/6	150/-	—	—		—	—


Dust-proof Stopper—Sectional.

Dust-proof stoppered bottles are so-called on account of the patented stopper, designed so that it overlaps the lip of the bottle, ensuring that no dust shall settle on the upper surface of rim, as is possible with bottles fitted with ordinary stoppers.



B 16-550—566.

BOTTLES, Reagent, Stoppered, Labelled, sandblast or enamelled. (*For list of standard names see page* 429.)

Sandblast Labels.

(*a*) **Ordinary Labels. B 16-550—552.** Clear letters on rectangular matt, sandblast background with clear line border.

Special names.—One dozen or more of any given name:—standard rate as below. Less than 1 dozen:—first label, 4/- (*bottle extra according to size*); remainder at standard rates.

(*b*) **Deeply Cut Sandblast Labels. B 16-554—556.** Clear letters on matt background cut away to leave the name standing up in **strong relief.** They are easily read and remain legible indefinitely even in laboratories in which HF fumes abound.

Special names.—No extra charge, *i.e.* at the standard rates shown below.

Enamelled Labels.

Black letters on white ground. B 16-564—566. Dead-black letters and pure white background.

Special names.—One dozen or more of any given name:—standard rates as below. Less than 1 dozen:—first label, 8/- (*bottle extra according to size*); remainder at standard rates.

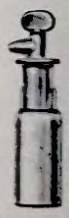
		SANDBLAST LABELS Clear letters on matt ground				ENAMELLED LABELS Black letters on white ground (Dust-Proof)	
		Ordinary label (Flat Stoppered)		Deeply cut label (Dust-Proof)			
Cat. No. →		B 16-550	B 16-552	B 16-554	B 16-556	B 16-564	B 16-566
Nominal capacity oz. ▼	ml.	Narrow mouth each	Wide mouth each	Narrow mouth each	Wide mouth each	Narrow mouth each	Wide mouth each
4	125	2/3	2/6	4/-	4/6	4/9	5/3
6	175	2/6	2/9	4/3	4/6	5/3	5/9
8	250	2/6	2/9	4/3	4/9	5/9	6/-
10	300	2/9	3/3	4/6	5/3	6/-	6/9
12	350	3/3	3/9	4/9	5/6	6/3	6/9
16	500	3/6	3/9	5/3	5/6	6/9	7/6
20	625	3/9	4/-	5/6	5/9	7/6	8/-

Large quantities, and bottles of other sizes and types, prices on application.

B 16-550—566. Labelled Reagent Bottles—*continued.*

BOTTLES, Reagent, Stoppered, Labelled, List of standard names supplied at prices quoted on p. 428. The list below is intended as a guide to the selection of labelled bottles most commonly in demand. Bottles can, however, be prepared bearing any other specified label at prices indicated in each of the sub-sections on p. 428.

Acetic Acid.
Acetic Acid Glacial.
Acetone.
Alcohol Absolute.
Aluminium.
Ammonia Sol. 0·880.
Ammonium Acetate.
Ammonium Carbonate.
Ammonium Chloride.
Ammonium Hydroxide.
Ammonium Hydroxide Conc.
Ammonium Molybdate.
Ammonium Nitrate.
Ammonium Oxalate.
Ammonium Persulphate.
Ammonium Phosphate.
Ammonium Sulphate.
Ammonium Sulphide.
Ammonium Thiocyanate.
Antimony Metal.
Asbestos, Gooch.
Barium Chloride.
Barium Hydroxide.
Barium Nitrate.
Benzene.
Bleaching Powder.
Borax.
Bromine Water.
Bromoform.
Calcium Carbonate.
Calcium Chloride.
Calcium Hydroxide.
Calcium Sulphate.
Carbon Disulphide.
Carbon Tetrachloride.
Charcoal.
Chlorine Water.
Chloroform.
Cobaltous Nitrate.
Copper.
Copper Nitrate.
Copper Oxide (CuO).
Copper Sulphate.
Cupferron.
Dimethylglyoxime Solution.
Ether.
Ethyl Alcohol.
Fehling's Solution No. 1.
Fehling's Solution No. 2.
Ferric Chloride.
Ferrous Ammonium Sulphate.
Ferrous Sulphate.
Formic Acid.
Fusion Mixture.
Glass Wool.
Glycerine.
Hydrochloric Acid Conc.
Hydrochloric Acid. Dil.
Hydrogen Peroxide.
Hydrogen Sulphide Solution.
Iodine.
Iron Filings.
Lead Acetate.
Lead Nitrate.
Lead Peroxide.
Lime Water.
Litmus Solution.
Magnesium Sulphate.
Manganese Dioxide.
Manganous Chloride.
Mercuric Chloride.
Methyl Alcohol.
Methyl Orange.
Methylene Blue.
Microcosmic Salt.
Nessler's Reagent.
Nickel Nitrate.
Nickel Sulphate.
Nickel Uranyl Acetate.
Nitric Acid Conc.
Nitric Acid Dil.
Oxalic Acid.
Perchloric Acid.
Phenolphthalein.
Platinic Chloride.
Potassium Antimonate.
Potassium Bisulphate
Potassium Bromide.
Potassium Carbonate.
Potassium Chlorate.
Potassium Chloride.
Potassium Chromate.
Potassium Cyanide.
Potassium Dichromate.
Potassium Ferricyanide.
Potassium Ferrocyanide.
Potassium Hydroxide.
Potassium Iodide.
Potassium Mercuric Iodide.
Potassium Nitrate.
Potassium Permanganate.
Potassium Thiocyanate.
Potassium Thiosulphate.
Silver Nitrate (amber).
Soap Solution.
Soda Lime.
Sodium.
Sodium Acetate.
Sodium Arsenite.
Sodium Bismuthate.
Sodium Carbonate.
Sodium Carbonate (Anhydrous).
Sodium Cobaltinitrite.
Sodium Hydrogen Phosphate.
Sodium Hydrogen Tartrate.
Sodium Hydroxide.
Sodium Nitrate.
Sodium Nitrite.
Sodium Peroxide.
Sodium Phosphate.
Sodium Sulphide.
Sodium Sulphite.
Sodium Thiosulphate.
Stannous Chloride.
Starch.
Strontium Nitrate.
Sulphuric Acid Conc.
Sulphuric Acid Dil.
Tartaric Acid Cryst.
Test Papers.
Tin.
Universal Indicator.
Xylene.
Zinc.
Zinc Sulphate.


B 16-620—622.


B 16-630.


B 16-640.


B 16-642.


B 16-644.


B 16-646.

B 16-620. BOTTLES, Dropping, T.K. pattern, white.

Capacity	30	60	100 ml.
	11 -	12 -	14 - *dozen*
	1 1	1 2	1 4 *each*

B 16-622. Ditto, amber, sizes and prices as **B 16-620.**

B 16-630. BOTTLES, Dropping, with ground-in pipette and rubber teat.

Capacity	30	60 ml.
	£1 2 0	£1 4 0 *dozen*
	2 -	2 3 *each*

B 16-640. BOTTLES, Dropping, with lengthened ground-in stopper, capacity 50 ml. *each* 1 6 ; *dozen* — £ s. d. 0 16 0

B 16-642. BOTTLES, Dropping, with lengthened ground-in stopper and cap, capacity 50 ml. *each* 7 - ; *dozen* — 3 15 0

B 16-644. BOTTLES, Canada Balsam, with rod and loose cap, capacity 30 ml. *each* 4 6 ; *dozen* — 2 10 0

B 16-646. BOTTLES, Cedar Wood Oil, with ground-in inner tube for use when only small quantities are needed (a little xylol placed in the outer bottle will prevent drying up of the oil) ; stopper with metal cap and wire with loop .. .. *each* — 0 6 0


B 16-680.


B 16-690.


B 17-012.


B 17-014.


B 17-016.


B 17-040.


B 17-046.

B 16-680. BOTTLES, Oil Sample, clear glass, narrow mouth, cleaned and corked.

Capacity	2	4	6	8	16	*oz.*
	4/9	5/6	6/-	6/6	8/-	*dozen*

B 16-690. BOTTLES, Winchester pattern, narrow mouth, white glass, stoppered.

Capacity ..	2	4	8	12	16	20	32	48	90	*oz.*
	7/-	7/6	9/-	10/-	10/6	11/6	14/6	18/-	21/-	*dozen*
	8d.	9d.	10d.	11d.	1/-	1/1	1/4	1/8	2/-	*each*

B 17-012. BOTTLES, Weighing, stopper fitting inside, bottle of light blown glass, with **slight** shoulder, hollow blown stopper closed on underside. Height measured to top of grinding.

Height ..	40	50	60	80	100	*mm.*
Diam. ..	20	25	30	40	50	*mm.*
pb	16 6	£1 2 0	£1 5 0	£2 5 0	£4 0 0	*dozen*
pb	1/6	2/-	2/3	4/-	7/6	*each*

B 17-014. BOTTLES, Weighing, stopper fitting inside, bottle of light blown glass, **without shoulder**, hollow blown stopper closed on underside. Height measured to top of grinding.

Height ..	40	50	60	80	100	*mm.*
Diam. ..	20	25	30	40	50	*mm.*
pb	16 6	£1 2 0	£1 5 0	£2 5 0	£4 0 0	*dozen*
pb	1/6	2/-	2/3	4/-	7/6	*each*

B 17-016. BOTTLES, Weighing, stopper fitting outside, of light blown glass, **without shoulder**, flat topped cap without knob. Height measured to top of grinding.

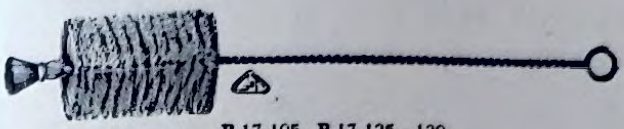
Height ..	40	50	60	80	100	*mm.*
Diam. ..	20	25	30	40	50	*mm.*
pb	£1 2 0	£1 7 0	£1 13 0	£2 15 0	£4 15 0	*dozen*
pb	2/-	2/6	3/-	5/-	8/6	*each*

BOTTLES, Woulff, stout glass.

Capacity	4	8	16	24	32	64	100	*oz.*
B 17-040. Two necks .. .. *a*	6/-	7/-	8/-	10/-	12/-	18/-	24/-	*each*
B 17-042. Three necks .. .. *a*	7/-	8/-	9/-	11/-	14/-	20/-	27/-	*each*

BOTTLES, Woulff, with tubulure at bottom.

Capacity	8	16	24	32	64	100	*oz.*
B 17-046. Two necks .. .. .. *a*	10/-	11/-	14/-	17/-	25/-	33/-	*each*
B 17-048. Three necks .. .. .. *a*	11/-	12/-	15/-	19/-	27/-	36/-	*each*



B 17-105, B 17-125—130.



B 17-115.



B 17-120.



B 17-135.



B 17-138.

		£	s.	d.
B 17-105.	**BRUSHES, Test Tube, bristle ends,** tinned iron wire handle — *each* 4d. ; *dozen*	0	3	0
B 17-107.	**BRUSHES, Test Tube, sponge ends,** tinned iron wire handle — *each* 4d. ; *dozen*	0	3	6
B 17-110.	**BRUSHES, Test Tube, bristle ends,** stout copper wire handle — *each* 1/1 ; *dozen*	0	11	6
B 17-115.	**BRUSHES, Tube,** bristles in middle, 18 in. long, for tubes up to ⅝ in. bore — *each* 3d. ; *dozen*	0	2	3
B 17-120.	**BRUSHES, Tube,** with bristles at end, 9 in. long, for tubes up to ⅜ in. bore — *each* 4d. ; *dozen*	0	3	0

BRUSHES, Bottle, bristle ends, stout wire handles either tinned iron, or copper.

Overall length	9	12	14	19	*in.*
Bristle head	2½ × 2	3 × 2	3 × 2	4 × 3	*in.*
B 17-125. Tinned iron	8/-	9/6	10/-	16/-	*dozen*
B 17-130. Copper	—	2/6	4/-	5/-	*each*

B 17-135. **BRUSHES, Bottle,** 12 in. long, with shaped tinned wire handle — *each* 1/3 ; *dozen* 0 12 6

B 17-138. **BRUSHES, Burette,** 30 in. long, bristles at end — *each* 10d. ; *dozen* 0 8 6



B 17-165.



B 17-170.



B 17-172.



B 17-175.

BRUSHES, Camel Hair (Pencils).

	Small.	Medium.	Large.	
B 17-165. Quill mounts	4/6	5/6	7/-	*dozen*
B 17-170. Wood handles	12/6	16/6	20/-	*dozen*

B 17-172. **BRUSHES, Camel Hair (Dabbers),** round, with wooden handles. Wire bound in quill mount.

No.	1	2	3	4	5	
Head approx.	1¼ × ⅛	1¼ × ⅛	1¼ × 7/16	1¼ × ½	1½ × 9/16	*in.*
	1/3	1/6	1/9	2/-	2/6	*each*

B 17-175. **BRUSHES, Camel Hair,** flat, tin bound, wooden handles.

Width	½	¾	1	1½	2	in.
	1/3	2/3	2/6	3/6	5/-	*each*

B 17-210. BURETTES, with jet and pinchcock, Grade B.

To deliver	10	25	50	100	*ml.*
Divided to	0·1	0·1	0·1	0·2	*ml.*
	65/-	77/6	87/6	120/-	*dozen*
	6/-	7/-	8/-	11/-	*each*



B 17-210.

BURETTES, with straight glass stopcock. (*Please state Catalogue No. when ordering.*)

Cat. No. →	B 17-235 Grade B		B 17-243 Grade A without Certificate	B 17-245 Grade A with 5-point Certificate	B 17-251 Class A with N.P.L. Certificate
To deliver	*each*	*dozen*	*each*	*each*	*each*
10 ml. in $\frac{1}{10}$ ml.	10/-	110/-	25/-	30/-	50/2
25 ml. in $\frac{1}{10}$ ml.	11/-	120/-	26/-	31/-	62/8
50 ml. in $\frac{1}{10}$ ml.	12/-	130/-	32/-	37/-	70/2
100 ml. in $\frac{1}{5}$ ml.	15/-	165/-	42/-	47/-	80/2



B 17-235—245.

B 17-270. Side Tube, for filling Burettes, fitted below graduations —add **11d.** each to prices.

B 17-271. Ditto, above graduations—add **11d.** each to prices.

B 17-273. Funnel Top, fitted to Burettes—add **11d.** each to prices.

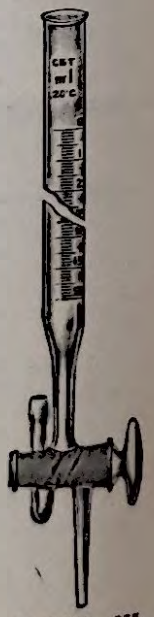
B 17-275. Stopper, for inlet of Burettes—add **2/9** each to prices.



B 17-285—295.

BURETTES, with stopcock at right angles. (*Please state Catalogue No. when ordering.*)

Cat. No. →	B 17-285 Grade B		B 17-293 Grade A without Certificate	B 17-295 Grade A with 5-point Certificate	B 17-301 Class A with N.P.L. Certificate
To deliver	*each*	*dozen*	*each*	*each*	*each*
10 ml. in $\frac{1}{10}$ ml.	10/-	110/-	25/-	30/-	50/2
25 ml. in $\frac{1}{10}$ ml.	11/-	120/-	26/-	31/-	62/8
50 ml. in $\frac{1}{10}$ ml.	12/-	130/-	32/-	37/-	70/2
100 ml. in $\frac{1}{5}$ ml.	15/-	165/-	42/-	47/-	80/2



B 17-345—355.

BURETTES, with 3-way stopcock. (*Please state Catalogue No. when ordering.*)

Cat. No. →	B 17-345 Grade B		B 17-353 Grade A without Certificate	B 17-355 Grade A with 5-point Certificate	B 17-361 Class A with N.P.L. Certificate
To deliver	*each*	*dozen*	*each*	*each*	*each*
10 ml. in $\frac{1}{10}$ ml.	14/-	155/-	31/-	36/-	57/8
25 ml. in $\frac{1}{10}$ ml.	15/-	165/-	32/-	38/-	70/2
50 ml. in $\frac{1}{10}$ ml.	16/-	175/-	38/-	43/-	75/2
100 ml. in $\frac{1}{5}$ ml.	19/-	210/-	48/-	53/-	85/2



B 17-420.



B 17-430—432.

B 17-420. BURETTES, Micro-, for accurate measurement of small quantities of liquid, graduated in 100 divisions, complete as shown in illustration.

Capacity ..	1	2	5	*ml.*
	p 11/6	12/6	13/6	*each*



B 17-460.

B 17-430. BURETTES, Automatic. Extremely simple in operation and easily cleaned. A half turn of the stopcock fills the burette and another half turn empties it. The action is entirely automatic, no pumping being necessary. The burette fills and sets itself at the zero point, all excess solution being automatically returned to the reservoir. The single air intake is situated just below the reservoir and is fitted with an absorption tube. **Without** stand.

Burette capacity	1	2	5	10	25	50	*ml.*
Graduated in ..	$\frac{1}{100}$	$\frac{1}{50}$	$\frac{1}{20}$	$\frac{1}{10}$	$\frac{1}{10}$	$\frac{1}{10}$	*ml.*
Reservoir capacity	250	250	500	500	1000	1000	*ml.*
	£2 4 0	£2 4 0	£2 8 0	£2 12 6	£3 7 6	£4 0 0	*each*

B 17-432. Retort Stands, with rectangular white vitreous enamelled cast iron base and ring and clamp, to support **B 17-430.** The white enamelled base provides an excellent background when titrating.

For burette, capacity ..	2	5	10	25	50	*ml.*
	25/-	25/-	25/-	25/-	25/-	*each*

B 17-460. BURETTE FLOAT, Erdmann (*state internal diam. of burette*), to eliminate uncertainty of reading of meniscus position by providing a graduated line on the float, which moves up and down with the liquid in the burette, and against which the reading is taken .. £ s. d. 0 3 0



B 17-550.



B 17-700, No. 1.



B 17-700, Nos. 2/3.

B 17-550. BURNERS, Spirit, glass, with ground-glass cap, porcelain wickholder, including wick.

Capacity	2	4	8	*oz.*
	£1 5 0	£2 0 0	£3 5 0	*dozen*
	3/3	3/9	6/-	*each*

B 17-700. BURNERS, Bunsen, on enamelled iron base; lacquered brass tube fitted with non-removable air regulator so that a luminous flame can be obtained for blowpipe work. Gas inlet tube of lacquered brass riffled for rubber tubing.

No.	1	2	3	*in.*
Outside diam. of tube	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{11}{16}$	
	£1 7 0	£2 3 0	£6 10 0	*dozen*
	2/6	4/3	12/-	*each*


B 17-770.


B 17-775.


B 17-790.


B 17-812.


B 17-830.

B 17-770. BURNER, Bunsen, brass, with copper chimney, star support and flame guard, as used with the **Marsh arsenic-testing apparatus.** Useful as a micro burner or in determination of melting points or wherever a slow rate of heating is required .. .. .. £ s. d. 0 15 0

B 17-775. BURNERS, Teclu. Give luminous, ordinary or blowpipe flames. The gas supply is adjusted by means of screw with milled head, and the air supply by a screwed milled disc.

Outside diam. of tube	$\frac{1}{2}$	$\frac{3}{4}$ in.
	p 9/6	14/- *each*

B 17-790. BURNER, Fishtail, 20 cm. high, on enamelled iron foot, brass tube and steatite top *r* 0 4 6

B 17-812. BURNER, Tube, simple pattern, for heating 4 in. of tube resting in cradles at ends. **Without** $\frac{7}{16}$ in. Bunsen burner 0 8 0

B 17-830. BUNSEN FLAME-STABILISERS, Griffin. A cheap and useful accessory for use on burner tubes $\frac{7}{16}$ in. diam. Allows maximum air to be consumed over the whole range of flame adjustment. Gives evenly distributed heating over a large area at full flame and permits reduction to a small blue cone about $\frac{1}{4}$ in. high without causing the burner to flash back, particularly useful for charring filter papers and for low-temperature ignitions. Approx. $1\frac{1}{2}$ in. high, nickel grid about $\frac{5}{8}$ in. diam. .. *each r* 1/8 ; *dozen* 0 18 0


B 17-835.


B 17-840.


B 17-855.


B 17-880—884.

B 17-835. ROSE TOPS, Iron.

To fit Bunsen tube	$\frac{7}{16}$	$\frac{1}{2}$ in. diam.
	1/5	1/10 *each*

B 17-840. FLAT-FLAME TOPS, Iron.

To fit Bunsen tube ..	$\frac{7}{16}$	$\frac{13}{16}$	$\frac{13}{16}$ in. diam.
Length	$1\frac{1}{2}$	4	6 in.
	1/5	5/6	7/6 *each*

B 17-855. FLAME GUARDS, with clamping screw to fit $\frac{7}{16}$ in. Bunsen burner .. *each* £ s. d. 0 5 0

B 17-880. GAS LIGHTER, Electric, battery operated. One battery will light gas over 7,000 times ; simple, clean and safe .. .. *tx* 0 5 0

B 17-882. Batteries, spare, for above .. .. *each tx* 0 2 0

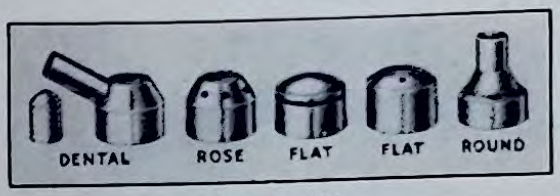
B 17-884. Elements, spare, for above .. .. *each tx* 0 1 0



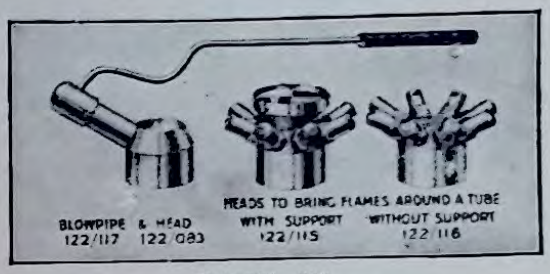
B 17-900.



B 17-905.



B 17-916—925.



B 17-926—930.

B 17-900. BURNERS, Meker pattern (replica of original Meker), for high temperatures. Burner-tube, body and inlet of solid brass, with deep pure nickel grid and air regulator. Base of mild steel, black stove enamelled.

Size No.	1	2	3	4	5	
Height	115	130	155	185	250	*mm.*
Diam. of grid ..	15	20	24	30	42	*mm.*
	p 9/6	11/-	14/-	24/-	48/-	*each*

BURNERS, Amal, for coal gas. Designed on sound principles to give a perfectly aerated flame of the **Meker type**, adjustable over a very wide range. The gas inlet is provided with a screw-down valve controlling a tapered needle which enables the burner to be adjusted to give maximum gas velocity according to the volume of gas consumed and the pressure available.

	£	s.	d.
B 17-905. Amal-minor, diam. of head 1 in., height 5½ in. .. .. *tx*	0	18	9
B 17-907. Amal-major, diam. of head 1·7 in., height 7¼ in. .. .. *tx*	1	2	6

B 17-909. BURNERS, Amal, for petrol-air gas, with air adjustment on mixing tube. *Sizes and prices as above.*

BURNERS, Amal, for butane, propane, Calor gas, Mansfield gas and similar gases, with fixed jet. Including 3 spare jets and key. *Please state type of gas when ordering.*

B 17-912. Amal-minor .. .. *tx*	0	18	9
B 17-914. Amal-major .. .. *tx*	1	2	6

BURNER HEADS, loose, to fit Amal burners, to give various flame shapes. *When ordering please state type of gas used.*

	Flat (horizontal)	Flat (vertical)	Round (Vertical)	Rose (horizontal)	
B 17-916. Amal-minor, town's gas ..	*tx* 1/6	1/6	1/6	1/6	*each*
B 17-917. Ditto, butane or propane ..	*tx* —	2/-	1/6	1/6	*each*
B 17-918. Amal-major, town's gas ..	*tx* 3/9	3/9	5/3	3/9	*each*
B 17-919. Ditto, butane or propane ..	*tx* —	5/3	5/3	3/9	*each*

B 17-924. Blowpipe Head, for Amal-minor burner, type 122/083, for giving a side flame, for use when melting waxes, etc. Prevents material falling into burner .. .. .. *tx*	0	3	0
B 17-925. Ditto, for Amal-major burner .. .. *tx*	0	5	3

BURNER HEADS, loose, to fit **Amal-minor burners.**

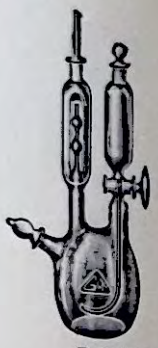
B 17-926. Mouth Blowpipe Attachment, type 122/117, for **B 17-924.** Slips over wide tube and gives a small flame for blowpipe estimations, fusions, or small repairs to glassware .. *tx*	0	5	3
B 17-928. Rose Top, type 122/116, having eight jets, giving flames inclined inwards. Most useful for heating walls of tubes where it is not desirable to concentrate heat on to base of tubes. Suitable for tubes of ¼ to 1 in. diam. .. .. *tx*	0	7	6
B 17-930. Ditto, type 122/115, fitted with centre table support. Enables tubes, crucibles, etc., to be placed on it so that flames heat sides only. A useful attachment which will suggest many uses .. .. *tx*	0	11	3



B 18-005.



B 18-552.



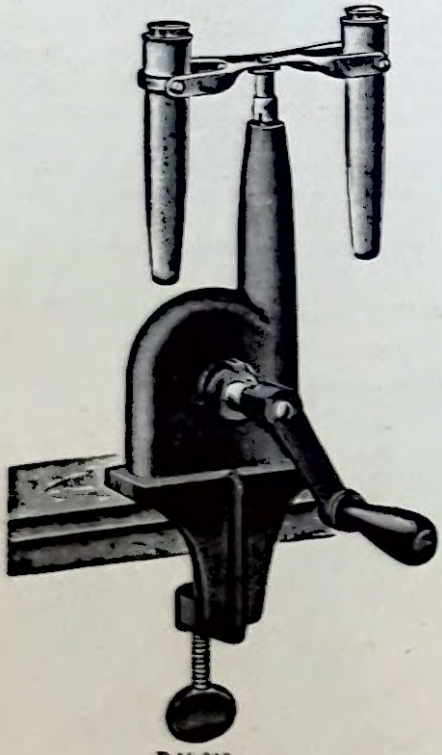
B 18-556.

B 18-005. BURNER, Boiling, Ring, black enamel finish. Diam. across vessel support 5¼ in., overall length 10 in. .. .. (*a*) *p* £ 0 6 6

B 18-552. CARBON DIOXIDE APPARATUS, Parnell, simple pattern .. .. .. *each* 0 5 6

B 18-556. Ditto, Schrötter, with tube to bottom .. .. *each* 0 13 6

B 18-615. CARDBOARD, 25 × 20 in., medium thickness, white both sides .. .. *sheet* 0 3 0



B 19-010.



B 19-260.



B 19-264.



B 19-320.



B 19-440.

B 19-010. CENTRIFUGE, Hand, finely japanned cast iron casing, worm gearing, nickel-plated head, aluminium buckets, clamp to screw to bench or table. To take 2, 15 ml. glass tubes. With one each plain and graduated glass tubes .. £ 3 5 0

B 19-015. Ditto, to take 4, 15 ml. tubes. With 3 plain and one graduated glass tubes .. .. £ 3 15 0

B 19-260. CENTRIFUGE TUBES, conical at bottom, capacity 15 ml., ungraduated *each* 8d.; *dozen* 0 6 6

B 19-264. Ditto, graduated 0 to 10 ml. in 0·1 ml., with mark at 15 ml. *each* 2/10; *dozen* 1 11 0

B 19-320. CHARCOAL BLOCKS, compressed.

Dimensions	2 × 1¼ × 1¼	2¾ × 1¼ × 1¼	4 × 1¼ × 1¼	6 × 1¼ × 1¼	*in.*
p	5/-	7/-	8/6	12/-	*dozen*

B 19-440. CHIMNEYS, Lamp, cylindrical.

Length × diam.	6 × 2	8 × 2	*in.*
p	10d.	1/6	*each*

THE GRIFFIN FOUR-SIX CLAMP

The Four-in-One Die-cast Clamp with Six Point Support, Precision Made throughout



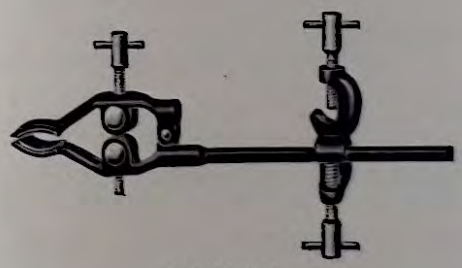
B 19-520.

This new clamp, precision diecast from corrosion resisting metal, was designed to overcome the defects which all users of clamps have found by experience in former types. Of robust proportions and accurately made on engineering lines, it will give many years' hard service. Modern production methods have enabled us to sell this high grade laboratory tool at an exceptionally low price.

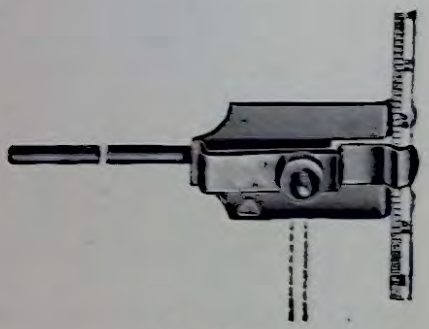
SPECIFICATION

Girder construction of arms to give strength with lightness in weight. Tongue and groove hinge with large bearing surfaces; hinge pin securely riveted and cannot work loose. Accommodates tubes, etc., from $\frac{3}{16}$ to $3\frac{1}{2}$ in. diam., thus performing the work of the four normal sizes of ordinary clamps. The single and two pronged jaws give six-point contact support for both parallel and tapered round apparatus. The stem is cast integrally with the stationary jaw and cannot therefore become unscrewed during use—an important point when slight adjustments to an apparatus may be required after its assembly has been completed. Cushioned jaws give positive, non-slip, yet controllable grip so that even very delicate apparatus can be supported firmly by light screw pressure. The linings are readily replaceable from laboratory rubber tubing, without adhesive. The clamp screw is machined to fine limits and there is no significant play in the jaws.

	£	s.	d.
B 19-520. GRIFFIN FOUR-SIX CLAMP, diecast, precision made, range $\frac{3}{16}$ in. to $3\frac{1}{2}$ in., with cushioned jaws and integral clamp stem .. .. *each* 4/3; *dozen*	2	6	0



B 19-540—542.



B 19-650.

CLAMPS, pressed sheet steel, with steel rod securely fixed, stove enamelled black, with cork-lined jaws, actuated by brass right- and left-hand screw.

Size	Small	Medium	Large	
To hold tubes up to ..	$1\frac{1}{8}$	$1\frac{7}{8}$	$2\frac{7}{8}$	in.
B 19-540. With bosshead	£3 15 0	£4 2 6	£4 17 6	*dozen*
	7/-	7/6	9/-	*each*
B 19-542. Without bosshead	£2 8 0	£2 12 6	£3 2 6	*dozen*
	4/6	5/-	6/-	*each*

	£	s.	d.
B 19-650. CLAMP, Brass, nickel plated, for thermometers, etc., fitted with spring and screw adjustment; rod is rotatable and can be fixed either horizontally or vertically as shown	0	5	0

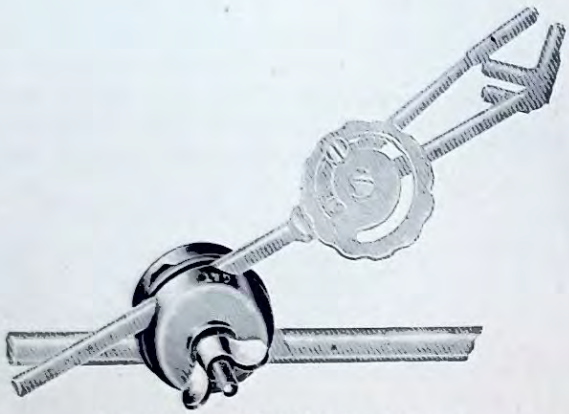
FASGRIF UNIVERSAL BOSSHEADS

New infinitely adjustable designs carried out in die-cast brass with stainless steel screw

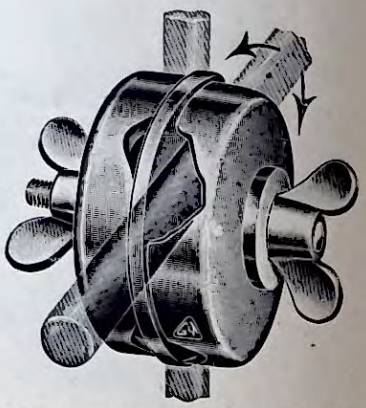
Registered Design No. 776037



B 19-750.—The Fasgrif Universal Bosshead, single screw type.



Fasgrif Universal Bosshead in use with Fasgrif Clamp.



B 19-752.—The Fasgrif Universal Bosshead, double screw type.

THE FASGRIF UNIVERSAL BOSSHEAD.—A one-screw, infinitely adjustable design, combining efficiency and simplicity in the highest degree.

A bosshead capable of adjustment in any plane and at any angle is an essential item in the equipment of every scientific worker and of every laboratory. Hitherto bossheads have been mainly of a single type, in which, with a fixed point on the retort stand rod as centre, the locus of a point on the end of the clamp is a circle. In the Fasgrif Universal Bosshead that locus is a sphere.

The many advantages, the convenience and saving of time, arising from the use of such a device will be immediately appreciated.

SPECIFICATION

The bosshead is of brass in three sections. The upper and lower sections are cup-shaped. Two similar pairs of V grooves of different sizes are cut in the rim of each of the two sections. One pair grips rods from $\frac{3}{16}$ to $\frac{3}{8}$ in. and the other $\frac{3}{8}$ to $\frac{1}{2}$ in.

In the centre of the lower section there is riveted a screwed stem of stainless steel, $\frac{1}{4}$ in. diameter. The upper section has at its centre a clearance hole through which the stem is passed.

The upper and lower sections are separated by a stout disc, $2\frac{1}{8}$ in. diameter, with small central hole through which the stem passes.

These three parts, forming the Universal Bosshead, are held together by a wing nut and washer. To ensure a firm grip of rods of all sizes between the limits specified, the nut and washer are spherically seated.

By these simple means a truly universal system is efficiently secured.

	£	s.	d.
B 19-750. FASGRIF UNIVERSAL BOSSHEAD, single screw type, *Regd. Design No.* 776037, **brass, with stainless steel screw,** to grip two rods at any angle, capacity $\frac{3}{16}$ to $\frac{1}{2}$ in. *each* 6/- ; *dozen*	3	5	0
B 19-752. Ditto, Double screw type, stainless steel screw **rigidly fixed** to centre disc and with two wing nuts. Enables one rod to be adjusted without simultaneously loosening the other, and is therefore preferred by some workers for this reason *each* 7/9 ; *dozen*	4	4	0

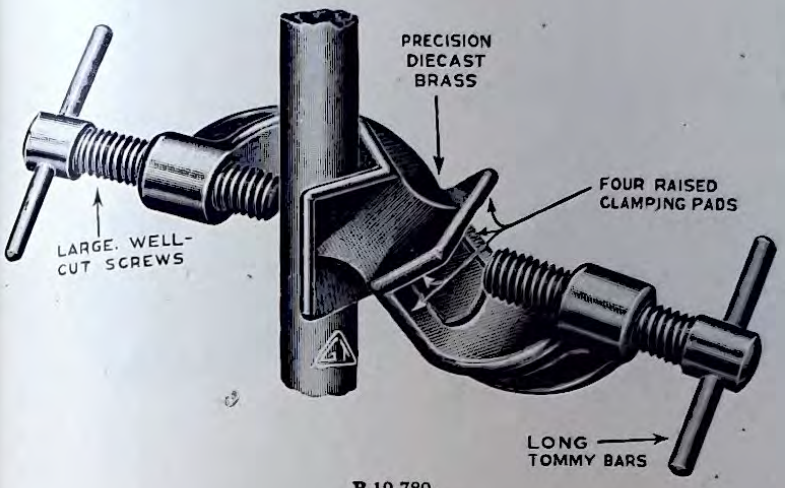
Directions for Use

Single Screw type, B 19-750.—Pass the retort stand rod, or other rod, through a pair of the V grooves in the lower section. Choose the grooves of most convenient size. Pass the stem of the clamp, or other rod, through similar grooves in the upper section. Keep the whole pressed lightly together with the left hand, the fingers being at the back and the thumb at the front.

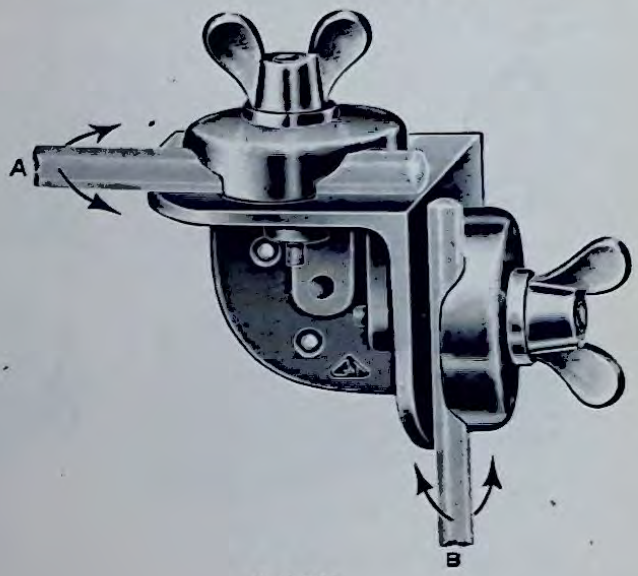
Screw up the butterfly nut just sufficiently to prevent the rods slipping out. Make the fina adjustments to the apparatus and then screw up the nut firmly.

A perfectly stable and rigid fixture is thus simply obtained.

Double Screw type B 19-752.—Adjustment of the apparatus supported by the two parts of this bosshead is carried out independently of the other. The universality of the system is not thereby impaired and its manipulation is simplified.



B 19-780.



B 19-790.

£ s. d.

B 19-780. FASGRIF BOSSHEAD. The best British-made bosshead, **precision die-cast** in brass. Bearing surfaces accurately made. Clamps and rods firmly supported by a **very light** screw pressure, due to accurate geometric construction of contact surfaces. Tommy bars of adequate length ensure comfort in handling without undue pressure on fingers. A first-class bosshead, universally approved. Will take clamp stems and retort stand rods up to $\frac{5}{8}$ in. diam. With brass screws and tommy bars .. *each* 2/6; *dozen* 1 7 0

B 19-790. BRACKET-BOSSHEAD, Griffin. A new form of laboratory bosshead intended for screwing to a vertical wall or partition or horizontal shelf or bench, for use where it is desired to assemble apparatus without the use of retort stands.

A cast brass bracket with three quadrant-shaped faces, each $2\frac{1}{2}$ in. side, inclined mutually at right angles. Each face reinforced inside. Two universal bossheads provided, each with two sets of grooves accommodating clamps or rods $\frac{3}{16}$–$\frac{1}{2}$ in. diam. The universal bossheads are components of and have all the unique advantages of the Fasgrif Universal Bosshead described on the preceding page. The rod A can be rotated through 180° to any position in a horizontal plane. The rod B can be rotated through 180° to any position in a vertical plane. Vice versa when the (back) fixing face is horizontal, as when screwed to a shelf or bench.

Has many applications and will be found as useful in the physics laboratory as in the chemistry laboratory. Can be used to support burettes, condensers, flasks, long trains of apparatus. Can be screwed to bench top, and frameworks easily erected thereon for very complex set-ups. Weight about 1 lb. 9 oz. .. .. *each* 1 0 17 6

B 19-810. CLIPS, Mohr, nickel-plated brass, flat jaws with rounded edges to prevent damage to tubing. Finger plates are riveted for maximum strength.

No.	1	2	3	4	
Length	$1\frac{3}{4}$	$2\frac{1}{8}$	$2\frac{3}{4}$	$3\frac{1}{8}$	*in.*
	5/6	6/6	9/-	10/6	*dozen*
	7d.	8d.	10d.	1/-	*each*



B 19-810.

B 19-825. CLIPS, Screw, Bunsen, nickel-plated brass, **improved form, with protection plate** to prevent the screw cutting the rubber tubing, and with bottom bar hinged to permit direct removal of clip from the tube.

Width between bars ..	$\frac{1}{2}$	$\frac{3}{4}$	1	*in.*
	12/-	13/6	15/-	*dozen*
	1/2	1/3	1/5	*each*



B 19-825.



B 19-870.

B 19-870. CLIPS, Spring, for making up racks to hold burettes, pipettes, etc., each with screw.

To take tubes diam.	¼	⅜	½	⅝	¾	1	*in.*
	19/6	£1 1 0	£1 2 0	£1 3 0	£1 7 0	£1 16 0	*gross*
	1/11	2/-	2/-	2/3	2/6	3/6	*dozen*



B 19-915.



B 19-925.

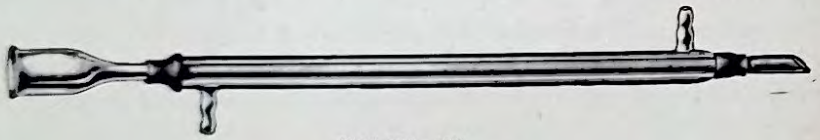


B 19-930.

	£	s.	d.
B 19-910. DUSTERS, Check, best quality, 23 × 23 in. .. .. .. *each* 1/10 ; *dozen*	1	0	0
B 19-915. CLOTHS, Sponge, open mesh for swabbing, 22 × 18 in. .. *each* 10d. ; *dozen*	0	8	6
B 19-925. CLOTHS, Polishing, yellow, soft and durable, about 22 × 18 in. *each* 1/6 ; *dozen*	0	16	0

B 19-930. CLOTHS, Selvyt, polishing.

Size	A	B	C	D	E	
Dimensions	10 × 10	14 × 14	14 × 17	21 × 17	21 × 20	*in.*
(*a*)	£1 2 6	£2 10 0	£3 0 0	£4 0 0	£4 5 0	*dozen*
(*a*)	2/3	4/6	5/6	7/6	8/-	*each*



B 22-170—172.

B 22-170. CONDENSERS, Liebig, Soda glass (*B.L.W.A. Standard T.C.D. No.* 101). With narrow jacket for efficiency, ease in handling and storage, inner tube fitted to jacket with rubber joints.

Jacket length	20	30	50	75	*cm.*
	pb 4/-	5/-	7/6	18/-	*each*

B 22-172. Inner Tubes, Soda Glass, for above.

For jacket length	20	30	50	75	*cm.*
	pb 1/5	1/10	2/9	4/-	*each*



B 22-180.

B 22-180. CONDENSERS, Liebig, Pyrex glass (*B.L.W.A. Standard T.C.D. No.* 102). Made in one piece with inner tube fused to jacket. Narrow jacket for efficiency, ease in handling and storage

Jacket length	20	30	50	75	*cm.*
	pb 7/-	8/6	11/-	15/6	*each*



B 22-185.



B 22-187.



B 22-190.



B 22-270.



B 22-400—405.



B 22-415.

B 22-185. CONDENSER ADAPTERS, straight, blown glass, bore of neck $\frac{7}{8}$ in.

£	s.	d.	
			each 11d. ; *dozen*
0	9	6	

B 22-187. Ditto, bent .. .. *each* 11d. ; *dozen*

0	9	6

B 22-190. Ditto, about 3 × 1 in. diam., having bent delivery tube about 6 in. long × $\frac{3}{8}$ in. diam. Parallel outlet tube easily inserted through cork to make tight joint for vacuum distillation .. .. *each* 2/- ; *dozen*

1	2	0

B 22-270. CONDENSERS, Double Surface, Davies, Pyrex glass (*B.L.W.A. Standard T.C.D. No.* 106). An extremely efficient type. With injector jet and vapour space 2·5–3 mm. between the innermost and middle walls. The 10 cm. size is useful for extraction apparatus.

Body length	10	15	20	30	*cm.*
pb	13/-	13/6	15/6	20/-	*each*

B 22-400. CORKS, long form, selected fine quality, for chemical work.

Diam. at small end ..	6	8	10	12	14	16	19	*mm.*
	2/6	3/6	3/9	4/9	5/-	6/6	7/-	*gross*
	3d.	5d.	5d.	6d.	6d.	8d.	8d.	*dozen*

Diam. at small end	22	26	29	32	35	38	*mm.*
	9/6	12/-	13/6	16/-	18/6	25/-	*gross*
	11d.	1/2	1/3	1/6	1/9	2/6	*dozen*

B 22-405. CORKS, Assorted, 24 each 10, 12, 16, 19, 22 mm. ; 6 each 26, 29, 32 and 35 mm.

£	s.	d.	
			gross
0	8	0	

B 22-410. CORK BUNGS, good quality, about 1 in. thick.

Diam. at small end ..	1½	1⅝	1¾	2	2¼	2½	*in.*
	2/6	3/-	3/6	3/9	4/9	5/6	*dozen*

Diam. at small end ..	2¾	3	3¼	3½	4	4½	*in.*
	7/-	8/-	10/-	12/-	14/6	19/6	*dozen*

B 22-415. CORK SHIVES, good quality, about $\frac{1}{2}$ to $\frac{5}{8}$ in. thick.

Diam. at small end	1	1⅛	1¼	1⅜	1¾	2	2¼	2½	*in.*
	5/-	6/-	7/6	11/-	13/6	20/-	24/-	34/-	*gross*
	6d.	7d.	9d.	1/1	1/3	1/10	2/3	3/3	*dozen*

Griffin and Tatlock Limited from their five centrally situated Houses, provide a unique organisation for the supply of Complete Laboratory Equipment.

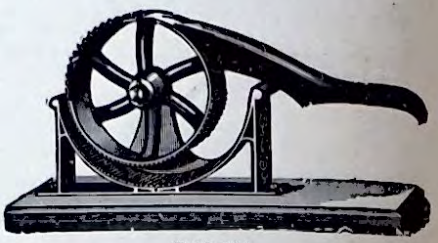

B 22-420


B 22-425.


B 22-450.


B 22-455.


B 22-475.


B 22-510.

B 22-420. CORK MATS, Compressed, 12 cm. diameter, on which to stand hot flasks, beakers, etc.

Thickness	6	12	20	25	30	40	*mm.*
	6d.	**8d.**	**9d.**	**1/1**	**1/3**	**1/6**	*each*

B 22-425. CORK RINGS, Compressed, nestable, about 4·5 cm. thick. Find a wide application in the support of round bottom flasks.

Outside diam. ..	7·5	11·5	15·5	20	24	*cm.*
	1/-	**1/9**	**3/6**	**4/6**	**7/-**	*each*

B 22-450. CORK-BORERS, nickel-plated brass, with milled collar and rod for use as tommy-bar and for clearing borers.

Set of	3	6	12	*borers*
Cutting from 5 mm. to	7·5	11	19	*mm.*
	2/-	**4/-**	**12/6**	*set*

B 22-455. CORK-BORERS, nickel-plated brass, with shaped handles, cutting same sizes as above. Handles securely fixed to tubes.

Set of	3	6	12	18	*borers*
	3/-	**5/9**	**15/-**	**27/-**	*set*

	£	s.	d.
B 22-475. CORK BORER SHARPENER, brass cone which serves as a guide for the borer, and also restores end to circular shape. Steel blade sets outer surface of borer to correct cutting angle. For use with borers up to 19 mm. diam.	0	4	0
B 22-510. CORK SQUEEZER, rotary wheel pattern, for corks up to a diameter of about 1¼ in. Mounted on wooden base. The only satisfactory pattern available for general laboratory use. Softens the cork evenly and makes it pliable by rolling, without rendering it unduly porous	0	12	6

CRUCIBLES AND LIDS, Royal Worcester Porcelain, Form A, squat shape.


B 22-722—724.

No.	000	00	0	1	2	3	4	5	
Diam.	32	40	43	49	59	68	81	98	*mm.*
Height	19	22	25	30	38	42	50	65	*mm.*
Capacity to brim ..	8	15	19	28	50	80	140	265	*ml.*
B 22-722. Crucibles only .. *tx*	**13/6**	**17/6**	**21/-**	**27/-**	**37/6**	**45/-**	**54/-**	**66/-**	*dozen*
tx	**1/4**	**1/8**	**2/-**	**2/6**	**3/6**	**4/-**	**5/-**	**6/-**	*each*
B 22-724. Lids only .. *tx*	**10/-**	**10/-**	**10/-**	**11/6**	**11/6**	**15/-**	**19/6**	**22/6**	*dozen*
tx	**1/-**	**1/-**	**1/-**	**1/2**	**1/2**	**1/6**	**1/10**	**2/-**	*each*

Please use our Catalogue Numbers in your requisitions and orders. They are a complete specification of your requirements.

CRUCIBLES AND LIDS, Royal Worcester Porcelain, Form B, tall shape.



B 22-732—734.

No.	000	00	0	1	2	3	4	5		
Diam.	28	32	39	43	55	66	78	89	*mm.*	
Height	20	25	26	37	46	51	62	70	*mm.*	
Capacity to brim ..	6	11	16	32	67	102	160	250	*ml.*	
B 22-732. Crucibles only ..	*tx* 10/-	13/6	16/6	27/-	37/6	45/-	53/6	63/-	*dozen*	
	tx 1/-	1/4	1/8	2/6	3/6	4/-	4/10	5/10	*each*	
B 22-734. Lids only ..	*tx* 10/-	10/-	10/-	10/-	11/6	15/-	19/-	22/6	*dozen*	
	tx 1/-	1/-	1/-	1/-	1/2	1/6	1/10	2/2	*each*	



Form A.

CRUCIBLES AND LIDS, Sillax British Porcelain, for educational and routine use.



Form B.

	Form A.					Form B.					
No.	000	00	0	1	2	000	00	0	1	2	
Diam.	32	40	43	49	59	28	32	39	43	55	*mm.*
Height	19	22	25	30	38	20	25	29	37	46	*mm.*
Capacity	8	15	19	28	50	6	11	16	32	67	*ml.*

B 22-742. Crucibles only.

No. ..	000	00	0	1	2	000	00	0	1	2	
tx	7/6	8/-	8/6	11/6	16/-	7/6	7/6	8/6	13/-	18/6	*dozen*
tx	10d.	10d.	10d.	1/2	1/6	10d.	10d.	10d.	1/4	1/10	*each*

B 22-744. Lids only.

tx	7/4	7/6	9/-	9/-	10/8	7/2	7/2	7/6	9/-	11/6	*dozen*
tx	10d.	10d.	10d.	10d.	1/-	8d.	8d.	10d.	10d.	1/2	*each*



B 22-760—768.



B 22-772—778.

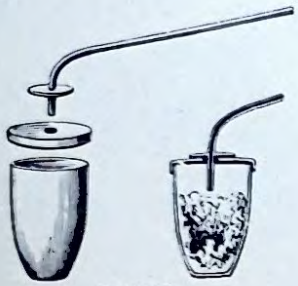
CRUCIBLES AND LIDS, Silica, glazed.

Diam.	29	41	41	47	57	67	79	*mm.*
Height	19	19	25	28	37	45	51	*mm.*
Capacity	5	10	15	25	40	80	150	*ml.*
B 22-760. Crucibles only, translucent *tx*	1/8	1/11	2/1	2/6	2/11	4/2	5/-	*each*
B 22-762. Lids only, translucent .. *tx*	1/6	1/6	1/6	1/8	2/1	2/6	2/11	*each*
B 22-766. Crucibles only, transparent *tx*	3/2	4/9	6/3	7/10	11/10	15/8	20/4	*each*
B 22-768. Lids only, transparent .. *tx*	3/2	4/9	5/-	6/3	9/5	11/10	15/8	*each*

CRUCIBLES, AND LIDS Silica, glazed, platinum shape.

Diam.	27	32	35	43	51	73	*mm.*
Height	32	33	38	38	51	81	*mm.*
Capacity	10	15	20	30	50	200	*ml.*
B 22-772. Crucibles only, translucent .. *tx*	3/4	3/4	3/4	3/4	4/2	6/8	*each*
B 22-774. Lids only, translucent .. .. *tx*	1/6	1/6	1/6	1/6	1/8	2/11	*each*
B 22-776. Crucibles only, transparent .. *tx*	4/9	6/3	7/1	7/10	14/11	37/6	*each*
B 22-778. Lids only, transparent .. .. *tx*	4/-	4/9	5/2	6/-	7/10	15/8	*each*

The General Index at the end of this Catalogue is a complete guide to its contents. Please consult it.



B 22-852.



B 22-862—866.

B 22-852. CRUCIBLES, Rose, Royal Worcester Porcelain, diam. 31 mm., height 37 mm., capacity 15 ml., with lid and with unglazed flanged tube

		Crucible	Lid.	Flanged Tube.	
	tx	2/4	10d.	8/-	*each*

CRUCIBLES, Rose, silica, translucent, glazed.

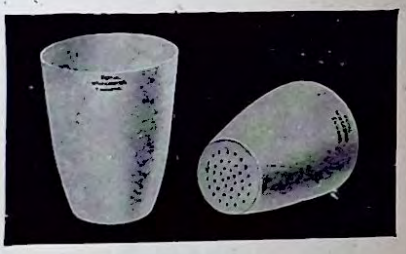
Capacity	12	25	35	75	*ml.*
B 22-862. Crucible only .. .. .. *tx*	2/1	2/6	2/11	4/2	*each*
B 22-864. Crucible Lid .. .. .. *tx*	1/8	2/1	2/1	2/6	*each*
B 22-866. Flanged Tube .. .. .. *tx*	5/10	5/10	5/10	5/10	*each*



B 22-880—882.



B 22-888—890.



B 22-960.

CRUCIBLES AND LIDS, Iron, Spun.

Diam.	50	60	75	80	*mm.*
Height	35	45	55	65	*mm.*
B 22-880. Crucible and Lid .. .. *r*	2/6	6/-	3/9	4/3	*each*
B 22-882. Crucible only .. .. .. *r*	1/5	2/3	2/6	3/-	*each*

CRUCIBLES AND LIDS, Nickel, in one piece, heavy sheet nickel.

Diam. ..	20	25	30	35	40	50	60	80	100	*mm.*
Capacity ..	5	10	15	25	30	70	130	270	600	*ml.*
B 22-888. Crucible and Lid *tx*	22/-	24/-	26/-	29/-	33/-	44/-	60/-	105/-	145/-	*dozen*
tx	2/3	2/3	2/6	2/9	3/-	4/-	5/6	9/6	13/6	*each*
B 22-890. Crucible only .. *tx*	16/-	17/6	19/6	22/-	24/-	35/-	44/-	77/6	110/-	*dozen*
tx	1/6	1/8	1/9	2/-	2/3	3/3	4/3	7/-	10/6	*each*

B 22-955. CRUCIBLES, Gooch, Sillax British Porcelain, with perforated bottoms, for average educational and routine use.

Height × diam. ..	30 × 20	31 × 29	40 × 36	45 × 42	*mm.*
Capacity	8	10	25	35	*ml.*
tx	£1 8 6	£1 16 0	£2 7 0	£2 12 6	*dozen*
tx	2/8	3/4	4/4	4/10	*each*

B 22-960. CRUCIBLES, Gooch, Royal Worcester Porcelain, with perforated bottoms.

Height × diam. ..	30 × 20	31 × 29	40 × 36	45 × 42	*mm.*
Capacity	8	10	25	35	*ml.*
tx	£1 11 6	£2 0 6	£2 14 0	£2 18 6	*dozen*
tx	2/10	3/8	5/-	5/4	*each*



B 23-025.



B 23-030.



B 23-060—066.



B 23-095.

B 23-025. CRUCIBLE HOLDERS, Filter, glass. Used with filter cones **B 23-030.**

No.	1	2	3	4	
For Gooch crucibles	8	10	25	35	*ml.*
	1/4	**1/6**	**1/10**	**2/3**	*each*

B 23-030. CONES, Filter, soft rubber, provide a good and easily-made vacuum-tight joint, to fit corresponding Nos. of filter crucible holders **B 23-025.**

No.	1	2	3	4	
Height × top diam. inside	22 × 32	25 × 25	30 × 32	35 × 40	*mm.*
	8d.	**9d.**	**11d.**	**1/2**	*each*

CRUCIBLES, Gooch, Pyrex, with sintered glass filter discs.

Pyrex ref. No.	SF2A	SF2B	SF2C	SF2D	
Disc diam. approx.	20	30	30	40	*mm.*
Top diam. approx.	31	42	38	50	*mm.*
Height	44	50	60	53	*mm.*
B 23-060. Grade 1	*tx* **4/3**	**4/3**	**4/3**	**6/4**	*each*
B 23-062. Grade 2	*tx* **4/3**	**4/3**	**4/3**	**6/4**	*each*
B 23-064. Grade 3	*tx* **4/3**	**4/3**	**4/3**	**6/4**	*each*
B 23-066. Grade 4	*tx* **4/3**	**4/3**	**4/3**	**6/4**	*each*

Grade 1.—Average pore diam. 100–120 microns. Suitable for coarse precipitate filtration, foundation for absorbing medium for gelatinous precipitates, extraction of coarse grain material.

Grade 2.—Average pore diam. 40–50 microns. Suitable for filtration in preparation of medium precipitates.

Grade 3.—Average pore diam. 20–30 microns. Suitable for preparation of fine precipitates, analyses involving medium precipitates, extraction of fine grain material.

Grade 4.—Average pore diam. 5–10 microns. Suitable for analyses involving very fine precipitates, *e.g.* $BaSO_4$, preparative work with fine precipitates, etc.

B 23-095. CRUCIBLES, Fireclay, "Battersea Round," for gold, silver and other assays. Used also for direct fusions.

Size.	Height. Inches.	Diameter at Top. Inches.	Crucibles. s. d.		Covers. s. d.	
				r		*r*
A	2⅝	1⅝	*dozen* 5	0	*dozen* 4	6
B	3	1⅞	,, 6	6	,, 4	6
C	3½	2¼	,, 9	0	,, 6	0
D	4	2⅝	,, 11	0	,, 6	0
E	4½	2⅞	,, 13	0	,, 9	0
F	5	3	,, 15	6	,, 11	0

Size.	Height. Inches.	Diameter at Top. Inches.	Crucibles. s. d.		Covers. s. d.	
				r		*r*
G	5⅝	3⅜	*dozen* 20	0	*dozen* 13	6
H	6	3¾	,, 24	0	,, 13	6
JJ	6⅜	3⅞	,, 26	6	,, 15	6
J	6⅝	4⅛	,, 30	6	,, 15	6
K	7½	4½	,, 39	0	,, 20	6
L	8	5¼	,, 56	6	,, 20	6



B 23-255—265.

CYLINDERS, Measuring, Graduated, Spouted, on foot. Figured to read one way. *(Please state Catalogue No. when ordering.)*

Cat. No. →	B 23-255 Grade B		B 23-263 Grade A without Certificate		B 23-265 Grade A with 5-point Certificate	B 23-271 Class A with N.P.L. Certificate
To contain	*each*	*dozen*	*each*	*dozen*	*each*	*each*
5 ml. in $\frac{1}{10}$ ml.	3/6	38/-	15/-	165/-	20/-	† —
10 ml. in $\frac{1}{10}$ ml.	3/6	38/-	15/-	165/-	20/-	42/8
25 ml. in $\frac{1}{5}$ ml.	5/-	55/-	19/-	210/-	24/-	44/8
50 ml. in $\frac{1}{2}$ ml.	4/6	50/-	18/-	195/-	23/-	44/8
100 ml. in 1 ml.	5/6	60/-	20/-	220/-	25/-	46/8
200 ml. in 2 ml.	6/6	70/-	21/-	230/-	26/-	48/8
250 ml. in 2 ml.	7/-	77/6	23/-	250/-	28/-	52/8
500 ml. in 5 ml.	9/6	105/-	27/-	295/-	32/-	65/2
1000 ml. in 10 ml.	12/6	135/-	32/-	350/-	37/-	72/8
2000 ml. in 20 ml.	25/-	275/-	—	—	—	—



B 23-285—295.

CYLINDERS, Measuring, Graduated, Stoppered, on foot. Figured to read one way. *(Please state Catalogue No. when ordering.)*

Cat. No. →	B 23-285 Grade B		B 23-293 Grade A without Certificate		B 23-295 Grade A with 5-point Certificate	B 23-301 Class A with N.P.L. Certificate
To contain	*each*	*dozen*	*each*	*dozen*	*each*	*each*
5 ml. in $\frac{1}{10}$ ml.	5/6	60/-	17/-	185/-	22/-	† —
10 ml. in $\frac{1}{10}$ ml.	5/6	60/-	17/-	185/-	22/-	44/8
25 ml. in $\frac{1}{5}$ ml.	7/-	77/6	21/-	230/-	26/-	48/8
50 ml. in $\frac{1}{2}$ ml.	6/6	70/-	20/-	220/-	25/-	48/8
100 ml. in 1 ml.	7/6	82/6	22/-	240/-	27/-	50/8
200 ml. in 2 ml.	9/-	95/-	24/-	260/-	29/-	52/8
250 ml. in 2 ml.	9/6	100/-	26/-	280/-	31/-	54/8
500 ml. in 5 ml.	12/6	135/-	30/-	325/-	35/-	66/8
1000 ml. in 10 ml.	18/-	195/-	35/-	380/-	40/-	74/8
2000 ml. in 20 ml.	31/-	340/-	—	—	—	—

B 23-360. CYLINDERS, Measuring, graduated, Pyrex resistance glass on foot, spouted, useful in measurement of volume of hot liquids. Figured to read one way.

To contain	10	25	50	100	250	500	1000	2000 *ml.*
Divided in	$\frac{1}{10}$	$\frac{1}{5}$	$\frac{1}{2}$	1	2	5	10	20 *ml.*
tx	3/11	3/11	4/3	4/7	5/8	8/5	10/6	21/- *each*



B 23-390.

B 23-390. CYLINDER PROTECTORS ("Lifebuoys"). Thick soft rubber rings for fitting over cylinders near top to prevent breakage through falling on bench.

For cylinders ..	100	250	500	1000 *ml.*
	4/6	5/6	7/-	9/- *dozen*
	5d.	7d.	8d.	10d. *each*

DESICCATORS.—When a desiccator is being charged with a desiccant, the conditions which the desiccant is required to fulfil should be considered. Many of the precipitates and ignited residues which need to be dried have themselves a greater affinity for water than some of the desiccants in common use, notably Calcium Chloride. Some of the modern solid desiccating agents are not only safer to handle and more convenient in use, but also have an affinity for water equal to or exceeding that of concentrated sulphuric acid.

The following table displays the properties of well known desiccants and enables a comparison of their efficiency to be made. Attention is drawn to the merits of activated Alumina, available in an impregnated form, which by a colour change indicates when regeneration is necessary.

Material	Residual Moisture[1]	Effective Absorptive Capacity[2]	Indicating?	Regenerating?	Temperature for Regeneration	Advantages	Disadvantages
Phosphorus pentoxide	0·00003	30%	Physical change	No	—	High efficiency	Cost Messiness
Magnesium perchlorate (anhydrous)	0·002	40%	No	Yes	230–250° C. in vacuo	Efficient up to 135° C.	Cost
Sulphuric acid	0·003	30%	Yes[4]	Uneconomic	—	Cost Efficiency	Corrosive liquid
Activated Alumina[5]	0·005	25%	Yes	Yes	200–250° C.	Cost Efficiency Convenience	None
Silica Gel	0·03	15%	Yes	Yes	150–180° C.	Convenience	Poor efficiency
Calcium chloride (Tech.)	1·25	30%	Physical change	Uneconomic	—	Cost	Very inefficient[3]

1. Expressed as mg. residual moisture in 1 litre of air after passing through desiccant in a drying train at 30°. Bower: *Bureau of Stds. J. Res.*, 1934, **12**, 241; 1944, **33**, 199.
2. Absorbed moisture as a percentage of weight of desiccant.
3. Many materials put in desiccator for drying are more efficient desiccants and will take moisture from the calcium chloride.
4. By dissolving 18 gms. $BaSO_4$/litre, indication is given that the acid needs renewal when the $BaSO_4$ is pptd.
5. Mantell, *Chem. and Met. Eng.*, 1940, **47**, 305.



B 23-620.



B 23-635.



B 23-675.

B 23-620. DESICCATORS, Scheibler, with knob cover. **Without** perforated zinc disc.

Inside diam. at top	4	5	6	7	8	10	12	*in.*
tx	10/-	12/-	15/-	22/-	30/-	45/-	80/-	*each*

B 23-625. DESICCATORS, Scheibler, moderate vacuum, with **tubulure in cover. Without** zinc disc.

Inside diam. at top	4	5	6	7	8	10	12	*in.*
tx	12/6	15/-	18/6	26/6	35/6	51/6	88/-	*each*

B 23-635. DESICCATORS, Scheibler, moderate vacuum, with ground-in stopcock in cover. **Without** zinc disc.

Inside diam. at top ..	4	6	8	10	*in.*
tx	£1 7 6	£1 14 6	£2 13 6	£4 0 6	*each*

B 23-641. DISCS, Perforated Zinc, for Desiccators. Diameters stated are to fit desiccators of this nominal diameter.

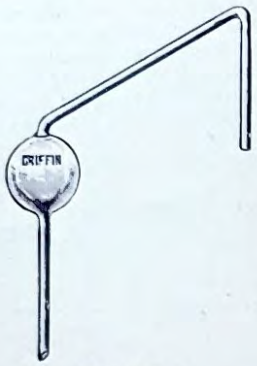
Diam.	4	5	6	7	8	10	12	*in.*
	6d.	9d.	10d.	1/1	1/4	2/-	2/6	*each*

B 23-675. DESICCATOR, high vacuum, Pyrex Glass, B.L.W.A. design with new design stopcock and loose desiccant container. 11½ in. internal diam. at flange, to take 10 in. diam. porcelain plate resting on desiccant container. **Without** plate .. .. *tx* £ 5 12 0

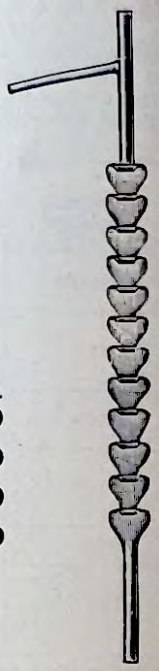
B 23-676. Plate, porcelain, for above .. .. *pb* 0 15 0

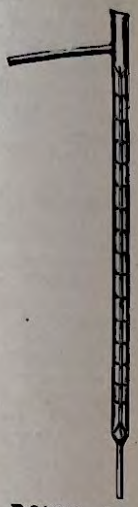


B 24-264.



B 24-270.





B 24-340—342.

		£	s.	d.
B 24-260.	**DISTILLATION HEAD**, one bulb, with trap	0	3	9
B 24-262.	**Ditto**, 2 bulb, with trap in upper bulb	0	3	9
B 24-264.	**Ditto**, with trap in lower bulb	0	3	9
B 24-270.	**DISTILLATION HEAD**	0	2	9

B 24-325. DISTILLATION COLUMNS, Fractionating, "Pear."

With	4	8	12	*pears*
	4/6	7/-	10/6	*each*
B 24-327. Ditto, Pyrex Glass ..	*tx* 5/6	8/-	12/6	*each*

B 24-325—327.

B 24-340. DISTILLATION COLUMNS, Fractionating, Rod and Disc.

With	15	20	*discs*
	4/6	5/6	*each*
B 24-342. Ditto, Pyrex Glass	*tx* 6/6	9/-	*each*



B 24-820.



B 24-970.



B 24-972.

B 24-820. DRAINING BOARDS, Pegged. Strongly made in oiled teak, suitable for hanging on wall over sink, for draining and drying test tubes, flasks, cylinders, etc.

Size	24 × 18	36 × 24	*in.*
No. of pegs	10	17	
	£1 14 0	£2 2 0	*each*

Other sizes to order.

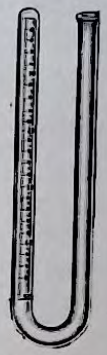
B 24-970. DRYING TOWERS, cylindrical, with tubulure. For solid absorbents.

Height × diam.	8 × 1½	10 × 2	12 × 2	16 × 2½	*in.*
	tx 7/-	8/-	9/-	12/-	*each*

B 24-972. DRYING TOWERS, stoppered, with hole in stopper. For solid absorbents. Very convenient for use in a purifying train.

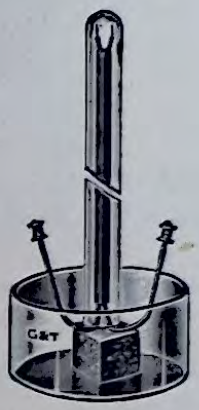
Height × diam.	8 × 1½	10 × 2	12 × 2	16 × 2½	*in.*
	tx 20/-	22/6	25/-	28/-	*each*


B 25-730—732.


B 25-736.


B 25-745.


B 25-748.


B 25-760.


B 25-800—802.


B 25-825.

B 25-730. EUDIOMETERS, Bunsen, graduated in millimetres, with platinum electrodes.

Graduated to	300	400	500	*mm.*
	11/6	**15/-**	**18/6**	*each*

B 25-732. Ditto, 50 ml. graduated in 0·2 ml., with platinum electrodes .. .. *each* **0 18 6**

B 25-736. Ditto, Ure's Syphon, 50 ml. graduated in 0·2 ml., with platinum electrodes *each* **0 13 6**

B 25-740. EUDIOMETER TUBE, Bunsen, graduated 250 mm. in 1 mm. divisions. **Without** platinum electrodes **0 6 6**

EUDIOMETER TUBES, graduated in ml. **Without** electrodes.

Capacity	25	50	100	200	*ml.*
Graduated in	$\frac{1}{10}$	$\frac{1}{5}$	$\frac{1}{2}$	1	*ml.*
B 25-745. Graduated	**6/-**	**6/6**	**7/6**	**12/6**	*each*
B 25-748. Ditto, with tap	**10/6**	**12/6**	**13/6**	**21/-**	*each*

B 25-755. RUBBER PAD, 2 × 2 × $\frac{3}{4}$ in. thick, for closing the ends of eudiometer tubes during explosions **0 1 3**

B 25-760. EUDIOMETER, Goddard, stout glass about 15 in. long, with insulated lead to sparking points inside at top of tube, terminals and resilient rubber pad. **Without** glass trough .. *r* **0 11 0**

Full instructions for using this apparatus are contained in "Fundamental Experiments in Chemistry," Goddard, pp. 28-32. The eudiometer has been designed to prove that the combining ratios of oxygen and hydrogen are 1 : 2 by volume. Electrolytic mixed gas is introduced into the eudiometer and, the tube having been pressed down firmly on the rubber pad, a spark is passed across the points at the top of the tube by connection to a ½-inch spark coil working from 2 volts. Higher voltages increase the danger of bursting the tube. Water is admitted to the tube after sparking and is found to fill at least 99 per cent. of the tube.

EXTRACTORS, Soxhlet, plain, with syphon.

Capacity to top of syphon tube	30	60	80	100	200	*ml.*
Suitable for thimbles ..	19 × 90	25 × 100	27 × 100	33 × 118	43 × 123	*mm.*
B 25-800. Soda Glass	**5/6**	**6/6**	**7/6**	**8/6**	**12/-**	*each*
B 25-802. Pyrex Glass .. .. *tx*	**6/4**	**7/9**	**8/5**	**9/2**	**14/-**	*each*

EXTRACTION APPARATUS, Soxhlet, Soda glass, with condenser and flask, cork fitted.

Capacity to top of syphon tube	30	60	80	100	200	*ml.*
Suitable for thimbles ..	19 × 90	25 × 100	27 × 100	33 × 118	43 × 123	*mm.*
B 25-820. With bulb type condenser ..	**17/6**	**18/-**	**19/-**	**21/-**	**26/-**	*each*
B 25-825. With double surface condenser	**22/-**	**23/-**	**24/-**	**26/-**	**33/-**	*each*



B 25-880.



B 26-070.



B 26-070.



B 26-530—535.

B 25-880. EXTRACTION APPARATUS, Soxhlet, Pyrex glass, with B.S. ground glass joints. With bulb condenser, extractor and one flask.

Capacity of extractor	30	60	80	100	200	*ml.*
Fitted B.S. Joints Nos.	B 29/B 24	B 34/B 24	B 40/B 24	B 40/B 24	B 50/B 24	
Suitable for thimbles	19 × 90	25 × 100	27 × 100	33 × 118	43 × 123	*mm.*
tx	£2 4 0	£2 10 0	£2 15 0	£3 2 6	£3 15 0	*each*

Component Parts for B 25-880

B 25-887 a. Flasks, B.S. Joint No. B. 24 .. *tx*	8/6	9/-	10/-	10/-	11/-	*each*
„ „ **b. Soxhlet extractors,** B.S. Joints .. *tx*	19/-	24/-	27/-	32/-	41/-	*each*
„ „ **c. Bulb condensers,** B.S. Joint .. *tx*	16/6	18/-	19/-	21/-	25/-	*each*

EXTRACTION THIMBLES, Whatman. Seamless, treated with ether to render as fat-free as possible. All thimbles should be extracted with ether before use, as in storage, ether-soluble substances tend to be formed to an extent capable of producing errors in exact work.

Inside dimensions	19 × 90	25 × 100	27 × 100	33 × 118	43 × 123	*mm.*
B 26-070. Single thickness *tx*	10/-	14/-	14/-	19/6	22/9	*box of* 25
B 26-075. Double thickness *tx*	17/-	23/9	23/9	32/6	38/-	*box of* 25

B 26-530. FILTER PAPERS, G. & T. No. 100, a paper of good quality for general laboratory and student use.

Diam.	9	11	12·5	15	*cm.*
	6/-	8/-	10/-	13/6	1000
	9d.	1/-	1/2	1/6	100

B 26-535. Ditto, G. & T. No. 222, of the purest material, leaving very little ash.

Diam. ..	5·5	7	9	11	12·5	15	18·5	24	32	*cm.*
	5/-	6/6	10/-	15/-	19/6	23/-	31/-	37/-	52/6	1000
	7d.	9d.	1/1	1/6	2/3	2/6	3/3	4/-	6/-	100

B 26-540. Ditto, in Sheets.

Dimensions	44 × 57	61 × 61	*cm.*
	£3 2 6	£4 7 6	*ream*
	3/6	5/-	*quire*

FILTER PAPER.—In selecting the size of filter paper the following table indicates the largest circle of paper which is advisable with a given size of funnel.

Diam. of funnel ..	2·5	4	5	6	7·5	8	10	13	15	20	25	*cm.*
Diam. of filter circle	5·5	7	9	11	12·5	15	18·5	24	32	40	50	*cm.*

WHATMAN High Grade FILTER PAPERS

WHATMAN FILTER PAPERS are made with meticulous care. There is a grade available for every problem which may confront the chemist whether in Biological, Bacteriological, Industrial or Educational Laboratories.

Grade No. 1.—Of good quality for general use. Will not retain fine precipitates. Ash per cent., 0·19.

Grade No. 2.—Stouter than No. 1. Will retain finer precipitates. Ash per cent., 0·19.

Grade No 3.—For general qualitative and rough quantitative work. Retains fine precipitates. Ash per cent., 0·16.

Grade No. 4.—Soft open texture, extremely rapid. Not suitable for fine precipitates. Ash per cent., 0·17.

Grade No. 5.—Hard and slow filtering. Recommended for use with Buchner funnels. Retains fine precipitates. Ash per cent., 0·21.

Grade No. 7.—Specially prepared for "yellow precipitate," fairly rapid. Ash per cent., 0·25.

Grade No. 11.—Thin, prepared for Tannin analysis. Ash per cent., 0·19.

Grade No. 12.—Folded. For filtering liquid extracts and tinctures. Free from acid and chlorine.

Grade No. 13.—Supplied to order only. Faster filtering and less retentive than No. 12.

Grade No. 14.—Similar to No. 12 but with centres hardened.

Grade No. 15.—Specially prepared and folded for filtering Agar.

Grade No. 20.—Close texture, retentive, pure, for preparation of indicator and *p*H papers. Ash per cent., 0·08.

Grade No. 21.—Thinner, less retentive than No. 20. Ash per cent., 0·08.

Grade No. 29.—Deep black. Will show up minute quantities of light coloured sediments.

Grade No. 30.—Single Acid Washed. Will retain medium precipitates. Suitable for general work where lowest ash is not important. Ash per cent., 0·035.

Grade No. 31.—Single Acid Washed. Rapid in filtering. Not recommended for fine precipitates. Ash per cent., 0·035.

Grade No. 32.—Single Acid Washed. Close texture. Slow in filtering. Will retain fine precipitates. Ash per cent., 0·035.

Grade No. 40.—Double Acid Washed. Ashless. Will retain barium sulphate properly precipitated. Ash per cent., 0·015.

Grade No. 41.—Double Acid Washed. Ashless. Rapid in filtration. Not recommended for fine precipitates. Ash per cent., 0·016.

Grade No. 42.—Double Acid Washed. Ashless. Recommended for the finest precipitates and for precise quantitative work. May be used with filter pump or pleated. Ash per cent., 0·010.

Grade No. 43.—Double Acid Washed. Ashless. Treated with ether to extract fatty matter as far as possible. Convenient for filtering ether extract in Rose-Gottlieb fat test. Ash per cent., 0·015.

Grade No. 44.—Double Acid Washed. Ashless. Thin, retentive. Recommended for use when the greatest possible degree of accuracy in quantitative analysis is desired. Ash per cent., 0·010.

Grade No 50.—Possesses great wet strength, slow but retentive. Excellent for biological work, its smooth surface permitting slimes and other masses to be easily removed without bringing away any appreciable quantity of the fibre. A very pure filter paper. Ash per cent., 0·025.

Grade No. 51.—Hardened cones. Can be used with or without filter pump to act as supports for large size circles.

Grade No. 52.—Has a matt surface and all the qua of grade No. 54 except that it retains finer precipitates. Ash per cent., 0·025.

Grade No. 54.—Single Acid Washed. A hardened, fast filtering paper of great wet strength. Filters rapidly and not recommended for fine precipitates. Ash per cent., 0·025.

Grade No. 530.—Similar to No. 30 but hardened. Retains medium size particles, very strong. Ash per cent., 0·025.

Grade No. 531.—Improved form of grade No. 31. Fast filtering and intended only for large particle precipitates. Will not pulp or break under severe washing with boiling aqueous liquids. Ash per cent., 0·025.

Grade No. 540.—Similar to No. 40, but hardened, retains medium sized particles. Ash per cent., 0·008.

Grade No. 541.—Improved form of grade No. 41. Fast filtering and intended only for large particle precipitates. Will not pulp or break under severe washing with boiling aqueous liquids. Ash practically negligible. Ash per cent., 0·008.

Grade No. 542.—Similar to No. 42, but hardened. Slow filtering, retains fine precipitates. Ash per cent., 0·008.

Grade No. 544.—Similar to No. 44, but hardened, recommended when greatest accuracy is required. Suitable for use in assaying laboratories. Ash per cent., 0·008.

[Sizes and prices on next page.







B 26-600.

B 26-600. FILTER PAPERS, Whatman. Prices shown are for boxes of 100 circles.

See previous page for brief description of each grade.

Diameter ↓	Whatman Grade No.											
	1	2	3	4	5	7	12	20	29	30	31	32
cm.	*tx*	*tx*	*tx*	*tx*	*tx*	*tx*	*tx*	*tx*	*tx*	*tx*	*tx*	*tx*
5·5	7d.	8d.	1/2	11d.	8d.	8d.	..	..	1/2	1/7	1/7	1/7
7·0	8d.	11d.	1/4	1/-	11d.	11d.	..	..	1/4	2/-	2/-	2/-
9·0	9d.	1/2	1/8	1/4	1/2	1/2	..	..	1/8	2/8	2/8	2/8
11·0	1/-	1/4	2/-	1/8	1/4	1/4	..	..	2/-	3/6	3/6	3/6
12·5	1/4	1/10	2/6	2/2	1/10	1/10	3/9	..	2/6	4/3	4/3	4/3
15·0	1/8	2/6	3/6	3/-	2/6	2/6	5/-	..	3/6	5/6	5/6	5/6
18·5	2/4	3/6	5/-	4/6	3/9	3/6	6/-	..	5/-	8/-	8/-	8/-
24·0	4/-	5/9	8/6	7/6	6/-	5/9	8/6	..	..	14/-	14/-	14/-
32·0	7/9	11/-	15/9	13/9	11/3	11/-	13/9	..	..	..	..	..
40·0	10/6	15/3	23/9	19/-	15/3	15/3	18/6	..	..	..	..	..
50·0	14/9	20/-	28/9	25/-	20/3	20/-	23/3	..	..	..	..	..
62·25	22/3	31/3	..	38/-	..	31/3	..	..	..	..	..	..
Sheets 18¼ × 22½ in. 100	15/-	23/-	34/3	29/6	23/3	23/-	Sheets 23 × 27 in. 100	44/9	..	..	..	..
Sheets 18¼ × 22½ in. 500	67/9	104/-	155/-	133/6	105/9	104/-	Sheets 23 × 27 in. 500	203/-	..	..	..	..

Diameter ↓	Whatman Grade No.														
	40	41	42	43	44	50	51	52	54	530	531	540	541	542	544
cm.	*tx*	*tx*	*tx*	*tx*	*tx*	*tx*	*tx*	*tx*	*tx*	*tx*	*tx*	*tx*	*tx*	*tx*	*tx*
5·5	2/8	2/8	2/8	4/-	4/-	2/9	2/-	2/9	2/9	1/7	1/7	2/9	2/9	2/9	2/9
7·0	3/6	3/6	3/6	4/3	4/3	3/6	2/9	3/6	3/6	2/-	2/-	3/6	3/6	3/6	3/6
9·0	5/-	5/-	5/-	6/3	6/3	5/-	4/3	5/-	5/-	2/8	2/8	5/-	5/-	5/-	5/-
11·0	6/-	6/-	6/-	7/6	7/6	6/-	4/9	6/-	6/-	3/6	3/6	6/-	6/-	6/-	6/-
12·5	6/9	6/9	6/9	8/3	8/3	6/9	..	6/9	6/9	4/3	4/3	6/9	6/8	6/9	6/9
15·0	8/-	8/-	8/-	10/6	10/6	8/-	..	8/-	8/-	5/6	5/6	8/-	8/-	8/-	8/-
18·5	10/6	10/6	10/6	14/9	14/9	10/6	..	10/6	10/6	8/-	8/-	10/6	10/6	10/6	10/6
24·0	17/9	17/9	17/9	25/6	25/6	17/9	..	17/9	17/9	14/-	14/-	17/9	17/9	17/9	17/9
32·0	..	..	..	..	..	33/-	..	33/-	33/-	23/9	23/9	33/-	33/-	33/-	33/-
40·0	..	..	..	..	..	46/-	..	46/-	46/-	36/9	36/9	46/-	46/-	46/-	46/-
50·0	..	..	..	..	..	61/-	..	61/-	61/-	49/-	49/-	61/-	61/-	61/-	61/-
62·25	..	..	..	..	..	91/-	..	91/-	91/-	73/3	73/3	91/-	91/-	91/-	91/-

Please apply for fully descriptive catalogue of Whatman products.

B 26-630. ACCELERATORS, Whatman. Made from double acid-washed material. One or two pieces, added when precipitating, coagulate the precipitate and greatly assist and hasten filtration. Pieces measure 1 × ¾ × 1/16 in. thick approx., weight 0·33 gramme

	£	s.	d.
box of 100 *tx*	0	3	0

B 26-635. CLIPPINGS, Filter Paper, Whatman Ordinary. Very convenient for making up filter pulp for use in Buchner funnels .. .. 1 *lb. box tx* 0 2 3

B 26-640. CLIPPINGS, Filter Paper, Whatman Ashless. Make a pure filter pulp by treatment with distilled water. Useful in bacteriological work for filtering agar. Ash content does not exceed 0·02 per cent. .. .. 1 *lb. box tx* 0 7 0

B 26-675. TABLETS, Ashless, Whatman. Made from double acid-washed material and are used as accelerators or for other purposes where an ashless paper is required in disc form. The tablets are 4·25 cm. diam., and 4 mm. thick. Average weight each 2·28 grammes

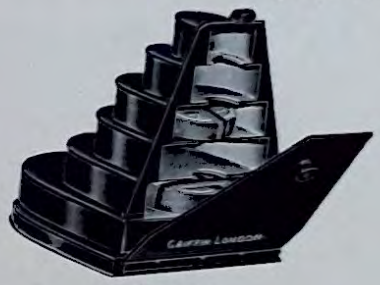
	£	s.	d.
box of 100 *tx*	0	8	6



B 26-720.



B 26-750.



B 26-755.

B 26-720. FILTER DISCS, porcelain, perforated.

Diam.	14	20	25	30	35	40	45	*mm.*
tx	12/5	13/2	15/-	16/6	18/5	20/8	23/3	*dozen*
tx	1/3	1/3	1/5	1/8	1/9	2/-	2/3	*each*
Diam.	50	60	70	80	90	100	130	*mm.*
tx	17/6	31/6	37/2	43/11	49/6	54/5	73/11	*dozen*
tx	1/8	3/-	3/6	4/2	4/8	5/-	6/11	*each*

B 26-750. FILTER BOXES, japanned tin, dust-tight. These boxes are slotted so that a single paper can be taken out without removing the whole packet.

Diam.	6	8	10	12	16	20	25·5	35	*cm.*
To hold filters, diam.	5·5	7	9	11	15	18·5	24	32	*cm.*
p	1/3	1/5	1/10	2/6	3/3	4/9	7/-	9/6	*each*

B 26-755. FILTER CASE, japanned tin, pyramid shape, with 6 compartments and hinged door. To hold 6 sizes of circular filter papers from 5·5 to 18·5 cm. .. .. £ 1 s. 7 d. 0



B 26-760.



B 27-200.

B 26-760. FILTER DRYERS, tinned iron, 4½ in. high. .. .. .. *each p* 1/8; *dozen* 0 17 6

B 27-200. FLAME TEST RODS, unglazed porcelain. Substitute for platinum wire, approx. 15 cm. long, 2 mm. diam. .. .. *dozen tx* 0 6 0



B 27-251—265.

B 27-251. FLASKS, flat bottom, British resistance glass.

Nominal capacity	50	175	250	350	500	750	1000	*ml.*
tx	10/-	13/8	14/7	16/5	20/-	27/3	32/9	*dozen*
tx	11d.	1/5	1/5	1/7	1/10	2/7	3/1	*each*

FLASKS, flat bottom, resistance glass.

Cat. No. →	B 27-255 Chance's Hysil		B 27-260 Monax		B 27-265 Pyrex		
Nominal capacity ml.	*each*	*dozen*	*each*	*dozen*	*each*	*dozen*	Standard cases contain
↓	*tx*	*tx*	*tx*	*tx*	*tx*	*tx*	
50	1/5	14/1	1/3	12/10	1/4	13/-	144
100	1/5	14/6	1/5	14/1	1/4	13/4	144
125	—	—	—	—	1/5	14/9	96
150	1/5	14/11	—	—	1/7	15/9	96
175	1/7	15/8	1/7	15/8	—	—	—
200	1/7	16/6	—	—	1/8	16/10	84
250	1/8	17/4	1/8	17/4	1/9	18/3	84
300	1/10	18/7	—	—	1/9	18/11	72
350	—	—	1/10	19/-	—	—	—
400	2/1	21/6	—	—	2/-	20/8	72
500	2/3	23/2	2/3	23/2	2/2	22/5	72
600	2/4	25/2	2/4	25/2	2/4	25/3	48
700	—	—	—	—	2/7	28/-	36
750	2/9	30/2	2/9	30/2	—	—	—
800	2/11	31/10	—	—	—	—	—
1000	3/4	36/4	3/4	36/4	3/1	32/7	36
1250	—	—	3/9	40/10	—	—	—
1500	4/2	45/5	4/2	45/5	3/8	39/3	24
2000	4/8	52/10	4/8	52/10	4/3	45/11	18
3000	6/3	68/6	6/3	68/6	5/5	57/5	12
4000	7/5	85/10	7/5	85/10	6/5	70/-	6
5000	11/-	118/10	11/-	118/10	8/5	91/-	6
6000	—	—	13/3	141/11	—	—	—
7500	—	—	15/8	171/8	—	—	—
8000	—	—	—	—	11/5	—	—
10000	—	—	22/9	247/6	13/8	—	—
12000	—	—	—	—	15/5	—	—
20000	—	—	—	—	24/6	—	—
40000	—	—	—	—	56/-	—	—

Chance's Hysil Glass.—On orders of not less than 3 gross of Beakers and Flasks of any sizes, to be delivered in one consignment, a discount of 10% is allowed. On orders of not less than half a gross of one item a discount of 5% is allowed.

Monax Glass.—On orders of not less than 3 gross of Beakers and Flasks of any sizes, to be delivered in one consignment, a discount of 10% is allowed. On orders of not less than half a gross of one item a discount of 5% is allowed. Can be supplied in **heavy weight** at above prices plus 33⅓% on sizes up to and including 1000 ml. and plus 50% above 1000 ml.

Pyrex Glass.—Where available in standard cases and delivered in one consignment the following discounts are allowed.

No. of standard cases	1	10	20	30	40
	10%	10% & 2½%	10% & 5%	10% & 7½%	10% & 10%

B 27-281. FLASKS, round bottom, British resistance glass.

Nominal capacity	175	250	500	1000 *ml.*
tx	13/8	14/7	20/-	32/9 *dozen*
tx	1/5	1/5	1/10	3/1 *each*



B 27-281—295.

FLASKS, round bottom, resistance glass.

Cat. No. →	B 27-285 Chance's Hysil		B 27-290 Monax		B 27-295 Pyrex		
Nominal capacity ml. ↓	*each*	*dozen*	*each*	*dozen*	*each*	*dozen*	Standard cases contain
↓	*tx*	*tx*	*tx*	*tx*	*tx*	*tx*	
50	1/5	13/3	1/3	12/10	1/4	13/-	144
75	—	—	1/5	14/1	—	—	—
100	1/5	14/6	1/5	14/1	1/4	13/4	84
125	—	—	—	—	1/5	14/9	84
130	1/5	14/6	—	—	—	—	—
150	1/5	14/11	—	—	1/7	15/9	96
175	1/7	15/8	1/6	15/8	—	—	—
200	1/7	16/6	—	—	1/8	16/10	84
250	1/8	17/4	1/8	17/4	1/9	18/11	84
300	1/10	18/7	—	—	2/-	21/5	72
350	1/10	19/-	1/10	19/-	—	—	—
400	2/1	21/6	—	—	2/4	24/6	72
500	2/3	23/2	2/3	23/2	2/7	28/-	48
600	2/4	25/2	—	—	2/11	31/6	48
700	—	—	—	—	3/4	34/7	36
750	2/9	30/2	2/9	30/2	—	—	—
800	2/11	31/10	—	—	—	—	—
1000	3/4	36/4	3/4	36/4	4/-	42/9	36
1500	4/2	45/5	4/2	45/5	4/7	49/-	24
2000	4/8	52/10	4/8	52/10	5/8	60/7	18
3000	6/3	68/6	6/3	68/6	6/5	70/-	12
4000	7/5	85/10	7/5	85/10	7/9	84/-	6
5000	11/-	118/10	11/-	118/10	9/9	105/-	6
6000	—	—	13/3	141/11	—	—	—
7500	—	—	15/8	171/8	—	—	—
10000	—	—	22/9	247/6	15/5	—	—
12000	—	—	—	—	16/10	—	—
20000	—	—	—	—	25/11	—	—
50000	—	—	—	—	79/10	—	—

Chance's Hysil Glass.—On orders of not less than 3 gross of Beakers and Flasks of any sizes, to be delivered in one consignment, a discount of 10% is allowed. On orders of not less than half a gross of one item a discount of 5% is allowed.

Monax Glass.—On orders of not less than 3 gross of Beakers and Flasks of any sizes, to be delivered in one consignment, a discount of 10% is allowed. On orders of not less than half a gross of one item a discount of 5% is allowed. Can be supplied in **heavy weight** at above prices plus 33⅓% on sizes up to and including 1000 ml. and plus 50% above 1000 ml.

Pyrex Glass.—Where available in standard cases and delivered in one consignment the following discounts are allowed.

No. of standard cases	1	10	20	30	40
	10%	10% & 2½%	10% & 5%	10% & 7½%	10% & 10%



B 27-305.



B 27-315.

FLASKS, Bolthead, round bottom.

Cat. No. →	B 27-305 Chance's Hysil (Welted neck, ground)		B 27-310 Monax (Welted neck, ground)		B 27-315 Pyrex (Ring neck, unground)		
Nominal capacity ml.	*each*	*dozen*	*each*	*dozen*	*each*	*dozen*	Standard cases contain
▼	*tx*	*tx*	*tx*	*tx*	*tx*	*tx*	
100	1/8	17/4	—	—	1/8	16/10	144
200	1/10	19/-	—	—	1/9	18/11	144
250	1/11	20/3	1/11	20/3	2/-	21/-	84
300	2/1	21/6	—	—	2/3	23/6	84
350	—	—	2/1	18/11	—	—	—
400	2/4	24/9	—	—	2/6	26/8	72
500	2/8	27/3	2/8	27/3	2/11	30/10	60
700	3/6	37/2	—	—	3/4	37/6	48
750	—	—	3/6	37/2	—	—	—
1000	4/2	43/9	4/2	43/9	4/4	46/3	36
1500	5/-	53/8	5/-	53/8	4/11	53/3	24
2000	6/3	66/10	6/3	66/10	6/-	64/5	18
3000	7/5	82/6	7/5	82/6	6/11	74/11	12
4000	—	—	—	—	8/7	92/5	12
5000	12/5	133/8	12/5	133/8	10/4	112/-	6
7500	—	—	17/4	188/2	—	—	—
10000	24/5	265/8	26/-	282/2	21/7	235/3	—
12000	—	—	29/4	321/9	23/2	252/-	—
15000	—	—	38/-	415/10	—	—	—
20000	43/7	475/3	—	—	38/6	420/-	—

Chance's Hysil Glass.—On orders of not less than 3 gross of Beakers and Flasks of any sizes, to be delivered in one consignment, a discount of 10% is allowed. On orders of not less than half a gross of one item a discount of 5% is allowed.

Monax Glass.—On orders of not less than 3 gross of Beakers and Flasks of any sizes, to be delivered in one consignment, a discount of 10% is allowed. On orders of not less than half a gross of one item a discount of 5% is allowed. Can be supplied in **heavy weight** at above prices plus 33⅓% on sizes up to and including 1000 ml. and plus 50% above 1000 ml.

Pyrex Glass.—Where available in standard cases and delivered in one consignment the following discounts are allowed.

No. of standard cases	1	10	20	30	40
	10%	10% & 2½%	10% & 5%	10% & 7½%	10% & 10%

B 27-326. FLASKS, conical, narrow neck, British resistance glass.

Nominal capacity	150	250	500	750	1000 *ml.*
tx	12/9	14/7	20/-	27/3	32/9 *dozen*
tx	1/3	1/5	1/10	2/7	3/1 *each*



B 27-326—340.

FLASKS, conical (Erlenmeyer), narrow neck, resistance glass.

Cat. No. →	B 27-330 Chance's Hysil		B 27-335 Monax		B 27-340 Pyrex		
Nominal capacity ml. ↓	*each*	*dozen*	*each*	*dozen*	*each*	*dozen*	Standard cases contain
	tx	*tx*	*tx*	*tx*	*tx*	*tx*	
25	—	—	—	—	1/2	12/3	144
50	1/5	13/8	1/3	12/10	1/2	12/3	144
75	—	—	—	—	1/4	13/-	144
100	1/5	14/6	1/5	14/1	1/4	13/4	144
125	—	—	1/5	14/11	1/4	13/4	96
150	1/5	14/11	1/5	14/11	1/4	13/4	96
175	1/7	15/8	1/7	15/8	—	—	—
200	1/7	16/6	1/7	16/6	1/7	15/9	84
250	1/8	17/4	1/8	17/4	1/8	16/10	72
300	1/10	18/2	—	—	1/9	18/11	72
350	1/10	19/-	1/10	19/-	1/11	19/8	72
400	—	—	2/1	21/6	—	—	—
500	2/3	23/2	2/3	23/2	2/2	22/5	72
600	2/4	25/2	2/4	25/2	2/3	23/6	60
750	2/9	30/2	2/9	30/2	2/6	25/11	48
800	2/11	31/10	—	—	—	—	—
1000	3/4	36/4	3/4	36/4	3/1	31/11	36
1500	4/2	45/5	4/2	45/5	3/8	39/3	24
2000	4/8	52/10	4/8	52/10	4/3	45/11	24
3000	6/3	68/6	6/3	68/6	5/6	58/10	12
4000	9/11	107/3	9/11	107/3	6/11	74/3	12
5000	—	—	11/-	118/10	9/6	102/3	12
6000	13/3	141/11	13/3	141/11	14/6	156/10	12

Chance's Hysil Glass.—On orders of not less than 3 gross of Beakers and Flasks of any sizes, to be delivered in one consignment, a discount of 10% is allowed. On orders of not less than half a gross of one item a discount of 5% is allowed.

Monax Glass.—On orders of not less than 3 gross of Beakers and Flasks of any sizes, to be delivered in one consignment, a discount of 10% is allowed. On orders of not less than half a gross of one item a discount of 5% is allowed. Can be supplied in **heavy weight** at above prices plus 33⅓% on sizes up to and including 1000 ml. and plus 50% above 1000 ml.

Pyrex Glass.—Where available in standard cases and delivered in one consignment the following discounts are allowed.

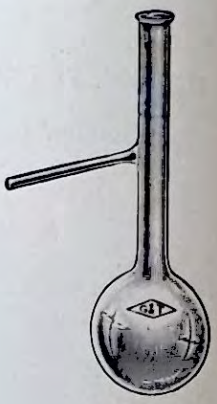
No. of standard cases	1	10	20	30	40
	10%	10% & 2½%	10% & 5%	10% & 7½%	10% & 10%



B 27-366—380.

B 27-366. FLASKS, CO_2 or Extraction, flat bottom, short wide neck, British resistance glass.

Nominal capacity	50	100	250 *ml.*
	tx 10/11	12/9	15/6 *dozen*
	tx 1/3	1/3	1/9 *each*



B 27-405—415.

FLASKS, CO_2 or Extraction, flat bottom, short wide neck, resistance glass.

Cat. No. →	B 27-370 Chance's Hysil		B 27-375 Monax		B 27-380 Pyrex		
Nominal capacity ml. ↓	*each*	*dozen*	*each*	*dozen*	*each*	*dozen*	Standard cases contain
	tx	*tx*	*tx*	*tx*	*tx*	*tx*	
50	1/5	14/1	1/3	12/10	1/2	12/3	144
100	1/7	15/4	1/3	14/1	1/4	13/4	96
150	1/5	15/8	1/5	15/8	1/5	14/9	84
200	1/8	17/4	1/8	17/4	—	—	—
250	—	—	1/10	18/2	1/7	15/9	72
450	2/3	23/2	—	—	—	—	—
500	—	—	2/3	23/7	2/2	22/5	60
750	—	—	3/6	33/10	—	—	—
1000	3/9	40/1	—	—	3/11	41/-	36

FLASKS, Distillation, resistance glass.

Cat. No. →	B 27-405 Chance's Hysil		B 27-410 Monax		B 27-415 Pyrex		
Nominal capacity ml. ↓	*each*	*dozen*	*each*	*dozen*	*each*	*dozen*	Standard cases contain
	tx	*tx*	*tx*	*tx*	*tx*	*tx*	
50	2/6	23/11	2/3	23/11	2/6	25/11	60
100	2/9	28/1	2/8	28/1	2/6	26/8	36
125	—	—	—	—	2/10	29/5	36
150	2/11	31/5	—	—	2/11	31/6	36
175	3/1	32/7	3/1	32/7	—	—	—
200	—	—	—	—	3/2	33/8	24
250	3/1	33/-	3/1	33/-	3/6	37/10	24
350	3/11	41/3	3/11	41/3	—	—	—
400	4/-	42/11	—	—	4/7	49/-	24
500	4/4	46/3	4/4	46/3	5/1	53/7	18
600	4/10	52/5	—	—	5/10	63/-	18
750	6/1	65/2	6/1	65/2	—	—	—
1000	6/8	71/10	6/8	71/10	8/-	85/5	12
1500	8/3	89/2	8/3	89/2	9/-	98/-	9
2000	11/7	124/1	11/7	124/1	11/3	121/2	6
3000	14/1	152/8	14/1	152/8	12/10	140/-	6
4000	19/-	207/11	19/-	207/11	15/5	168/-	4
5000	21/2	231/-	21/2	231/-	19/3	210/-	4

See notes, p. 457, re discounts.



B 27-425—430.



B 27-435.



B 27-450.



B 27-620– 625.

FLASKS, Kjeldahl, round bottom, long neck, resistance glass.

Cat. No. →	B 27-425 Chance's Hysil		B 27-430 Monax		B 27-435 Pyrex		
Nominal capacity ml.	*each*	*dozen*	*each*	*dozen*	*each*	*dozen*	Standard cases contain
↓	*tx*	*tx*	*tx*	*tx*	*tx*	*tx*	
50	—	—	—	—	1/7	15/5	144
100	1/11	20/3	1/10	18/7	1/7	15/9	84
150	1/11	20/8	—	—	—	—	—
200	2/1	22/4	2/1	22/4	1/11	19/3	84
250	—	—	—	—	1/11	20/4	60
500	2/11	31/5	2/11	31/5	2/7	28/-	36
800	3/11	41/8	3/11	41/8	3/4	34/7	36
1000	4/2	47/1	—	—	4/3	44/10	24

See notes, p. 457, re discounts.

£ s. d.

B 27-450. STOPPERS, Hollow Glass, for necks of Kjeldahl Flasks during digestions, 1 to 1½ in. diam., assorted .. .. *each* 8d.; *dozen* 0 7 0

B 27-620. FLASKS, Filter, stout glass, with flanged neck and side tube, for connection to filter pump.

Capacity ..	100	250	500	750	1000	1500	2500	5000	*ml.*
tx	3/1	3/4	4/4	5/6	6/1	7/10	12/-	22/4	*each*

B 27-625. FLASKS, Filter, Pyrex resistance glass, with side tube for connection to filter pump. Heavy walled and of great mechanical strength.

Capacity ..	100	250	500	1000	2000	4000	5000	10000	*ml.*
tx	2/10	3/2	4/3	6/-	8/5	14/-	21/-	33/8	*each*



B 27-665.



B 27-724.



B 27-755—765.



B 27-785—795.

B 27-665. FLASKS, Oxygen Generation, thick combustion glass, round bottom.

Capacity	100	175	250	500	*ml.*
	r 19/6	£1 2 0	£1 4 0	£1 9 0	*dozen*
	r 1/11	2/-	2/3	2/9	*each*

B 27-724. FLASKS, Wash-Bottle, flat bottom, fitted with rubber stopper and bent tubes.

Capacity	250	500	750	1000	*ml.*
	2/9	3/6	4/-	4/6	*each*

FLASKS, Graduated, Unstoppered. *(Please state Catalogue No. when ordering.)*

Cat. No. →	B 27-755 Grade B		B 27-763 Grade A without Certificate		B 27-765 Grade A with Certificate	B 27-771 Class A with N.P.L. Certificate
To contain	*each*	*dozen*	*each*	*dozen*	*each*	*each*
						t
25 ml.	3/3	36/-	6/-	65/-	7/-	17/8
50 ,,	3/6	38/-	8/6	90/-	9/6	17/8
100 ,,	4/3	44/-	8/6	90/-	9/6	18/8
200 ,,	4/6	48/-	9/-	95/-	10/-	20/8
250 ,,	4/6	49/-	10/-	110/-	11/-	22/8
500 ,,	6/-	66/-	12/-	130/-	13/-	29/8
1000 ,,	8/6	90/-	15/-	165/-	16/-	34/8
2000 ,,	12/6	135/-	18/-	195/-	19/-	46/8

FLASKS, Graduated, Stoppered. *(Please state Catalogue No. when ordering.)*

Cat. No. →	B 27-785 Grade B		B 27-793 Grade A without Certificate		B 27-795 Grade A with Certificate	B 27-801 Class A with N.P.L. Certificate
To contain	*each*	*dozen*	*each*	*dozen*	*each*	*each*
25 ml.	5/-	52/6	8/-	87/6	9/-	20/8
50 ,,	5/-	55/-	9/-	95	10/-	20/8
100 ,,	5/6	60/-	11/-	120/-	12/-	22/8
200 ,,	6/6	70/-	12/-	130/-	13/-	24/8
250 ,,	6/6	70/-	13/-	140/-	14/-	26/8
500 ,,	8/-	85/-	16/-	175/-	17/-	34/8
1000 ,,	11/6	125/-	19/-	210/-	20/-	39/8
2000 ,,	12/-	130/-	22/-	240/-	23/-	51/8


B 28-125.


B 28-130.


B 28-132.


B 28-195.


B 28-255.

B 28-125. FUNNELS, Glass, plain, with sides inclined at an angle of 60° ; stem ground off obliquely.

Diam. ..	2·5	4	5	6·5	7·5	9	10	11·5	*cm.*
	9/6	9/6	9/6	9/6	9/6	10/6	11/6	13/-	*dozen*
	11d.	11d.	11d.	11d.	11d.	1/-	1/1	1/3	*each*

Diam.	12·5	14	15	18	20	23	25	*cm.*
	16/-	20/-	25/-	33/-	44/-	62/6	80/-	*dozen*
	1/6	1/10	2/4	3/1	4/1	5/9	7/4	*each*

B 28-130. Ditto, ribbed. Sizes and prices as **B 28-125.**

B 28-132. FUNNELS, "Phœnix Sixty." Precision pressed in heat-resisting glass with dead-smooth surfaces and accurate 60° angle. Filter papers fit tightly and form a complete air seal. The long narrow bore stem enables a water column to be started by capillarity, with suction head equal to 4 in. water, giving quicker filtration. External ribs prevent air locks when the funnel is used directly in the neck of a flask or bottle.

Diam. inside rim	2	3	*in.*
To take papers, diam.	7–9	11–12·5	*cm.*
	tx 21/8	26/5	*dozen*
	tx 2/-	2/5	*each*

B 28-140. FUNNELS, Pyrex resistance glass, plain, for use with hot liquids.

Diam. ..	5	6·5	7·5	9	10	15	20	*cm.*
	tx 1/5	1/7	1/8	1/11	2/2	7/-	9/10	*each*

£ s. d.

B 28-195. G. & T. FUNNEL STIRRUP (*Patent Application No.* 9764/46), glass rod bent to shape illustrated, legs about 40 mm. long. Packed in stout cardboard box containing ½ doz. stirrups .. .. *box ½ doz. r* 3/- ; *doz. boxes* **1 13 0**

The G. & T. Funnel Stirrup is designed for use in supporting filter funnels up to about 11 cm. diameter, using the beaker itself as the stand.

The funnel is in contact with the beaker and the stirrup at the four points A, B, C and D. The length of the loop is so designed that the funnel top leans slightly towards the centre of the beaker, thus ensuring stability. The legs of the stirrup act as counter-balance weights to maintain the plane of the stirrup in a nearly horizontal position when it is placed on the beaker rim. The stirrup is therefore always in the "open" position, ready to receive the funnel stem, without adjustment by the other hand.

The contact at A results in accelerated filtration and avoids loss by splashing. Being made of glass rod, the stirrup is unattacked by reagents normally in use. In educational laboratories its use solves one of the long-standing problems in locker accommodation.

B 28-255. FUNNELS, Büchner, Royal Worcester porcelain, with fixed perforated porcelain disc and vertical sides.

Size No. ..	1	2	3	4	5	6	7	8	9	*cm.*
Diam. approx.	5·4	6·9	8·7	11·1	13·6	15·8	19	22·4	28·7	*cm.*
To take papers	4·25	5·5	7	9	11	12·5	15	18·5	24	*cm.*
	tx 6/6	8/-	10/-	15/-	21/-	30/-	55/-	67/-	120/-	*each*



B 28-270—276.



B 28-300—306.



B 28-330—336.



B 28-355.



B 28-360.

FUNNELS, Büchner, Pyrex, with sintered glass filter discs.

		S.F.3A	S.F.3B	S.F.3C
	Pyrex ref. No.			
	Disc diam., approx. ..	65	90	120 *mm.*
	Top diam., approx. ..	75	105	135 *mm.*
	Height (excluding stem) ..	90	135	155 *mm.*
B 28-270.	Grade 1	*tx* 14/9	27/-	42/6 *each*
B 28-272.	Grade 2	*tx* 14/9	27/-	42/6 *each*
B 28-274.	Grade 3	*tx* 14/9	27/-	42/6 *each*
B 28-276.	Grade 4	*tx* 14/9	27/-	42/6 *each*

FUNNELS, Mercury, Pyrex, with sintered glass filter discs.

		S.F.1A	S.F.1B	S.F.1C
	Pyrex ref. No.			
	Disc diam., approx. ..	30	40	40 *mm.*
	Top diam., approx. ..	38	48	53 *mm.*
	Height (excluding stem) ..	65	75	127 *mm.*
B 28-300.	Grade 1	*tx* 7/9	8/5	8/5 *each*
B 28-302.	Grade 2	*tx* 7/9	8/5	8/5 *each*
B 28-304.	Grade 3	*tx* 7/9	8/5	8/5 *each*
B 28-306.	Grade 4	*tx* 7/9	8/5	8/5 *each*

FUNNELS, Filtering, Pyrex, with sintered glass filter discs.

		S.F.4A	S.F.4B	S.F.4C
	Pyrex ref. No.			
	Disc. diam., approx. ..	20	30	30 *mm.*
	Top diam., approx. ..	45	80	100 *mm.*
	Height (excluding stem) ..	35	65	85 *mm.*
B 28-330.	Grade 1	*tx* 9/2	11/3	14/9 *each*
B 28-332.	Grade 2	*tx* 9/2	11/3	14/9 *each*
B 28-334.	Grade 3	*tx* 9/2	11/3	14/9 *each*
B 28-336.	Grade 4	*tx* 9/2	11/3	14/9 *each*

(For details of porosity grades see p. 445.)



B 28-370.

FUNNELS, Separating and Dropping. *Please state Catalogue Number when ordering.* (s.s. = short stem for use as separating funnels ; l.s. = long stem for use as dropping funnels.)

Cat. No.→	B 28-355	B 28-360	B 28-365	B 28-370	B 28-380
		Cylindrical		Conical	Spherical
Capacity (Nominal)	Open	Stoppered	Stoppered Graduated	Stoppered	Stoppered
	each	*each*	*each*	*each*	*each*
25 ml.	5/- l.s.	—	—	—	—
50 ,,	6/6 l.s.	7/6 l.s.	11/- l.s.	7/6 s.s.	7/6 s.s.
100 ,,	8/6 l.s.	8/6 l.s.	13/6 l.s.	8/6 s.s.	8/6 s.s.
250 ,,	11/- l.s.	11/- l.s.	17/6 l.s.	11/- s.s.	11/- s.s.
500 ,,	—	15/6 l.s.	23/- l.s.	15/6 s.s.	15/6 s.s.
1000 ,,	—	22/- s.s.	32/- s.s.	23/- s.s.	22/- s.s.
2000 ,,	—	41/- s.s.	—	—	—



B 28-380.

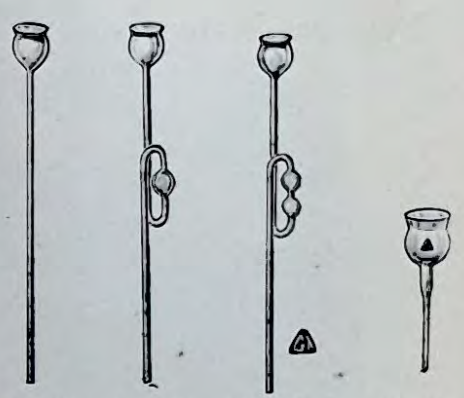
B 28-420. FUNNELS, Thistle.

Length ..	20	30 *cm.*
	5/-	6/6 *dozen*
	6d.	8d. *each*

B 28-425. FUNNELS, Thistle, with one safety bulb, 30 cm. long .. .. *each* 1/4 ; *dozen* £ 0 14 0

B 28-427. Ditto, with two safety bulbs *each* 1/10 ; *dozen* 1 0 0

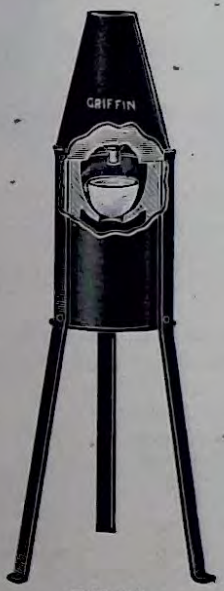
B 28-430. FUNNELS, Thistle, drawn off to a point, for filling burettes, pipettes, barometers, etc. *each* 5d. ; *dozen* 0 4 6



B 28-420. B 28-425 B 28-427. B 28-430.



B 28-505.



B 28-510.



B 28-520 + 522.

B 28-505. FURNACE, Crucible, of stout iron, insulated inside with asbestos. With Bunsen burner $\frac{7}{16}$ in., and star support .. .. *p* £ 0 10 2

B 28-510. FURNACE, Crucible, Griffin, consisting of a refractory moulding well lagged with asbestos, bound with a sheet iron jacket and mounted on a tripod stand 1 11 0

B 28-512. Ditto, with No. 2 Meker Pattern Burner 2 2 0

A refractory dome which rests on the body of the furnace enables high temperatures to be reached quickly. Using a Meker Burner No. 2, a porcelain crucible can be raised to a temperature of 900° C.

The furnace is suitable for porcelain crucibles Nos. 00, 0A, 0, 1, and fireclay crucibles, Battersea Type **B 23-095,** Size A. Without chimney and refractory dome the body of the furnace can be used as a tripod stand and flame screen.

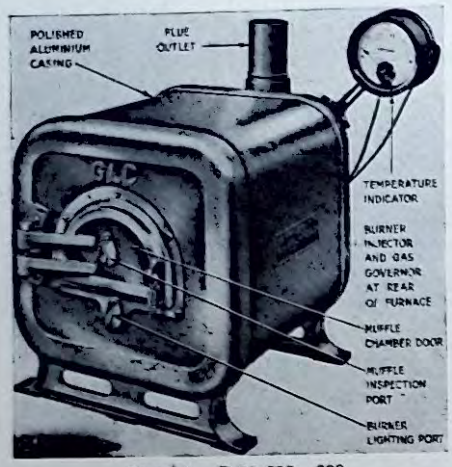
B 28-520. FURNACE, Crucible, gas-heated, G.L.C. Laboratory, for temperatures up to 1100° C. Designed to provide a simple but efficient furnace for such routine operations as the ignition of precipitates, determination of ash contents, and the melting of small metal samples. It is built to work with a $\frac{1}{2}$ in. Bunsen burner with which a temperature of 1100° C. can be reached in the crucible. The casing is lined with Morgan's △ FF material and three solid projections are provided to support the crucible. The lid is also of Morgan's △ FF material and is provided with three ribs on the underside to allow free passage for escaping gases. Suitable for crucibles 30 to 45 mm. diam., maximum height 55 mm., overall height about 13 in. **Without** burner .. .. *l* 1 18 6

B 28-522. Burner, Bunsen, for use with above, special type consuming 15 cu. ft. of gas per hour *l* 0 10 6

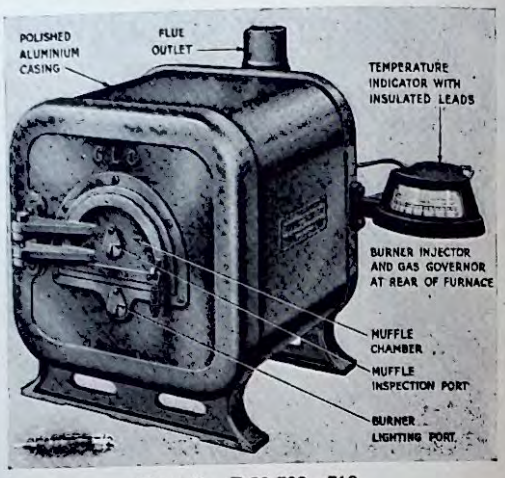
G.L.C. MUFFLE FURNACES

New gas-heated types of modern design, high temperature attainment and economical gas consumption

Patent No. 403112, *Registered Design No.* 765165



Type A. B 28-680—690.



Type B. B 28-702—712.

The design of these furnaces is the outcome of 12 months' intensive research by the Industrial Heating Section of the Gas Light and Coke Co., Watson House. Great attention has been given to the correct design of burners, gas and air venturi tubes, lagging and flue outlets. Each furnace is mounted in cast end plates encased with polished aluminium to reduce radiation losses to a minimum. The furnaces are therefore highly efficient designs recommended especially for laboratory use, and, in their larger sizes, for works use. They may be employed for all ashing and ignition work, and, in addition, for assaying, tempering, hardening, heat treatment, enamel and glazing work, etc. The muffle temperatures are exceptionally uniform with a maximum variation of $\pm 5°$, ensuring extreme accuracy in all heating operations.

Made in two types as listed below—

FURNACES, Muffle, Gas Heated, Type A, G.L.C. design, for continuous use up to 1000° C., and for occasional use up to 1100° C. Fitted with fireclay muffles, and edgewise pyrometer indicator.

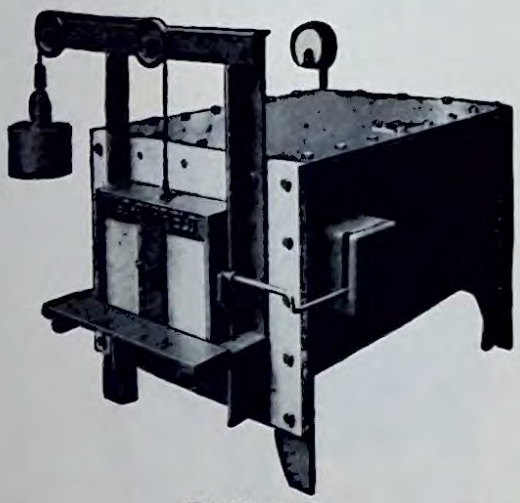
Cat. No.	Internal Dimensions of Muffle (Inches)			Overall External Dimensions of Furnace (Inches)			Furnace Weights, excluding Pyrometer equipment	Performance Data with 500 B.T.U. Gas		Furnace only, including Gas Governor	Pyrometer Equipment comprising Indicator Thermo-Couple and Leads
	Depth front to back	Width	Height to crown	Depth front to back	Width	Height	lb.	Time to reach 1000° C. Mins.	Gas Rate maintaining at 1000° C. cu. ft./hour	£ s. d.	£ s. d.
B 28-680.	4	2½	2½	13½	10	11½	40	30	12	11 4 0	9 9 9
B 28-682.	6	4	3	18½	14	15	95	40	24	14 14 0	9 12 6
B 28-684.	8	5	3½	22½	16	17	145	45	40	22 8 0	9 16 0
B 28-686.	10	7	4	27½	20	20½	255	60	60	29 8 0	10 3 0
B 28-688.	12	9	5½	30½	24	25	420	75	100	42 0 0	10 10 0
B 28-690.	14½	11½	5½	34½	27½	27½	600	80	128	52 10 0	10 10 0

FURNACES, Muffle, Gas Heated, Type B, G.L.C. design, for continuous use up to 1250° C., fitted with silicon-carbide muffles.

Cat. No.	Internal Dimensions of Muffle (Inches)			Overall External Dimensions of Furnace (Inches)			Furnace Weights excluding Pyrometer equipment	Performance Data with 500 B.T.U. Gas				Furnace Only, including Gas Governor	Pyrometer Equipment comprising Indicator, Thermo-Couple, and Leads
	Depth front to back	Width	Height to crown	Depth front to back	Width	Height	lb.	Time to reach 1100° C. Mins.	Gas Rate maintaining at 1100° C. cu. ft. /hour	Time to Reach 1250° C. Mins.	Gas Rate maintaining at 1250° C. cu. ft. /hour	£ s. d.	£ s. d.
B 28-702.	4	2½	2½	16	12½	14½	75	30	21	70	27	20 6 0	12 12 0
B 28-704.	6	4	3	21½	16½	18	165	35	42	80	55	24 10 0	13 6 0
B 28-706.	8	5	3½	25½	19½	21	260	40	70	90	90	37 0 0	13 13 0
B 28-708.	10	7	4	30½	24½	25½	445	45	105	100	135	48 6 0	14 0 0
B 28-710.	12	9	5½	35	27½	29½	690	50	155	110	195	62 6 0	14 14 0
B 28-712.	14½	11½	5½	39	30½	31	910	55	210	120	270	82 6 8	14 14 0



B 28-970 size A.
Furnace, with circular pattern pyrometer B 28-992.



B 28-970 size E.
Furnace, with counter-balanced door, pyrometer B 28-992 and excess temperature cut-out B 28-980.

FURNACES, Electric, Muffle, for temperatures up to 1000° C., of robust construction suitable for all laboratory work. The proportions of width, height and length, have been designed to give ample space for heating in the uniform temperature zone and to ensure a satisfactory winding giving a long element life.

Maximum Furnace Temperature. 1000° C.—If fitted with the excess temperature cut-out, the current supplied to the furnace is broken when a temperature of 940–960° C. is attained. (Size F is not recommended for continuous operation above 900° C.)

Heating Unit.—Moulded refractory chamber wound with nickel-chromium wire. The leads are brought to terminals in a porcelain block fitted with cover. The chamber is supplied, with an entry at the back for thermocouple.

Frame and Casing.—Stout sheet metal case with angle iron bracing and legs. Sizes A and C are supplied with a flap type door forming a foreplate when open. Sizes D, E and F have counterbalanced doors, filled with insulating brick and carried in angle iron door guides.

Lagging.—A highly efficient insulating material in powder form which ensures low radiation loss.

Temperature Controllers.—Resistance type **(B 28-972—974)** with an operating range of 650–1000° C. Energy Regulator type **(B 28-975)** operating range 300–1000° C. The former consists of resistance spirals carried on a framework with radial contact arm, the whole thoroughly protected. The Energy Regulator provides a "wattless" form of current adjustment for furnace temperature control. It operates on A.C. or D.C., is more economical in use than resistances and maintains temperature within a narrow range. It comprises a wall mounting control panel, with isolator, main and control circuit fuses, contactor, regulator and pilot lamps: the standard panel is supplied for operation on 200-250 volts, single phase, 50 cycle A.C. supply.

Excess Temperature Cut-out.—This patented safety device protects the windings from damage due to accidental overheating, and can be fitted to any of the muffle furnaces listed below. It consists of a fuse of silver wire exposed to the chamber temperature. When the temperature rises to a danger point, the wire fuses, automatically cutting off the current and causing a pilot lamp to glow.

Size		A	C	D	E	F	
Inside l. × w. × h.		8 × 3 × 3	9 × 4 × 4	15 × 6 × 3½	19 × 7½ × 5	18 × 9 × 9	*in.*
Rating		850	1100	2100	3600	5000	*watts*
B 28-970. Furnace ..	*t*	£16 2 0	£20 8 3	£24 8 9	£32 15 6	£41 2 3	*each*
B 28-972. Resistance Controller for 100–150 volts ..	*t*	£4 15 0	£4 15 0	£6 18 0	£10 12 0	£10 12 0	*each*
B 28-974. Ditto for 200–250 volts	*t*	£4 15 0	£4 15 0	£6 18 0	£6 18 0	£6 18 0	*each*
B 28-975. Energy Regulator	*t*	£19 6 6	£19 6 6	£19 6 6	£19 6 6	£19 6 6	*each*
B 28-976. Renewal Wound Muffle	*t*	£2 7 3	£3 13 9	£5 12 3	£9 1 9	£12 18 9	*each*

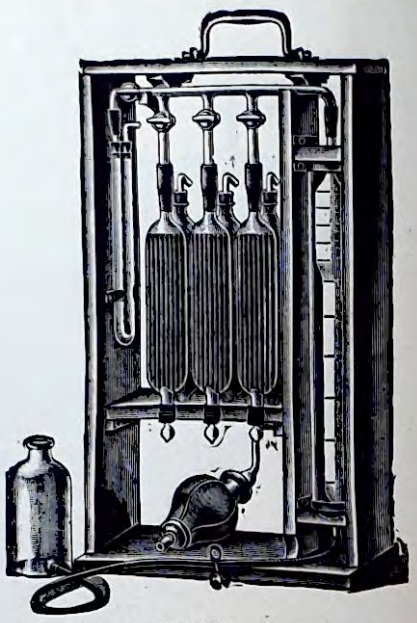
When ordering please state voltage.

Extras for Furnaces B 28-970

			£ s. d.
B 28-980.	Excess Temperature Cut-out, for sizes A, C, D or E	*t*	3 12 6
B 28-982.	Ditto, for size F	*t*	5 9 3
B 28-984.	Flue and Damper, for sizes A, C or D	*t*	0 11 6
B 28-986.	Ditto, for sizes E or F	*t*	0 11 6
B 28-992.	Pyrometer and thermocouple, circular pattern, with 3½ in. scale on bracket attached to furnace, chromel-alumel thermocouple in sheath	*t*	9 9 9
28-993.	Leads, in 4 ft. flexible metallic tubing for connecting Energy Regulator **B 28-975** to furnace	*t*	1 0 9



B 29-160.



B 29-895.

FURNACES, Electric, Single and Double Tube, for temperatures up to 1150° C. A high temperature tube furnace for all general laboratory work, specially suitable **for carbon estimations.** The furnaces are manufactured in single and double tube types and the two lengths available will be found to cover most requirements in the laboratory.

Furnace Temperature.—Normal working temperature 1100° C., maximum permissible temperature for short periods 1150° C.

Heating Unit.—A replaceable cylindrical section type heater wound with high temperature steel alloy, spiralled and embedded in refractory. The heater is designed to produce uniform temperature round the tube.

Frame and Casing.—Rectangular mild steel case with angle steel frame also forming legs, finished in glossy grey paint. Arranged for bench mounting.

Thermal Insulation.—Low density heat insulating brick capable of withstanding the maximum furnace temperature.

Temperature Controller.—Sun-Vic Energy Regulator and suitable relay in sheet steel box arranged for wall or bench mounting and fitted with bushed holes for conduit or plain cable.

Combustion Tubes.—A Morgan Triangle-H tube, 1 in. bore, is supplied with each furnace.

B 29-160. Furnaces, single tube, 1 in. bore.

Total length of tube	20	26	*in.*
Heated length of tube	10	15	*in.*
Consumption	1000	1500	*watts*
	t £7 15 0	£10 0 0	*each*
B 29-162. Temperature Controller	*t* £10 5 0	£10 5 0	*each*
B 29-164. Renewal Wound Heaters	*t* £2 5 0	£2 15 0	*each*

Please state voltage when ordering.

B 29-170. Furnaces, double tube, 1 in. bore. With hole for insertion of 8 mm. diam. pyrometer sheath between tubes and inside heater.

Total length of tube	20	26	*in.*
Heated length of tube	10	15	*in.*
Consumption	1200	1800	*watts*
	t £12 10 0	£15 10 0	*each*
B 29-172. Temperature Controller	*t* £10 5 0	£10 5 0	*each*
B 29-174. Renewal Wound Heaters	*t* £2 15 0	£3 10 0	*each*

Please state voltage when ordering.

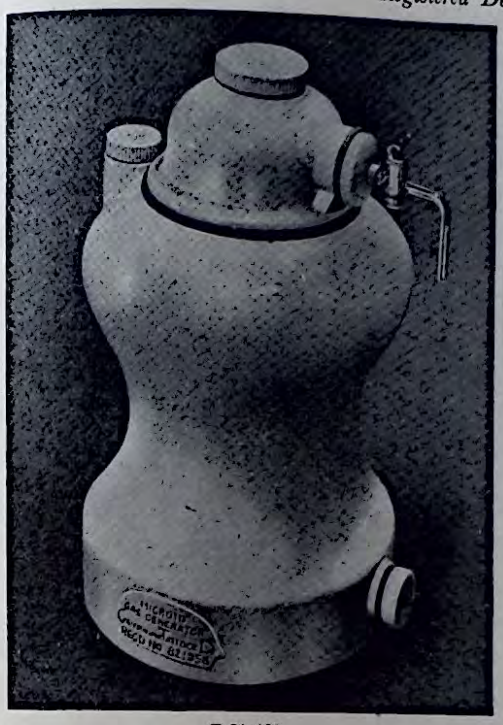
£ s. d.

B 29-895. GAS ANALYSIS APPARATUS, Orsat, with three absorption vessels for the determination of carbon dioxide, oxygen and carbon monoxide. In oak case measuring 22 × 12 × 5¾ in. with sliding doors back and front. Weight 13 lb. With instructions for use 10 10 0

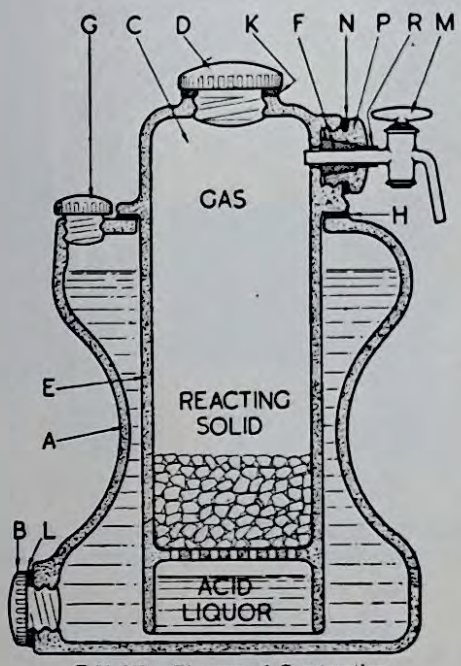
Replacement parts for **B 29-895** *can be supplied, prices on application.*

THE MICROID GAS GENERATOR

Registered Design No. 821958



B 31-460.



B 31-460.—Diagram of Construction.

The conventional type of Kipp's apparatus possesses acknowledged advantages but many disadvantages, *e.g.* fragility, number of small parts, liability to seizure of stoppers and ground glass joints, difficulty of cleaning, and relatively small capacity necessitating frequent re-charging. In this new Microid Gas Generator all these sources of criticism have been eliminated. It is clean and pleasing in external appearance, with only two parts and a high gas capacity per charge. It is readily cleaned. The mouth of the reagent chamber is made with a wide aperture, closed when in use by a screw stopper, so that large lumps of ferrous sulphide or marble can be introduced without difficulty. The generator delivers gas up to a pressure equal to a head of about 18 cm. of water in sufficient volume to enable it to be connected to a distribution manifold supplying gas to half a dozen points. With these distinctive features, which are not incorporated in any other form of laboratory gas generator, the Kipp's apparatus is rendered obsolete.

SPECIFICATION

The Microid Gas Generator is made in best chemically resistant glazed stoneware in two separable parts. The large waisted acid container A is about 12 in. high and 10 in. diameter, and has a filling aperture, closed with a loosely fitting screw stopper G. A drain, fitted with a screw stopper B and rubber washer, is provided. The reagent chamber C fits into the acid chamber, bedding down on a rubber washer H, and the solid reagent is supported out of contact with acid by a non-removable perforated plate E. Fitted into the rubber bung F is a glass tap which controls the rate of gas generation.

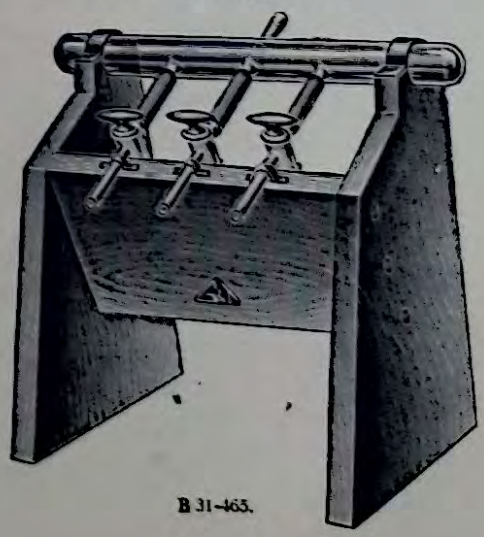
B 31-460. MICROID GAS GENERATOR, as described above, in non-returnable carton. With instructions for use .. .. *Price on application.* £ s. d.

COMPONENT PARTS OF B 31-460

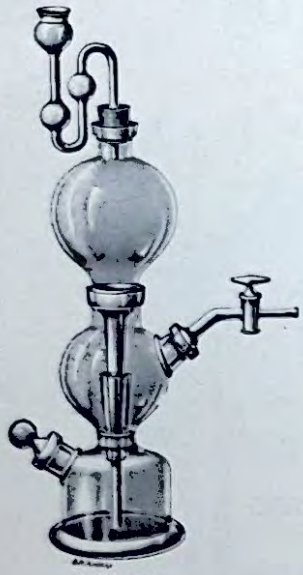
		£ s. d.
B 31-460 a.	Outer Vessel A (complete with stoppers and with washer L)	*On app.*
,, ,, b.	Stopper B (or G same size)	r 0 1 3
,, ,, d.	Stopper D	r 0 2 0
,, ,, e.	Inner Vessel E (complete with stoppers D and P and their washers) ..	*On app.*
,, ,, f.	Rubber stopper F	r 0 0 6
,, ,, h.	Washer H	r 0 3 0
,, ,, k.	Washer K	r 0 1 0
,, ,, l.	Washer L	r 0 0 8
,, ,, m.	Stopcock M (no rubber stopper)	r 0 5 0
,, ,, p.	Stopper P	r 0 2 3

B 31-465. Distribution Manifolds for use in delivering gas at a number of points. Oak stand supporting glass distribution tube, about 1 in. diam., provided with glass side tubes fitted, by means of pressure tubing, with glass stopcocks.

No. of Points ..	3	6
	r £2 2 6	£2 15 0 *each*



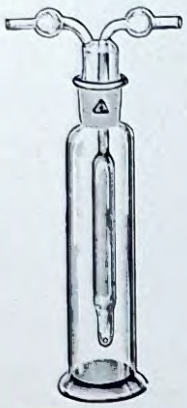
B 31-465.



B 31-495.



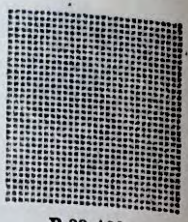
B 31-756—757.



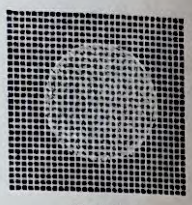
B 31-762—763.



B 31-770.



B 32-400.



B 32-405.

	£	s.	d.
B 31-495. GAS GENERATOR, Kipp, capacity of centre globe, 1 litre, complete with ground-in stopper to lower vessel, ground-in stopcock, thistle-funnel and rubber stopper, loose fitting glass gallery .. .. *tx*	3	3	0

GAS WASHING BOTTLES, Drechsel (*B.L.W.A. Standard T.C.D. No.* 123), with B.S. interchangeable joints B 24.

Capacity	125	250	500 *ml.*
B 31-756. Bottle, complete	6/-	8/6	11/- *each*
B 31-757. Head and tubes only	3/-	3/-	3/- *each*

GAS WASHING BOTTLE, Muencke, with B.S. interchangeable joint B 24. Capacity approx. 250 ml.

B 31-762. Bottle, complete	0	10	6
B 31-763. Head and tubes only, for above	0	4	9
B 31-770. GAS WASHING BOTTLE (*B.L.W.A. Standard T.C.D. No.* 125), cylindrical, 12·5 × 2·5 cm.	0	3	0

B 32-400. GAUZES, Iron wire, 30 mesh, in squares, extra stout, for use on tripods.

Dimensions	4	5	6 *in. square*
	2/6	4/-	5/- *dozen*

B 32-405. GAUZES, Iron wire, flat, with asbestos-filled centre, for use on tripods.

Dimensions	4	5	6 *in. square*
	6/6	7/6	9/- *dozen*
	7d.	9d.	10d. *each*

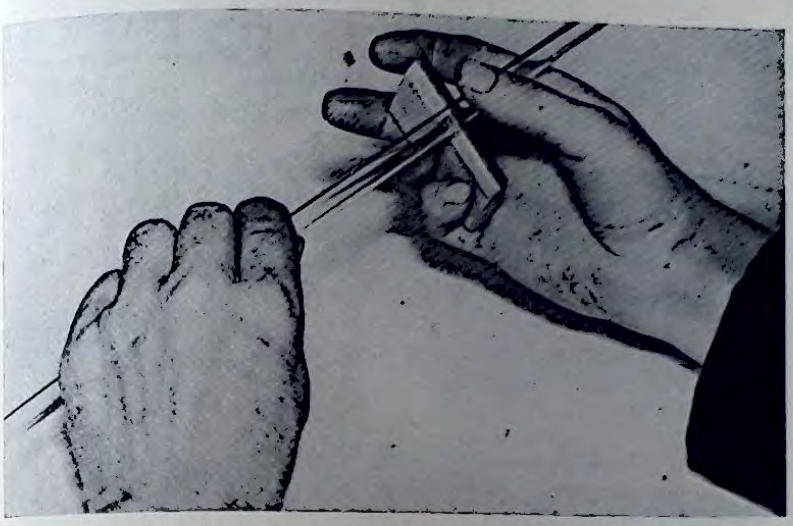
B 32-420. GAUZES, Nickel wire, 6 in. square, about 30 mesh, for use on tripods .. *each* 0 2 6

GAUZE, Wire ..	20	30	60	90	120	160	200	240 *mesh*
B 32-424. Brass	3/-	3/-	5/-	9/-	15/-	23/-	27/-	— *sq. ft.*
B 32-426. Copper	3/-	3/6	6/-	9/6	—	—	—	— *sq. ft.*
B 32-428. Iron	2/6	2/9	5/6	9/-	—	—	—	— *sq. ft.*

	£	s.	d.
B 32-694. GLASS CUTTING KNIFE, specially hard steel. Edge maintained by carborundum stone **B 32-698,** but knife can be re-ground on an emery wheel and will last, in ordinary use, for many years .. .. *each* 4/-; *dozen*	2	5	0



B 32-694.



B 32-697.—How the professional glassblower uses the G. & T. Super-hard Glass-cutting Knife.



B 32-800.



B 32-825.

B 32-697. **GLASS-CUTTING KNIFE, G. & T. Super-hard,** non-ferrous alloy, suitable for the heaviest service, will deal efficiently with soda glass, Pyrex glass and combustion glass, without any turning of the edge, and with an ease and lightness of stroke that ensures a clean, even break. Retains its edge for very long periods, and can be ground and carborundum-honed when required. Will outlast dozens of files. Blade approx. $2\frac{1}{2} \times \frac{1}{2} \times \frac{1}{16}$ in. thick, reversibly mounted in wood holder with brass clamping screw — £ s. d. r 0 12 6

B 32-698. **Sharpening Stone, Carborundum,** to maintain cutting edges on glass cutting knives. Used until angle of cutting edge becomes so oblique that re-grinding on an emery wheel is necessary. Dimensions about $6 \times 2 \times \frac{5}{8}$ in. .. .. p 0 5 6

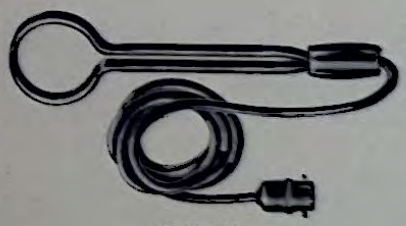
B 32-800. **GLASS-BLOWERS' TOOLS,** consisting of iron rod in handle, iron cone in handle, pair of flat tongs, iron plate with pointed ends .. .. *set* 0 10 0

B 32-825. **GLASSES, Cobalt,** for blowpipe work and flame tests, *e.g.* examination for potassium in the presence of sodium.

Size	3 × 2	4 × 3 *in.*
	5/6	9/6 *dozen*
	7d.	11d. *each*

B 33-080. **HEATERS, Immersion,** for heating small quantities of liquids. Can be used for many purposes. For use on mains voltage. With rubber sheathed flex and plug.

Loading ..	300	500 *watts*
Length × diam.	7 × 2	$7\frac{1}{2} \times 3$ *in.*
	p 10/-	15/- *each*



B 33-080.

B 33-085. **HEATER, Immersion,** loading 500 watts, length $7\frac{1}{2}$ in. The heating element is a hollow cylinder, $1\frac{1}{4}$ in. outside diam., $1\frac{1}{2}$ in. inside diam., $1\frac{1}{2}$ in. high. Can be used in a beaker of liquid. With 4 ft. flex .. — £ s. d. p 1 1 9

B 33-086. **Ditto,** loading 700 watts .. .. p 1 5 0

Please state voltage when ordering.



B 33-085—086.



B 33-200.



B 33-205.



B 33-210.

	£	s.	d.
B 33-200. HOLDER, Test-Tube, wood, with spring, takes tubes up to ¾ in. diam. *each* **8d.** ; *dozen*	0	7	0
B 33-205. Ditto, sheet brass, with handle, takes tubes up to 1¼ in. diam. *each* **1/5** ; *dozen*	0	15	0
B 33-210. HOLDER, Test-Tube, spring steel, tinned. Will take tubes up to 1 in. diam. *each* **8d.** ; *dozen*	0	7	0



B 33-290. 3-heat.



B 33-328.



B 34-720.



B 34-725.

B 33-290. HOT PLATES, electric. Convenient pattern for laboratory use for attachment to a retort stand. The plates are constructed with a heavy cast-iron circular top provided with drip edge, which protects the enclosed elements from damage by spilt liquids. A heavy bosshead is incorporated with the casting.

The elements are of the heavy-duty type. A length of asbestos-insulated and cotton-braided 3-core cable is supplied for connection to a suitable plug point. The third wire is provided for earthing.

Diam.	4	6	*in.*
Type	Single heat	3-heat	
Approx. weight	2½	5¼	*lb.*
,, max. surface temp.	200° C.	360° C.	
Loading	250	750	*watts*
	r **£1 15 0**	**£3 17 6**	*each*

Please state voltage when ordering.

B 33-328. HOT PLATE, Electric, single heat, strongly constructed. Open top, 8 in. diam. With large base support and drip tray, finished stove black. With flex. Maximum loading 1000 watts. .. .. *p* **1 3 6**

B 34-720. JARS, Filtrate, 12 cm. high, approx. 200 ml. capacity, for use with filtering funnels *each r* **4/-** ; *dozen* **2 2 0**

B 34-725. JARS, Gas, with base and ground flange.

Height × diam.	15 × 4	15 × 5	20 × 4	20 × 5	25 × 5	*cm.*
	tx **16/-**	**18/-**	**18/-**	**£1 2 6**	**£1 6 0**	*dozen*
	tx **1/6**	**1/8**	**1/8**	**2/1**	**2/5**	*each*

Height × diam.	30 × 5	30 × 6·5	30 × 7·5	40 × 7·5	*cm.*
	tx **£1 10 0**	**£2 2 0**	**£2 12 0**	**£4 4 0**	*dozen*
	tx **2/9**	**3/11**	**4/9**	**7/9**	*each*

B 34-730. JARS, Gas, graduated, from bottom upwards with figures reversed, for use in quantitative experiments on gas composition, etc.

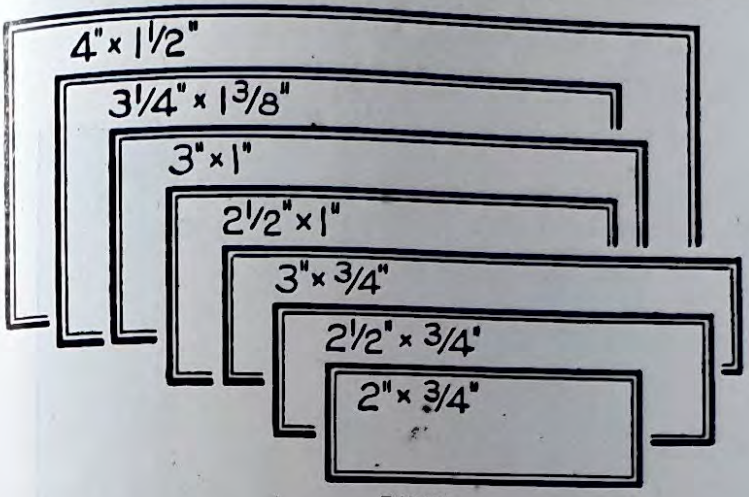
Capacity	250 in 2	350 in 5	500 in 5	*ml.*
	5/6	**6/-**	**6/6**	*each*

B 34-735. COVERS, Gas Jar, circular, ground one side.

Diam.	5	6·5	7·5	10	11·5	12·5	15	*cm.*
	16/-	**19/-**	**20/-**	**35/-**	**45/-**	**60/-**	**70/-**	*gross*
	1/6	**1/10**	**1/10**	**3/3**	**4/-**	**5/6**	**6/6**	*dozen*



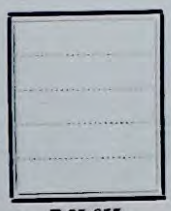
B 34-735.



B 35-850.



B 35-852.



B 35-855.



B 35-865.

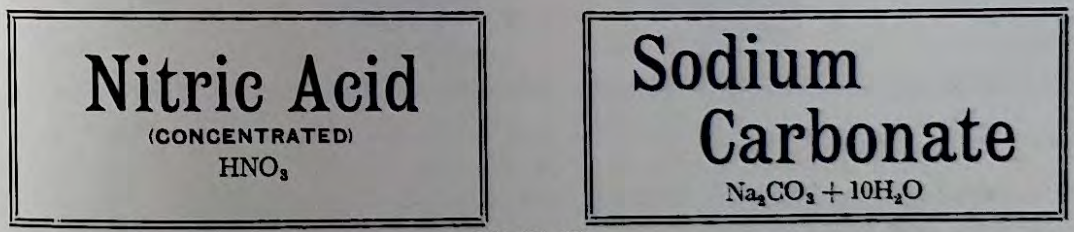
B 35-850. LABELS, plain with border, gummed, in cartons of 100, convenient for storage.

Dimensions	2 × ¾	2½ × ¾	3 × ¾	2½ × 1	3 × 1	3¼ × 1⅜	4 × 1½	*in.*
	4/-	4/-	4/9	4/-	4/9	6/-	8/-	*per* 1000
	5d.	5d.	6d.	5d.	6d.	7d.	9d.	*per* 100

	£	s.	d.
B 35-852. LABELS, microscope slide, ⅞ in. square, plain, with border. Gummed *packet* 100 **6d.**; 1000	0	4	6
B 35-855. Ditto, with faint lines .. .. *packet* 100 **7d.**; 1000	0	5	6

B 35-865. LABEL VARNISH, Bakelite, Griffin. An ideal varnish (greatly superior to varnishes of the lac type commonly used for the purpose), for covering labels with a tough, durable, glass-like coat, resistant to all except strong mineral acids. Labels should first be lightly sized (a solution of size or gelatine is suitable), allowed to dry and the varnish then applied. It dries rapidly and will last indefinitely. Many other useful laboratory applications may be found for it. Can be thinned by the use of turpentine.

Bottle	50	100	250	500 *ml.*
	r 1/8	2/9	5/6	10/- *each*



B 35-870—875.

	£	s.	d.
B 35-870. BOOKS OF LABELS, varnished and gummed, bound and perforated, in books of 360 names and formulae of usual reagents and spare blanks .. .. .. *book*	0	3	0
B 35-875. LABELS, varnished and gummed, as list below, in cardboard boxes containing 25 labels of one name and formula .. .. *box*	0	0	6

Ammonium Carbonate.
Ammonium Chloride.
Ammonium Hydroxide.
Ammonium Oxalate.
Ammonium Sulphate.
Ammonium Sulphide.
Barium Carbonate.
Barium Chloride.
Barium Nitrate.
Benzene.
Bleaching Powder.
Borax.
Calcium Carbonate.
Calcium Chloride.
Calcium Oxide.
Cobalt Nitrate.
Distilled Water.
Ether.
Ferrous Sulphate.
Fusion Mixture.
Hydrochloric Acid (conc.).
Hydrochloric Acid (dilute).
Iron Perchloride.
Lead Acetate.
Lead Nitrate.
Lime.
Lime Water.
Litmus.
Magnesium Sulphate.
Methyl Orange.
Nitric Acid (concentrated).
Nitric Acid (dilute).
Oxalic Acid.
Phenolphthalein.
Potassium Carbonate.
Potassium Chromate.
Potassium Ferricyanide.
Potassium Ferrocyanide.
Potassium Hydroxide.
Potassium Nitrate.
Silver Nitrate.
Sodium Acetate.
Sodium Bisulphate.
Sodium Bisulphite.
Sodium Carbonate.
Sodium Hydroxide.
Sodium Phosphate.
Sulphur.
Sulphuric Acid (concentrated).
Sulphuric Acid (dilute).
Zinc.

The list above provides for the usual reagents appearing on working benches. Labels for special reagents such as are placed on side benches and racks will be found in the book of labels **B 35-870.**

B 36-392. LEATHERS, Chamois, best quality, for straining mercury, etc.

Approx.	12 × 11	15 × 14	*in.*
	3/-	6/6	*each*



B 36-775.

B 36-775. LEVELLING BULBS, Mercury, heavy glass.

Capacity ..	125	250	500	*ml.*
tx	3/-	4/-	5/-	*each*



B 36-965.

B 36-965. MERCURY PURIFIER, Jones (*J. Soc. Chem. Ind.*, 1930, **49**, 437T, Modified) all glass construction, mounted on board about 36 in. high for attaching to wall .. .. *r* £ 4 10 0

When filter pump is operated air rushes up left-hand tube and carries globules of mercury over into dilute nitric acid causing a mercury-acid emulsion in the wide portion of the right-hand tube. The amount of mercury in the Woulff bottle should be regulated, so that the left-hand tube just dips below the surface to such a depth that a continuous stream of small globules of mercury, intermingled with acid, is carried up the tube with only an occasional pulsation. The apparatus gives intimate mixing of air, acid and mercury thus accelerating the process of purification. It requires no attention after it has once started, as the mercury-acid-air emulsion is maintained in continuous circulation.



B 38-725.

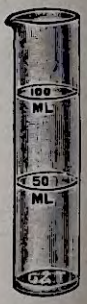


B 38-750.



B 38-761.





B 41-090.

B 38-725. MORTARS and PESTLES, thick glass, with heavy base and spout, and glass pestle.

Diam.	6	8	12	14	*cm.*
	4/-	4/6	7/-	8/-	*each*

B 38-750. MORTARS and PESTLES, Porcelain, with spout. Mortar glazed outside; inside partially glazed. Porcelain pestle, glazed except grinding surface.

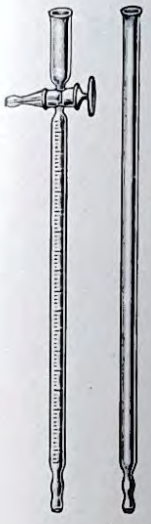
No.	00	0	1	2	3	4	5	6	
Diam. ..	65	80	90	110	130	150	175	200	*mm.*
tx	1/9	2/5	3/5	4/6	6/6	9/9	15/-	21/3	*each*

B 38-761. MORTARS and PESTLES, Porcelain, acid proof, good quality, unglazed. Pestles fitted with wood handles.

Diam.	3	4	5¼	6	7	8	9	10	11	12	*in.*
	3/-	4/-	5/6	6/9	10/-	12/6	15/-	20/-	26/-	35/-	*each*

B 41-090. NESSLER GLASSES, B.S. 612—1935, selected colourless lead-free glass, as free from striae as possible, well annealed, with smooth-finished spouted top and clear bottom. Each graduation mark is numbered and carried completely round the cylinder and is in a plane perpendicular to the axis of the cylinder and horizontal when the cylinder is standing on a level surface.

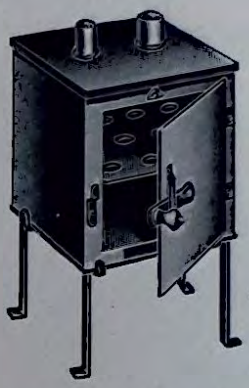
Capacity	50	100	*ml.*
Marks at	50	50 and 100	*ml.*
	£2 2 0	£2 15 0	*dozen*
	3/9	5/-	*each*



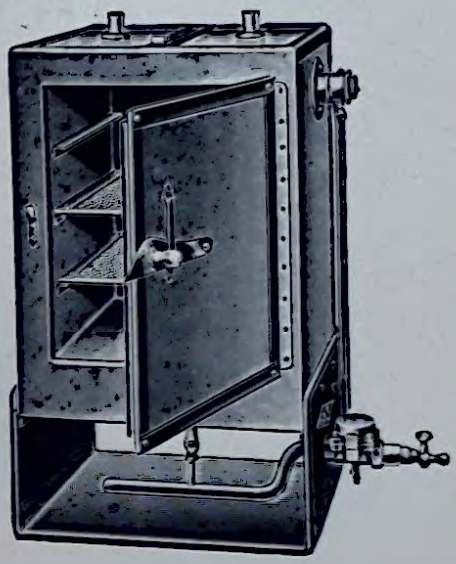
B 41-182.



B 41-184.



B 41-300.



B 41-316—318.

	£	s.	d.
B 41-182. NITROMETER, Lunge, graduated 50 ml. in $\frac{1}{5}$ml., with 3-way stopcock and glass levelling tube	1	7	6
B 41-184. Ditto, with double-bored stopcock	1	10	0

B 41-300. OVENS, Drying, Air, gas heated, polished copper with removable perforated shelf, thermometer tubulure, and air regulator on door. Mounted on iron stand.

Inside dimensions ..	15	20	25	30	*cm. cube*
p	£3 5 0	£4 0 0	£4 5 0	£5 0 0	*each*

OVENS, Drying, Air, gas heated, thermostatically controlled, maximum temperature 250° C. Double walled, asbestos covered with two tubulures and ventilator on top. Fitted asbestos covered double walled door and provided with two woven wire shelves. In order to prevent burning, a hole is made in outer casing at bottom, allowing gas flame to impinge on a replaceable plate attached to inner wall of bottom of oven. The "Perfecta" thermostat controls temperature within $\pm 5°$ C. Mounted on draught screen stand with gas governor and burner with by-pass.

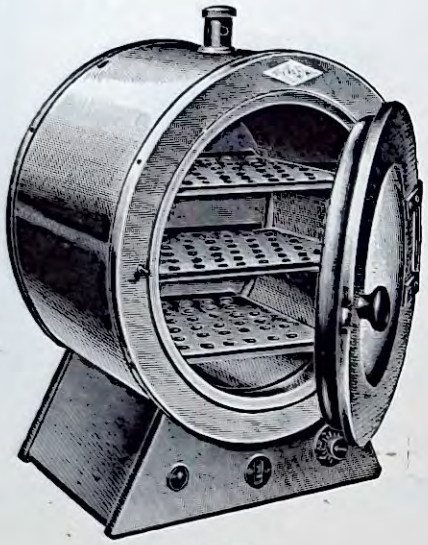
Inside height × width × depth	18 × 11 × 10	16 × 20 × 14	16 × 24 × 16	*in.*
B 41-316. Iron .. .. *p*	£23 15 0	£29 15 0	£34 5 0	*each*
B 41-318. Copper .. .. *p*	£33 10 0	£40 5 0	£45 0 0	*each*

Inside height × width × depth	24 × 24 × 18	30 × 30 × 20	36 × 36 × 24	*in.*
B 41-316. Iron .. .. *p*	£38 0 0	£51 0 0	£59 5 0	*each*
B 41-318. Copper .. .. *p*	£51 0 0	£64 0 0	£78 15 0	*each*

Orders for Export are handled in a department organised for the purpose and are packed with special care by an expert staff.

ELECTRIC DRYING OVEN

New cylindrical easy-clean design with rock-steady automatic temperature control over the range 30-250°C.



B 41-500.

Design and Construction.—This new oven has been designed specially for use in chemical, metallurgical, bacteriological and pathological laboratories. The external form has been made pleasingly cylindrical to simplify manufacture and, therefore, to reduce cost and also to provide an exterior which can readily be sponged and is therefore "easy-clean." To this end the whole casing is finished in a durable cream enamel which does not readily chip and which indefinitely withstands the action of heat. The heating chamber is of nickel-plated copper and contains three removable shelves mounted on runners.

The door and casing are heavily lagged and the door is fitted with a roller catch operated by a lever handle. A thermally insulated combined thermometer support and rotatable ventilator is provided at the top of the oven.

Low Current Consumption.—The design and disposition of the elements ensures a remarkably low current consumption as is exhibited by the following figures resulting from actual test on the oven.

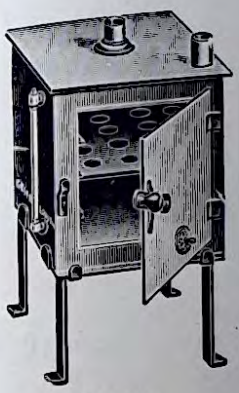
Temperature	50	100	150	200	250	° *C.*
Consumption	90	160	290	400	520	*watt/hours*

Heating-up Time.—The maximum temperature of 220° C. is attained within an hour of switching on the current by setting the dial to the 100 mark. A switch is provided.

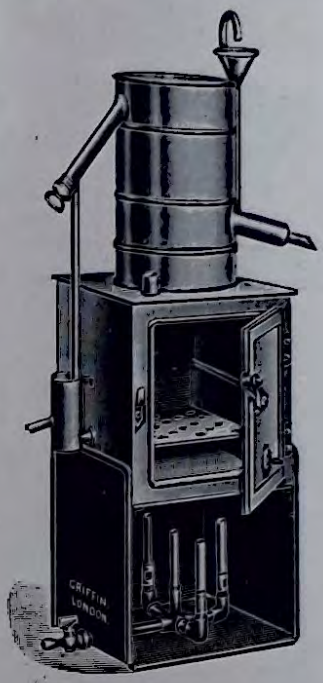
Temperature Control and Uniformity.—The oven is provided with a sensitive slow motion temperature adjustment against a circular scale angularly divided into 100 parts. Although a constancy of control of ± 1° C. is claimed, it is found in practice that so well have the characteristics of the oven been worked out in balancing the heat input to the heat loss and in designing the thermostat that **no variation of temperature was detectable** on a sensitive recording pyrometer over a long period. A pilot lamp is alight during the time when the thermostat is operating. Instructions are supplied for alteration of the internal connections if at any time the mains supply voltage should be changed.

	£	s.	d.
B 41-500. OVEN, Drying, Air, electrically heated, thermostatically controlled, temperature range 30-250° C., new cylindrical design. Heating chamber 36 cm. diam., 36 cm. deep. With three perforated shelves. Suitable for use on all voltages 100-110 and 200-250 A.C. and D.C. Complete with length of 3-core rubber covered cable and instructions .. *t*	32	10	0
B 41-510. Spare Pilot Lamps for **B 41-500.** *Please state voltage when ordering* .. .. *each tx*	0	2	9

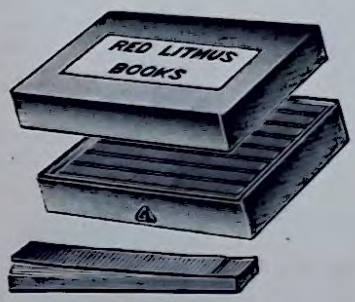
Your attention is drawn specially to the numerous new and distinctive designs in this Catalogue. They are of exceptional interest to you.



B 41-610.



B 41-660.



B 42-116.

B 41-610. OVENS, Drying, Water, gas heated, polished copper, double walled with removable perforated shelf, tubulures for thermometer and for filling, air regulator on door. Water gauge tube at side. Mounted on iron stand.

Inside dimensions ..	15	20	25	30	*cm. cube*
	£5 5 0	£6 0 0	£6 10 0	£11 0 0	*each*

B 41-660. OVEN and STILL, Combined, gas heated, fitted with constant water level, door covered with insulating medium, condenser tinned inside. Capacity about 3 litres distilled water per hour. Polished copper with burners and iron flame guard. Internal dimensions of oven, 23 × 23 × 23 cm. .. .. *p* 15 0 0

PAPERS, Test, in books and sheets.

		£	s.	d.
B 42-102.	**COBALT,** in books of 20 leaves .. .. *dozen*	0	3	6
B 42-104.	**CONGO RED,** in books of 20 leaves .. .. *dozen*	0	2	3
B 42-106.	**LEAD ACETATE,** in books of 20 leaves .. .. *dozen*	0	2	3
B 42-116.	**LITMUS, Red, Bibulous,** in books of 20 leaves .. .. *dozen*	0	2	3
B 42-118.	Ditto, **Red, Bibulous,** in sheets 15½ × 10⅛ in. .. .. *dozen*	0	4	0
B 42-120.	Ditto, **Blue, Bibulous,** in books of 20 leaves .. .. *dozen*	0	2	3
B 42-122.	Ditto, **Blue, Bibulous,** in sheets 15½ × 10⅛ in. .. .. *dozen*	0	4	0
B 42-124.	Ditto, **Neutral, Bibulous,** in books of 20 leaves .. .. *dozen*	0	2	3
B 42-126.	**PHENOLPHTHALEIN,** in books of 20 leaves .. .. *dozen*	0	2	3
B 42-128.	**STARCH,** in books of 20 leaves .. .. *dozen*	0	2	3
B 42-130.	**STARCH and POT. IODIDE,** in books of 20 leaves .. .. *dozen*	0	2	3
B 42-132.	**TURMERIC,** in books of 20 leaves .. .. *dozen*	0	2	3
B 42-136.	**TEST PAPERS, pH Universal,** in books of 20 leaves, range 1·0 to 10 *p*H, in steps of 1 *p*H. Colour change deep red through orange and green to blue. Colour change chart printed on inside covers .. .. *each* 1 **7d.** ; *dozen*	0	6	0
B 42-137.	**TEST PAPERS, pH,** in books of 20 leaves, each book covering a range of 1·5 *p*H, in steps of 0·3 *p*H. Colour change chart printed on inside of covers. *p*H ranges available 3·6 to 5·1, 5·2 to 6·7, 6·8 to 8·3 and 8·4 to 10 .. .. .. *each* 1 **7d.** ; *dozen*	0	6	0

Please state range required when ordering.



B 42-150.

B 42-150. PENCILS, Wax, for writing on glass. Do not run to any appreciable extent when used on beakers, etc., placed on a steaming water bath. Colours:—blue, red, green, yellow, brown, black .. .. *each* 1 **4d.** ; *dozen* | 0 | 3 | 9



B 42-310—320.

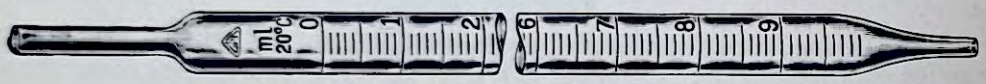
PIPETTES, Delivery, graduated one mark. *(Please state Catalogue No. when ordering.)*

Cat. No. →	B 42-310 Grade B		B 42-318 Grade A without Certificate		B 42-320 Grade A with Certificate	B 42-326 Class A with N.P.L. Certificate
To deliver	*each*	*dozen*	*each*	*dozen*	*each*	*each*
						£
1 ml.	1/10	20/-	5/-	55/-	6/-	18/8
2 ,,	1/10	20/-	5/-	55/-	6/-	18/8
5 ,,	2/3	24/-	6/-	65/-	7/-	18/8
10 ,,	2/9	28/-	7/-	77/6	8/-	20/8
15 ,,	3/-	32/-	8/-	87/6	9/-	22/8
20 ,,	3/-	32/-	8/-	87/6	9/-	22/8
25 ,,	3/-	32/-	8/6	90/-	9/6	22/8
50 ,,	4/-	42/-	11/-	120/-	12/-	23/8
100 ,,	6/-	65/-	13/-	140/-	14/-	25/8



B 42-310+370.

B 42-370. SAFETY BULBS, fitted to pipettes **B 42-310—326,** add to prices .. .. *each* £ 0 s. 0 d. 5



B 42-395—405.

PIPETTES, Graduated to point, zero at top. *(Please state Catalogue No. when ordering.)*

Cat. No. →	B 42-395 Grade B		B 42-403 Grade A without Certificate		B 42-405 Grade A with 5-point Certificate	B 42-411 Class A with N.P.L. Certificate
To deliver	*each*	*dozen*	*each*	*dozen*	*each*	*each*
						£
1 ml. in $\frac{1}{100}$ ml.	4/-	42/-	11/-	120/-	16/-	41/8
2 ml. in $\frac{1}{50}$ ml.	4/-	42/-	11/6	125/-	16/6	42/8
5 ml. in $\frac{1}{20}$ ml.	4/3	45/-	12/-	130/-	17/-	43/8
10 ml. in $\frac{1}{10}$ ml.	4/6	48/-	14/-	155/-	19/-	46/8
25 ml. in $\frac{1}{2}$ ml.	4/9	50/-	—	—	—	—
25 ml. in $\frac{1}{10}$ ml.	5/6	57/6	17/-	185/-	22/-	52/8



B 42-460.



B 42-664.



B 42-668.

B 42-460. PIPETTES, Dropping, ungraduated, with rubber teat .. .. *each* 4d.; *dozen* £ 0 s. 3 d. 0

B 42-664. PLATES, Porous, thick, for drying crystals, seed germinating, etc.

Diam.	8	12·5	15 *cm.*
	5/-	8/6	12/- *dozen*

B 42-668. PLATES, Porous, deep, 22 cm. diam., for drying crystals, etc. *Prices on application.*

B 42-672. PLATES, Porous (Saucers), approx. 5 in. diam., for drying crystals .. *each* 7d; *dozen* 0 6 0

THE MICROID NALIK PRESS

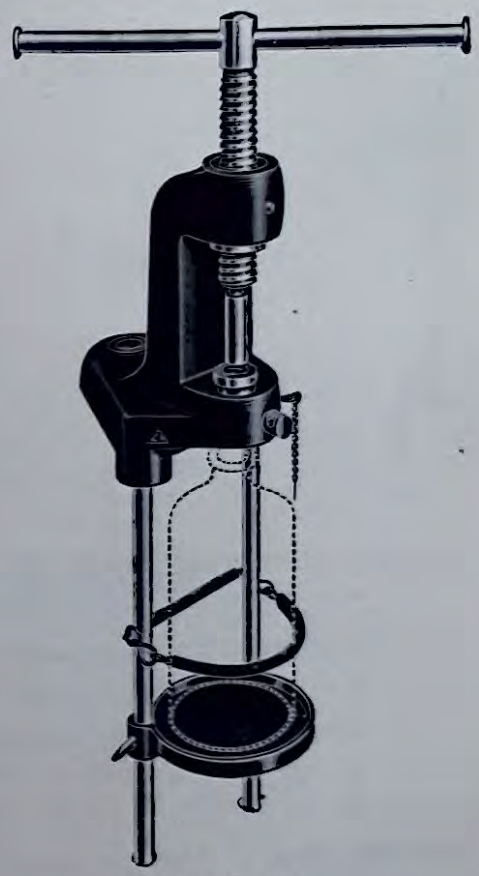
An improved British-made Press for use in extruding the alkali metals as wire

Registered Design No. 844585

Sodium is an extremely effective reagent for removing water by destruction from such liquids as ether, toluene and benzene. In the preparation of a Grignard solution thorough drying of the ether is essential; and when such liquids as benzene are used in the Friedel-Crafts reaction much better results are often obtained after efficient dehydration. The use of sodium has the additional advantage over most other reagents, that the liquid can be stored in contact with the metal and merely poured off when required, neither filtration nor distillation usually being necessary.

For rapid and effective drying the sodium should have as great a surface area as possible, and should be distributed throughout the body of the liquid. Both of these objectives are attained by extruding the metal in the form of wire. Potassium and sodium are easily extruded through a 0·5 mm. diam. orifice, the resulting wires having a surface area of 93 and 82 sq. cm./gm. respectively. Lithium, a harder metal, which is finding increasing applications in organic chemistry, requires a 1 mm. orifice. The wire falls into large, loose coils, which are self-supporting in the body of the liquid. Wire is also the most convenient form in which to use sodium as a reagent in many organic preparations such as that of ethyl acetoacetate.

Formerly sodium presses were largely of foreign origin. In the Microid Nalik Press many improvements have been introduced. The one-piece die and mould and the floating plunger are of stainless steel. The body, stove enamelled to eliminate corrosion, can be attached to the bench in a few moments by means of a single bolt. Rotation of the press when in use is prevented by two lugs which bear against the edge of the bench. An adjustable bottle stand is provided, so that bottles up to a capacity of one Winchester quart can be used and their necks brought up to the under side of the mould.



B 43-040—042.

B 43-040. MICROID NALIK PRESS (*Regd. Design No.* 844585). Body casting stove enamelled, with 1⅛ in. Acme thread screw, handle 12 in. long, adjustable bottle stand, fully-floating stainless steel plunger. Bolt ⅝ in. diam. to suit bench tops up to 1¾ in. thick. Weight 30 lb. **Without** mould .. .. £ s. d. r 12 10 0

B 43-042. Moulds, for above, stainless steel, with pricker.

Orifice diam.	0·5	1·0	*mm.*
	r £2 15 0	£2 15 0	*each*

Directions for Use.—Raise the plunger by rotating the screw. Make sure that the mould is clean before placing it in the socket. Use the pricker to ensure that the orifice is not obstructed. Tighten the mould locking screw. Cut the crust from the sodium and pack the clean metal into the mould. Place receiving bottle on the stand and raise the table until the neck of the bottle is almost touching the lower side of the mould. Screw down the plunger until resistance is felt and then continue with a slow, steady motion. The metal is thus easily extruded into the bottle and if one mouldful is insufficient the mould can be recharged after raising the plunger.

Ether prepared in this way should be dried for a few days over the sodium, then filtered into a clean, dry bottle and stored over fresh sodium. Bottles containing any liquid in contact with sodium should never be stoppered (hydrogen is evolved), but should be provided with a cork and calcium chloride tube to exclude moisture.

It is **very important** to keep the mould clean. Immediately after use it should be placed in alcohol until the whole of any metal remaining in it is destroyed (*N.B.*—Alcohol enflames in the air in contact with potassium). It should then be rinsed with water, dried by gentle warming and stored with the pricker provided in the orifice. The plunger should be swabbed with a filter paper soaked in alcohol. If these simple precautions are taken, no trouble will be experienced and the mould will give good service for many years. The plunger thread should be kept well-lubricated, preferably with graphite grease.



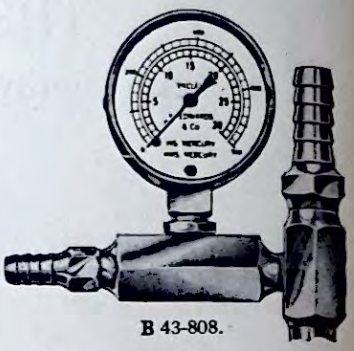
B 43-750.



B 43-778.



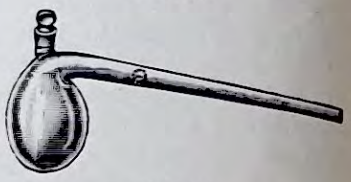
B 43-803.



B 43-808.



B 44-936.
B 44-942.



B 44-938.
B 44-944.

B 43-750. PUMP, Filter, glass, " University College " pattern. One of the most popular and satisfactory types. Well made and **each pump tested** before issue .. .. .. £ 0 4 6

B 43-778. PUMP, Filter, nickel-plated brass, with cylindrical chamber at end, which breaks water jet and makes attachment of rubber tube to outlet of pump unnecessary .. *r* 0 13 6

PUMPS, Filter, metal, chromium plated finish. Highly efficient design producing a vacuum of 12 mm. mercury. High pumping speed. Operate on a water pressure as low as 15 lb./sq. in. Each pump has two types of connections as below:—

B 43-803. Model 1. With connections for ½ in. rubber tubing and ¼ in. British standard pipe thread .. .. *each tx* 0 15 6

B 43-805. Model 2. With connections for ¼ in. rubber tubing and ¼ in. British standard pipe thread .. .. *each tx* 0 15 6

B 43-807. Model 3. With ⅜ in. union cap for ½ in. tap and ¼ in. British standard pipe thread *each tx* 1 0 0

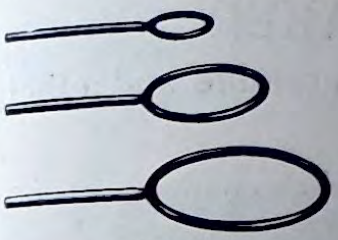
B 43-808. Vacuum Gauge Attachment for Filter Pumps **B 43-803—807.** Vacuum gauge 2½ in. diam. reading 0–30 in. and 0–760 mm. fixed by a back nut to a special arm screwed to take the side connecting nozzle of the pump .. .. *tx* 1 4 0

RETORTS, Monax resistance glass.

Capacity		125	250	500	1000	*ml.*
B 44-936. Tubulated	*tx*	£1 14 8	£2 4 7	£2 14 6	£3 16 9	*dozen*
	tx	3/4	4/2	5/-	7/1	*each*
B 44-938. Stoppered	*tx*	£2 9 6	£2 19 5	£3 11 10	£4 14 1	*dozen*
	tx	4/7	5/5	6/8	8/3	*each*

RETORTS, Pyrex resistance glass.

Capacity		100	150	250	500	1000	*ml.*
B 44-942. Tubulated	*tx*	3/6	3/9	4/3	4/11	6/-	*each*
B 44-944. Stoppered	*tx*	6/-	6/3	6/8	7/9	8/9	*each*



B 45-020.



B 45-025.



B 45-032.

B 45-020. **RINGS, Malleable Iron,** with straight stems, for use with bossheads.

Diam. ..	2	2½	3	4	5	6	*in.*
Stem ..	6 × 5/16	5 × 5/16	5½ × 5/16	5½ × 5/16	5½ × ⅜	5 × ⅜	*in.*
	11/6	17/-	19/-	20/-	25/-	27/-	*dozen*
	1/1	1/7	1/9	1/9	2/3	3/-	*each*

B 45-025. **RINGS, Malleable Iron, with bossheads,** suitable for rods of diameter 5/16 to ½ inch.

Diam.	2¼	2¾	3¼	4¼	5¼	6¼	*in.*
Distance from rod to centre of ring	3	3½	3½	4	4½	5	*in.*
	32/-	33/-	35/-	40/-	48/-	57/6	*dozen*
	3/-	3/-	3/3	3/9	4/6	5/6	*each*

B 45-032. **TABLE SUPPORTS, Iron,** 4 in. diam., with bosshead for attaching to retort stand rods up to ½ in. diam. Useful for holding a Bunsen burner at adjustable heights as in distillation operations .. .. *each* 5/-; *dozen* **2 15 0**



B 45-035.

B 45-035. **ROD, Glass, soft soda,** free from lead, for bending, stirring rods, etc., in lengths of about 5 feet. The prices of rod assume that the usual tolerances are allowed. If selection to very close limits is required an extra charge is made.

Diam.	2·75–3	4–11	12–17	18–25	*mm.*
Approx. no. of feet per lb.	190–90	50–6	5–2½	2–0·8	
	2/9	2/-	3/6	3/9	*lb.*

B 45-065. **RODS, Stirring, glass,** ends rounded.

Length × diam. (approx.)	6 × 3/16	9 × 3/16	12 × ¼	12 × ⅜	18 × ½	24 × ⅝	36 × ¾	*in.*
	2/6	3/-	4/6	18/-	35/-	44/-	97/6	*dozen*
	3d.	4d.	5d.	1/8	3/3	4/-	9/-	*each*



B 45-370.



B 45-390.

B 45-370. **SCISSORS, Laboratory,** best quality, Sheffield make.

Length	6	9	*in.*
	(*a*) *p* 6/-	9/6	*each*

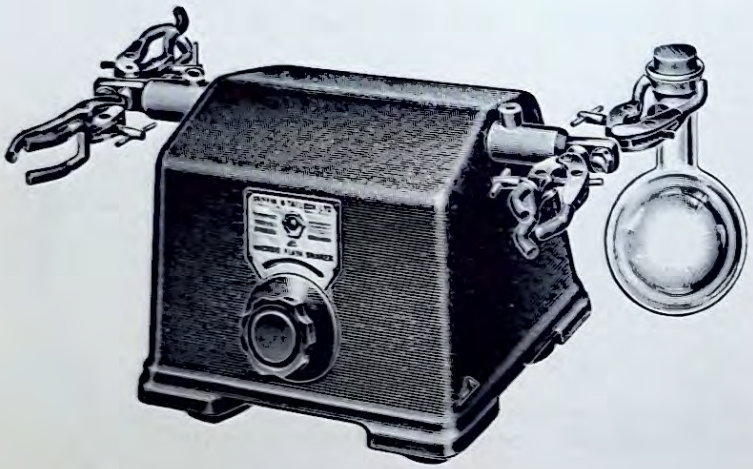
B 45-390. **SCOOPS, Horn,** narrow deep type, with smooth surface.

Length	10	12	15	*cm.*
	10/-	15/-	22/-	*dozen*
	11d.	1/5	2/3	*each*

THE MICROID FLASK SHAKER

A new variable speed "wrist-action" shaker, silent, portable and efficient

Registered Design No. 842861



B 45-460.



Film 16 mm. Super XX, 2½ in. lens f.2·7 used at stop f.4·5, lighting 4 kw., exposure 1/10,000 sec. Taken at 2,000 frames/sec. Projected at 16 frames/sec. Slowing down 125 to 1.

The Microid Flask Shaker carries up to four 500 ml. flasks, each half-full of liquid. It is silent in operation. It can be placed on the laboratory bench. It does not need permanently fixing. By good design, perfect balance, and high mechanical advantage, the power consumption is only 60 watts. It can be plugged into A.C. or D.C. lighting circuits, and is continuously variable in speed from zero up to 500 oscillations per minute. Its agitation can be varied instantly from a gentle slopping, useful for viscid solutions such as collodion, to a violent cascade. In a round bottom flask suitably adjusted, the liquid can be made to swirl around the flask on a hollow *horizontal* axis. In a conical flask the liquid can be made to rise spirally up the walls; in returning in droplets to the bottom, it is brought into intimate contact with the gaseous phase and is effectively "aerated" for such purposes as hydrogenation. In the incidental daily laboratory operations of dissolving and dispersing solids, extracting residues, emulsifying oils, it abolishes the tedium of prolonged hand-shaking, saves time and accelerates the processes. If suitably supported it could be used for shaking flasks in a thermostatic bath. Since it reproduces so many different types of agitation hitherto attainable only by hand it may be termed a "wrist-action" shaker.

This shaking has been studied in detail by an ultra high speed camera through the courtesy of the Research Laboratories of Messrs. Kodak Ltd. One "still" is shown above. Blackened ⅛ in. cubes of teak of nearly the same density as water, were used to follow the motion of the liquid in flasks each half-filled. It was seen that they circulated throughout every part of the liquid. A portion of the film in colour exhibits how the reaction between solid potassium permanganate and a solution of sodium metabisulphite is affected by the speed of shaking. The complete film, about 400 ft. long, is available on loan by request. It will be of special interest to scientific film societies, as it is believed that it is the first film of its type ever made.

SPECIFICATION

A heavy iron box-shaped casting 10½ × 9½ × 9 in. high is mounted on four vibration-absorbing rubber feet. Running on bearings through the casting there passes a spindle, ⅜ in. diam. fitted at each end with split sleeve non-ferrous castings, to which are bolted four Griffin Four-Six Clamps. Inside the casting there is mounted a 1/30 H.P. universal, ball-bearing fan-cooled motor which, by an eccentric, coupled with a sturdy link motion, causes the spindle to oscillate through a small amplitude. The speed of the motor is controlled by a toroidally-wound potentiometer. An on-off switch is provided. Lubricators for the spindle bearings are located on the top of the casing. Weight about 45 lbs. Bench space required, about 22 × 10 in.

B 45-460. MICROID FLASK SHAKER (*Regd. Design No.* 842861), complete as described above, with clamps and motor for use on 200-250 volts A.C. and D.C., loading 60 watts .. £ 25 0 0



B 45-512.

B 45-512. SHELVES, Beehive, stoneware.

Diam.	3	4 *in.*
	1/1	1/6 *each*



B 45-530—532.

B 45-530. SIEVES, Drum form, nestable, with brass gauze and tinned iron frame.

Mesh ..	10	20	30	40	50	60	
Diam. 4 in.	3/6	3/6	3/6	3/6	3/9	4/-	*each*
Diam. 6 in.	4/-	4/-	4/-	4/-	4/3	4/6	*each*
Diam. 8 in.	5/-	5/-	5/-	5/-	5/6	5/9	*each*
Mesh ..	80	90	100	120	160	200	
Diam. 4 in.	4/-	4/-	4/3	4/3	5/-	5/6	*each*
Diam. 6 in.	4/6	4/6	4/9	4/9	6/6	9/6	*each*
Diam. 8 in.	5/9	6/-	6/6	7/-	9/6	12/6	*each*

B 45-532. Lids and Receivers, for sieves B 45-530.

Diam.	4	6	8 *in.*
	3/6	4/-	5/- *pair*



B 45-694.



B 45-700.



B 45-696.



B 45-752.

B 45-694. SPATULAS, Nickel, flat.

Length ..	7·5	9	12	15	18	*cm.*
	tx 8/6	11/-	13/6	19/6	£1 9 0	*dozen*
	tx 10d.	1/1	1/3	1/10	2/9	*each*

B 45-696. SPATULAS, Nickel, double, with flat ends.

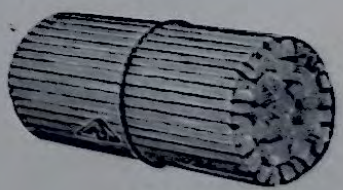
Length	12	15	18	21	*cm.*
	tx £1 0 0	£1 6 10	£1 11 8	£1 19 3	*dozen*
	tx 1/10	2/5	3/-	3/8	*each*

B 45-700. SPATULAS, Nickel, Chattaway, of pure nickel rod, drawn out flat towards each end, one cut square, other bent as illustrated, 8 in. long .. .. *each tx* 2/3 ; *dozen* — £ s. d. 1 3 5

B 45-752. SPATULAS, Non-metallic, Vulcanite, black, polished, with handle.

Total length ..	10	12	16	18	20	*cm.*
	6/-	7/6	8/-	10/6	14/6	*dozen*
	7d.	8d.	9d.	1/-	1/4	*each*

B 46-160. SPLINTS, Wood, thin, ¼ in. wide, for use in experiments with oxygen, etc. In bundles of about 250 .. .. *bundle* 4d. ; *doz. bundles* — £ s. d. 0 3 6

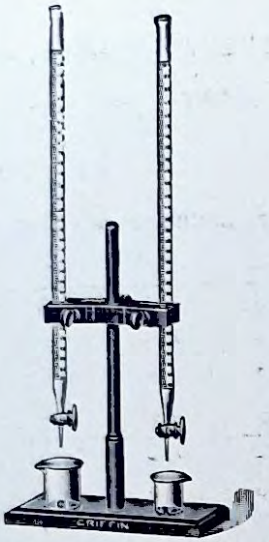


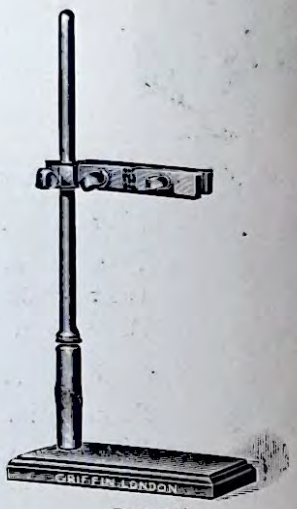
B 46-160.


B 46-190.


B 46-220.


B 46-320—322. Single.


B 46-320—322. Double.



B 46-344.

B 46-190. SPOONS, Deflagrating, ordinary quality, with brass spoon and flange *each* 1/6 ; *dozen* £ 0 16 s. 0 d.

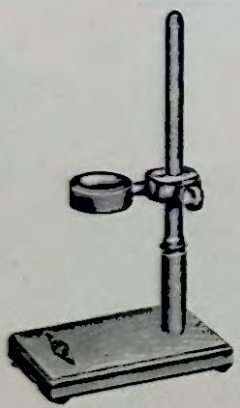
B 46-220. SPOONS, Nickel, with spatula end.

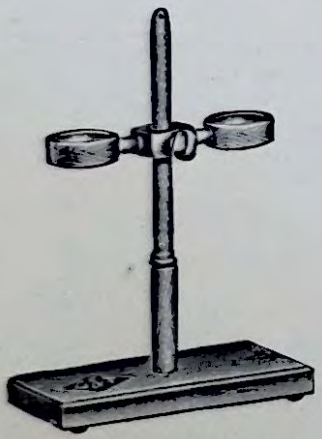
Total length ..	12	15	18	21	*cm.*
tx	18/7	£1 0 8	£1 9 7	£1 15 9	*dozen*
tx	1/9	2/1	2/9	3/4	*each*

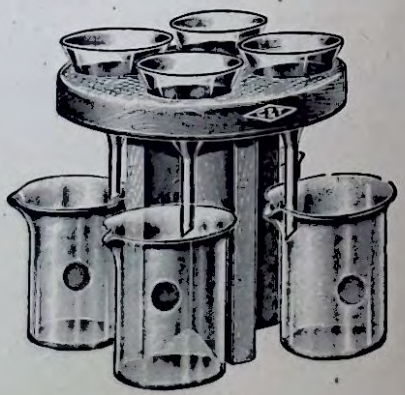
B 46-320. STANDS, Burette, Hardwood, with boxwood screws.

Type	Single.	Double.
	5/6	8/6 *each*
B 46-322. Clamps only	3/-	4/6 *each*

B 46-344. STAND, Universal, Hardwood, with lead-loaded base and clamp adjustable to any angle .. .. £ 0 s. 11 d. 0


B 46-384—386. Single.


B 46-384—386. Double.


B 46-414.

B 46-384. STANDS, Funnel, Hardwood, with boxwood screws

Type	Single.	Double.
	5/-	6/6 *each*
B 46-386. Funnel Holders only	2/9	4/- *each*

B 46-414. STAND, Funnel, Griffin. A compact and economical support that will be found of particular service where a large number of filtrations are carried out. Occupies little locker space. Top about 7 in. diam., with holes to take four funnels from 2 to 3 in. diam., height about 6 in. to take receivers up to 5 in. high. **Without** funnels or beakers .. £ 0 s. 6 d. 0



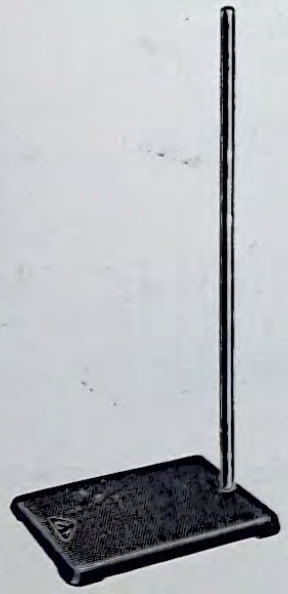
B 46-438.



B 46-439.



B 46-440.


B 46-455.


B 46-465.

B 46-438. STAND-CLAMP, Varnished Hardwood, extreme height 11 in., with joint at foot and leaded base. For retorts, flasks, etc. .. .. £ 0 10 6

B 46-439. STAND-CLAMP, Bunsen, Universal, Varnished Hardwood .. .. £ 0 12 6

B 46-440. STAND-CLAMP, Bunsen, Universal, Varnished Hardwood, extreme height 20 in., with sliding rod and movable clamp. For retorts, flasks, etc. .. .. £ 0 14 0

STANDS, Retort, with rectangular cast iron base coated acid-resisting paint. Very best construction, strong and rigid, properly trued, stand firmly on a level surface.

No.	1	2	3	4	5	6	
Base	$5\frac{1}{2} \times 3\frac{1}{2}$	$7\frac{1}{2} \times 4\frac{1}{2}$	$9 \times 5\frac{3}{4}$	$9 \times 5\frac{3}{4}$	12×6	12×6	*in.*
Rod	$16 \times \frac{3}{8}$	$20 \times \frac{1}{2}$	$24 \times \frac{1}{2}$	$30 \times \frac{9}{16}$	$30 \times \frac{9}{16}$	$36 \times \frac{9}{16}$	*in.*
Weight ..	$1\frac{1}{2}$	4	$6\frac{1}{2}$	7	$8\frac{3}{4}$	$9\frac{1}{4}$	*lb.*
B 46-455. With bright steel rods	**£1 19 0**	**£2 15 0**	**£4 10 0**	**£4 17 6**	**£6 15 0**	**£7 10 0**	*dozen*
	4/3	**5/-**	**8/6**	**9/-**	**12/6**	**13/-**	*each*

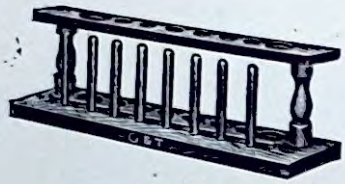
STANDS, Retort, with tripod cast-iron base, coated acid-resisting paint. Very best construction. Tripod base favoured by many workers, as it does not restrict adjustment of a Bunsen burner, and will stand firmly on an uneven surface.

No.	1	2	3	4	
Radius of base ..	$4\frac{1}{4}$	$4\frac{1}{4}$	$5\frac{1}{2}$	$6\frac{1}{2}$	*in.*
Rod	$16 \times \frac{3}{8}$	$20 \times \frac{1}{2}$	$30 \times \frac{9}{16}$	$36 \times \frac{9}{16}$	*in.*
Weight	3	$3\frac{1}{2}$	$5\frac{1}{4}$	$8\frac{1}{2}$	*lb.*
B 46-465. With bright steel rods	**£3 15 0**	**£4 10 0**	**£5 15 0**	**£8 5 0**	*dozen*
	7/-	**8/6**	**10/6**	**15/-**	*each*


B 46-550.

B 46-550. STANDS, Test Tube, wood, with holes $\frac{7}{8}$ in. diam. and with one large hole $1\frac{1}{4}$ in. diam. at each end for boiling tubes.

For	6	12	24	*tubes*
No. of rows ..	1	1	2	
	£1 3 0	**£1 18 0**	**£3 0 0**	*dozen*
	2/2	**3/6**	**5/6**	*each*



B 46-560.



B 46-570.



B 46-590.



B 46-595.

B 46-556. STANDS, Test Tube, Hardwood, with 6 large holes, $1\frac{3}{8}$ in. diam., for large boiling tubes — £ s. d.
each 0 4 0

B 46-560. STANDS, Test Tube, Hardwood, with pegs, with holes $\frac{7}{8}$ in. diam., and with one large hole $1\frac{1}{4}$ in. diam. at each end for boiling tubes.

For	6	8	12	*tubes*
	£1 18 0	£2 8 0	£3 0 0	*dozen*
	3/6	4/6	5/6	*each*

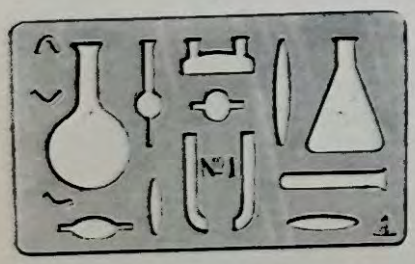
B 46-565. STANDS, Test Tube, Hardwood, with pegs and 6 large holes, $1\frac{3}{8}$ in. diam., for boiling tubes .. .. *each* 0 5 0

B 46-570. STANDS, Test Tube (Drainers), Hardwood, on stout base, with pegs for use in supporting test tubes during drainage.

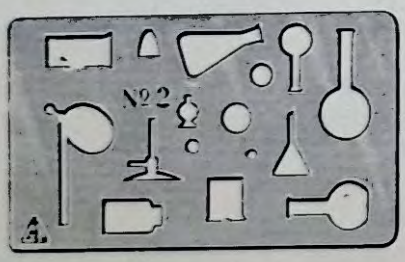
For	12	24	36	*tubes*
	£1 18 0	£3 10 0	£5 5 0	*dozen*
	3/6	6/6	9/6	*each*

B 46-590. STANDS, Tripod, Circular Top, soundly constructed. Malleable iron tops of adequate cross section fitted securely screwed-in mild steel legs shaped to give maximum stability. Height 8 in., top 5 in. diam. .. .. *each* 3/6 ; *dozen* 1 18 0

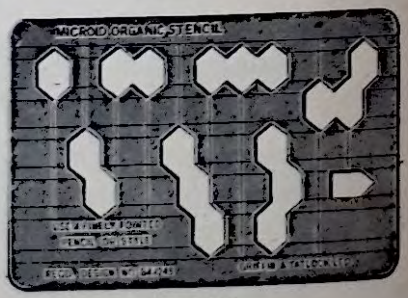
B 46-595. Ditto, Triangular Top .. .. *each* 2/9 ; *dozen* 1 10 0



B 46-630. No. 1.



B 46-630. No. 2.



B 46-632.

B 46-630. STENCILS, Chemistry, Celluloid, $5\frac{1}{8} \times 3\frac{1}{4}$ in., for the use of students. Enables neat and symmetrical drawings to be made quickly and easily.

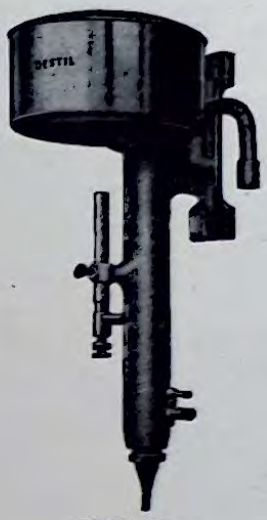
Type	No. 1	No. 2	
	18/-	18/-	*dozen*
	1/8	1/8	*each*

B 46-632. MICROID ORGANIC STENCIL (*Regd. Design No.* 844249), transparent plastic sheet, about 5 × 3 in., with sharp-edged, precision-cut rings .. .. *each* 4/6 ; *dozen* — £ s. d. 2 10 0

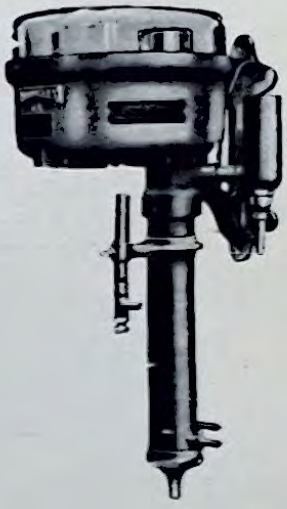
The Microid Organic Stencil consists of eight characteristic ring-systems cut in transparent plastic, viz., one five-membered ring, one benzene ring, and two arrangements each of the naphthalene, anthracene and phenanthrene types of ring, from which almost any five- or six-membered ring system can be constructed. Alignment is facilitated by the provision of horizontal lines, and the building up of complex formulæ, by the separation of the ring-systems from one another by a space equal to the width of one benzene ring.



B 46-730.



B 46-765.



B 46-770. Size OA, Gas.

B 46-730. STILLS, Water, Automatic, gas heated, new pattern, stout gauge hard rolled copper, boiler and other parts in contact with water are heavily coated with pure tin. Modern efficient design. Covered top prevents liberation of water vapour into the laboratory, and prevents also accumulation of dirt and dust on free water surface of open top exposed in earlier designs.

Output ..	½	1	2	4	6	*gals./hour*
Gas consumption	40	75	100	200	250	*cu. ft./hour*
	r £7 10 0	£10 0 0	£17 10 0	£32 10 0	£80 0 0	*each*

STILLS, Water, Automatic, Destil, designed for use in small laboratories where large quantities of distilled water are not required. Entirely automatic in action, fitted with Pyrex glass inner baffle, preventing entrainment of raw water in the vapour passing to the condenser, removable heavily-tinned brass condenser tube. Supplied with wall-mounting bracket. Occupy little space and are easy to clean. The electric model, fitted with a 1000 watt element, is automatically controlled, switching off current should the water supply fail.

	£	s.	d.
B 46-765. Gas heated, output 2 pints/hr., consumption 14 cu. ft./hr., weight 12 lb., height 21 in. *tx*	6	0	0
B 46-767. Electrically heated, output 2 pints/hr., loading 1 kw., weight 12 lb., height 21 in. *tx*	8	0	0
B 46-768. Elements, spare, for above .. .. *each tx*	2	4	0

Please state voltage when ordering.

B 46-770. STILLS, Water, Automatic, Manesty. For production of chemically pure water above B.P. requirements. Compact, cast iron construction. Use is made of heat given up by condensed vapour to preheat feed water before it enters boiling chamber. This frees the water from ammonia and other gaseous impurities, Efficient baffling separates all entrained drops of raw water before vapour enters block tin-lined condenser tubes, thereby preventing pollution from this source. No floor, or valuable bench space is required as the stills are arranged to hang on a bracket fastened to the wall.

A Pyrex glass dome permits observation of operation at all times and is easily removed for cleaning the boiling chamber. The efficiency of the triple baffles makes these stills particularly suitable for use with hard water, or natural waters having a tendency to froth. Automatic water feed regulator, easily detached for cleaning.

Electrically heated stills are fitted with an automatic cut-out operating when water supply fails, or excess scale causes overheating of the elements.

Gas-heated stills can be fitted at extra cost, with an automatic gas cut-off operating when the water supply fails. No pilot jet is fitted, as the gas supply cannot come on again until the valve is reset by hand.

Type	Output *pints/hr.*	Method of Heating and Consumption	Weight *lb.*	Height *in.*	Price £ s. d.	Spare Element £ s. d.
					tx	*tx*
OA	3	Electric, 1·5 kw.	46	25½	11 11 0	2 8 5
OA	3	Gas, 14 cu. ft./hr.	46	25½	9 9 0	—
OOA	8	Electric, 3 kw.	68½	29½	17 10 0	2 8 5
OOA	8	Gas, 36 cu. ft./hr.	68½	29½	11 8 0	—

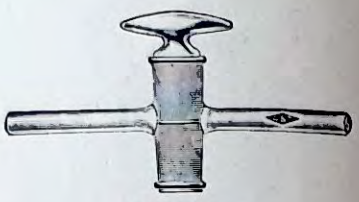
Please state voltage when ordering electric stills.



B 47-065.



B 47-068.



B 47-085.

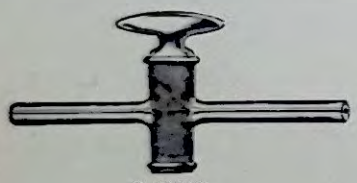
B 47-065. STOPCOCKS, Straight Bore, Soda Glass, for aspirators, water bottles, etc. Sizes 8 and 10 mm. are fitted with hollow plugs.

Approx. bore of plug ..	1	2	3	4	*mm.*
Approx. diam. of tubing ..	6–7	7–8	7–8	8–9	*mm.*
	4/6	**5/-**	**5/6**	**7/-**	*each*
Approx. bore of plug ..	5	6	8	10	*mm.*
Approx. diam. of tubing ..	9–10	11	12	14–15	*mm.*
	8/-	**10/-**	**19/-**	**27/-**	*each*

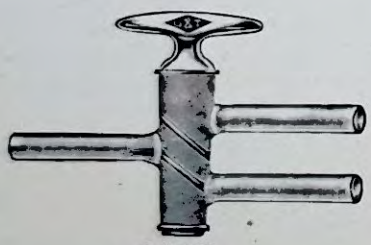
B 47-068. STOPCOCKS, Burette, Soda Glass, for sealing to burettes and other apparatus, straight bore 1–2 mm. .. .. £ s. d. *each* **0 4 0**

B 47-085. STOPCOCKS, Straight Bore, Soda Glass, with plug drilled to connect both arms, overall length about 30 cm. Sizes 8–15 mm. are fitted with hollow plugs.

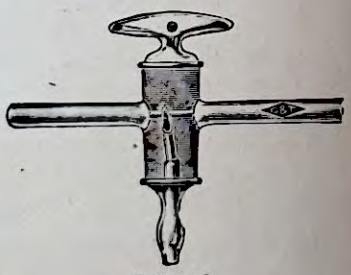
Approx. bore of plug	1	2	3	4	5	*mm.*
Approx. diam. of tubing	6–7	7–8	8	8–9	9–10	*mm.*
	4/3	**4/6**	**5/-**	**5/6**	**7/6**	*each*
Approx. bore of plug ..	6	8	10	15		*mm.*
Approx. diam. of tubing ..	10–11	11–12	15	18		*mm.*
	9/-	**15/6**	**£1 2 6**	**£2 5 0**		*each*



B 47-090.



B 47-106.



B 47-116.

B 47-090. STOPCOCKS, Straight Bore, Soda Glass, capillary tubing, overall length about 30 cm.

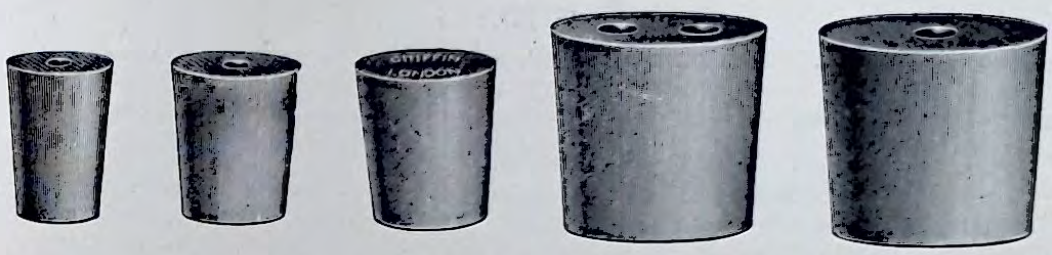
Approx. bore of plug	1	2	3	*mm.*
Approx. diam. of tubing	6–7	6–7	8	*mm.*
	5/-	**5/6**	**6/6**	*each*

B 47-106. STOPCOCKS, Oblique Bore, three-way, Soda Glass, plug drilled obliquely with two parallel bores to connect single tube to either of two tubes on opposite sides. Overall length about 30 cm.

Approx. bore of plug	2	3	*mm.*
Approx. diam. of tubing	7–8	8	*mm.*
	p **8/6**	**10/-**	*each*

B 47-116. STOPCOCKS, three-way, Soda Glass, with plug drilled to connect two side tubes at 180° and with bore through nozzle to connect either side tube to outlet at bottom. Overall length about 30 cm.

Approx. bore of plug ..	1	2	3	4	5	*mm.*
Approx. diam. of tubing ..	6–7	7–8	8	8–9	9–10	*mm.*
	8/-	**8/6**	**10/-**	**11/-**	**14/6**	*each*



B 47-220. Short Form.



B 47-225. Tall Form.

STOPPERS, Rubber, best quality. Stopper numbers express the bottom diameter of the stopper to the nearest 0·5 mm. Supplied either solid, or with one or two holes of diameter appropriate to the size of the stopper. Holes of special size bored if requested on order, stating size and position of holes. *Please state Cat. No. when ordering.*

Cat. No. → **B 47-220.**

SHORT FORM.

Size No.	Dimensions			Price	
	Bottom Diam. *mm.*	Top Diam. *mm.*	Length *mm.*	*each*	*dozen*
10 S	10	13	19	3d.	2/-
11 S	11	13	19	3d.	2/3
13 S	13	16	19	3d.	2/3
14 S	14	17	19	3d.	2/6
16 S	16	19	19	4d.	2/9
17 S	17	21	19	4d.	3/-
19 S	19	22	19	4d.	3/-
21 S	21	24	25	5d.	4/3
22 S	22	25	25	6d.	5/-
24 S	24	27	25	7d.	5/6
25 S	25	29	25	8d.	6/6
27 S	27	30	25	9d.	7/6
29 S	29	32	25	10d.	8/6
30 S	30	33	29	10d.	9/-
32 S	32	38	32	11d.	10/-
35 S	35	41	32	1/2	12/-
38 S	38	44	32	1/4	14/6
41 S	41	48	32	1/8	17/6
44 S	44	54	32	1/9	19/-
47 S	47	57	32	2/3	24/-
51 S	51	57	32	2/6	27/-
57 S	57	63	35	3/-	33/-
63 S	63	70	38	4/-	44/-
70 S	70	76	44	5/6	60/-
76 S	76	83	44	7/6	82/6

Cat. No. → **B 47-225.**

TALL FORM.

Size No.	Dimensions			Price	
	Bottom Diam. *mm.*	Top Diam. *mm.*	Length *mm.*	*each*	*dozen*
5 T	5	10	19	4d.	3/6
6 T	6	11	17	4d.	3/6
10 T	10	13	18	5d.	3/9
11 T	11	15	21	5d.	4/3
13 T	13	17	24	5d.	4/6
14 T	14	18	25	6d.	5/-
16 T	16	21	25	7d.	5/6
17 T	17	23	28	8d.	6/6
19 T	19	24	28	9d.	8/-
21 T	21	27	29	11d.	10/-
22 T	22	29	31	1/1	11/6
25 T	25	31	32	1/4	14/6
29 T	29	33	33	1/9	18/6
30 T	30	37	36	2/3	23/-
32 T	32	40	40	2/6	28/-
38 T	38	41	43	3/6	37/-
41 T	41	46	49	4/9	52/6
48 T	48	51	52	6/6	72/6
49 T	49	62	51	7/6	80/-

When ordering please quote Cat. No. and size No. and if solid, one or two hole required.

If not specified on order, short form solid will be supplied.



B 47-546.

TEST TUBES

Soda Glass B 47-546.—For student use. Prices less 5 per cent. for quantities of 10 gross assorted sizes and over, less 7½ per cent. for quantities over 20 gross. Quantities less than ½ gross, 10 per cent. additional to prices.

Resistance Glass B 47-548—551.—For chemical and bacteriological purposes. Can be supplied *without rim* at similar prices, if so ordered. Prices less 5 per cent. for quantities of 5 gross and over of any one size. Quantities less than ½ gross, 10 per cent. additional to prices.

Monax Glass B 47-552—554.—For chemical and bacteriological purposes. Can be supplied *without rim* at similar prices, if so ordered. Quantities less than ½ gross, 10 per cent. additional to prices.

Pyrex Glass B 47-556.—For chemical and bacteriological purposes. Can be supplied *without rim* at similar prices, if so ordered. Gross rates apply to lots of half-gross and over.

Please state Catalogue No. when ordering.



B 47-552—554.

Cat. No. → (See notes above)		B 47-546	B 47-548	B 47-551	B 47-552	B 47-554	B 47-556	
		Soda Glass	British Resistance Glass	Hysil Resistance Glass	Monax Resistance Glass	Monax Resistance Glass	Pyrex Resistance Glass	
Dimensions			Ord. weight		Ord. weight	Heavy weight		
inch	*mm.*	*gross*	*gross*	*gross*	*gross*	*gross*	*dozen*	*gross*
			r	*tx*	*tx*	*tx*	*tx*	*tx*
1½ × ⅜	—	7/-	—	—	—	—	—	—
2 × ¼	—	6/-	7/5	—	8/3	10/9	—	—
2 × ⅜	—	6/6	7/1	—	8/3	10/9	—	—
2 × ½	—	6/6	9/1	—	10/4	14/1	—	—
2¼ × ⅜	—	6/-	—	—	—	—	—	—
3 × ⅜	—	6/6	7/10	—	9/1	12/-	—	—
—	75 × 10	—	—	—	—	—	1/1	11/7
3 × ½	—	7/-	9/6	11/3	10/9	14/1	—	—
4 × ½	—	8/6	10/4	13/6	12/-	15/8	—	—
—	100 × 12	—	—	—	—	—	1/5	15/1
4 × ⅝	—	10/-	13/8	—	15/8	19/-	—	—
5 × ½	—	9/6	12/5	—	14/1	19/-	—	—
5 × ⅝	—	11/6	14/6	18/9	16/6	21/6	—	—
—	125 × 15	—	—	—	—	—	1/11	21/-
5 × ¾	—	13/6	17/9	—	20/3	26/-	—	—
6 × ½	—	11/-	13/8	—	15/8	21/6	—	—
6 × ⅝	—	13/-	16/6	21/5	19/-	25/2	—	—
—	150 × 16	—	—	—	—	—	2/2	24/2
6 × ¾	—	15/6	20/8	27/-	23/11	31/-	—	—
—	150 × 18	—	—	—	—	—	2/9	30/6
—	150 × 20	—	—	—	—	—	3/2	36/1
6 × 1	—	27/6	31/-	40/6	35/6	54/6	—	—
—	150 × 25	—	—	—	—	—	3/11	45/2
6 × 1¼	—	62/6	49/6	—	57/9	90/9	—	—
—	175 × 22	—	—	—	—	—	3/5	39/3
7 × 1	—	32/6	35/1	—	40/5	64/-	—	—
8 × 1¼	—	80/-	59/5	73/11	70/2	115/6	—	—
—	200 × 29	—	—	—	—	—	6/4	73/6
8 × 1½	—	105/-	78/5	101/3	99/-	160/11	—	—
10 × 1½	—	125/-	111/5	—	125/5	229/5	—	—

B 47-560. TEST TUBES, thick combustion glass.

Length × diam.	2 × ½	3 × ½	4 × ½	5 × ⅝	5 × ¾	6 × ⅝	6 × ¾	6 × 1	*in.*
r	£1 3 0	£1 5 0	£1 9 0	£2 2 0	£3 0 0	£2 15 0	£3 5 0	£5 0 0	*gross*
r	2/3	2/6	2/9	5/-	5/6	5/-	6/-	9/6	*dozen*

B 47-562. TEST TUBES, for ignition and arsenic tests, closed end, of hardest combustion glass.

Length × diam. ..	2 × ½	3 × ½	3 × ⅝	4 × ½	*in.*
r	18/6	£1 0 0	£1 4 0	£1 2 0	*gross*
r	1/10	1/11	2/3	2/3	*dozen*



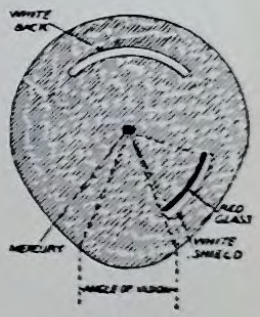
B 47-635.—Engraved Stem.

B 47-635. THERMOMETERS, Chemical, Engraved Stem, approx. 6 mm. diam., 30 cm. long, mercury filled. **British manufacture,** nitrogen filled, with bulbs of N.P.L. standard blue stripe thermometric glass, and top safety chamber. Accurate to within 2 per cent. of total scale range. In cylindrical card case.

	Fahrenheit				Centigrade					
Range →	150°	240°	400°	600°	110°	150°	210°	250°	360°	400°
Graduated	1°	1°	2°	2°	1°	1°	1°	1°	2°	2°
dozen .	£3 0 0	£3 0 0	£3 5 0	£4 10 0	£3 0 0	£3 5 0	£3 12 6	£3 17 6	£4 7 6	£4 10 0
each .	5/6	5/6	6/6	8/6	5/6	6/-	6/6	7/-	8/-	8/6



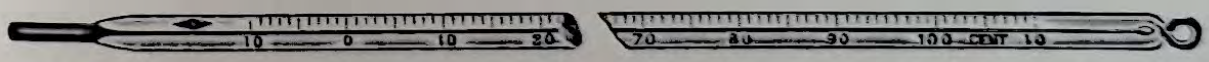
B 47-645.—Red-reading Mercury.



B 47-645.
Cross-section of Stem.

B 47-645. THERMOMETERS, Chemical, Engraved Stem, RED-READING MERCURY. Mercury filled, approx. 6 mm. diam., 30 cm. long. These thermometers are constructed of special glass tube containing a strip of opaque red coloured glass backed by an integral opal strip. The flattened bore of the tube is placed at such an angle that the red strip is reflected from the bright surface of the mercury column, which is considerably magnified by the lens front. The mercury thus appears to be coloured red. The red strip is permanently embedded in the glass tube, and cannot be displaced, nor affected by acids or heat. The mercury column is easily visible at a distance and is sharply defined at the point to be read. Steam and condensed water do not affect visibility, which is good even in dimly illuminated situations.

Range ..	240° F.	400° F.	600° F.	110° C.	200° C.	360° C.	
Graduated	2°	2°	2°	1°	2°	2°	
	£5 10 0	£6 10 0	£7 5 0	£5 10 0	£6 10 0	£7 5 0	*dozen*
	10/-	11/6	13/-	10/-	11/6	13/-	*each*



B 47-650—652.—Engraved Stem, Short pattern.

THERMOMETERS, Chemical, Engraved Stem, short pattern, approx. 6 mm. diam., mercury filled. These thermometers will be found to have many useful laboratory applications in cases where the normal length of chemical type of thermometer is unsuitable. Graduated in single degrees.

Range 0° to	100° F.	220° F.	50° C.	110° C.	
B 47-650. Length 15 cm.	3/6	3/6	3/6	3/6	*each*
B 47-652. Length 20 cm.	4/6	4/6	4/6	4/6	*each*



B 47-660.—Engraved Stem with 15 cm. blank

B 47-660. THERMOMETERS, Chemical, Engraved Stem, with 15 cm. blank stem above bulb, overall length approx. 30 cm., diam. 6 mm., mercury filled. Specially designed to be used in calorimeters and other apparatus, in which the lower, ungraduated portion is obscured, and full scale visibility is required.

Range ..	0° to 240° F.	200° to 450° F.	450° to 700° F.	
Graduated ..	2°	2°	2°	
	£3 0 0	£4 10 0	£5 5 0	*dozen*
	5/6	8/-	10/-	*each*
Range ..	0° to 110° C.	100° to 210° C.	200° to 360° C.	
Graduated ..	1°	1°	2°	
	£3 0 0	£4 10 0	£5 5 0	*dozen*
	5/6	8/-	10/-	*each*



B 47-670.—Engraved Stem, Specially Tested.

B 47-670. THERMOMETERS, Chemical, Engraved Stem, specially tested, and accurate to 0·1°. Approx. 6 mm. diam., 30 cm. long. British manufacture, mercury filled bulbs of N.P.L. standard blue stripe thermometric glass, safety chamber at top. Complete in case.

Range	220° F.	600° F.	110° C.	360° C.	
Graduated	1°	2°	1°	1°	
	£6 0 0	£7 10 0	£6 0 0	£7 10 0	*dozen*
	11/-	14/-	11/-	14/-	*each*

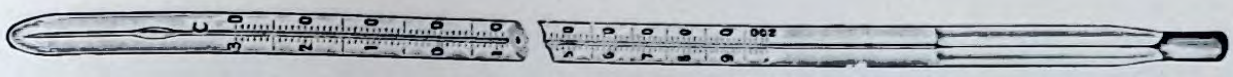


B 47-675.—Engraved Stem, Sub-divided.

B 47-675. THERMOMETERS, Chemical, Engraved Stem, sub-divided, approx. 6 mm. diam., 35 cm. long, mercury filled. British manufacture, white enamel back tube, with bulbs of N.P.L. standard blue stripe thermometric glass, and safety chamber at top. Graduated at 6 cm. immersion. In cylindrical card case.

	Centigrade.						
Range →	— 20° to + 20°	— 5° to 35°	— 5° to 50°	— 5° to 50°	— 40° to 105°	— 5° to 105°	50° to 105°
Sub-division	0·1°	0·1°	0·1°	0·2°	0·5°	0·2°	0·1°
dozen .	£7 10 0	£7 10 0	£8 15 0	£6 15 0	£7 10 0	£8 5 0	£8 5 0
each .	14/-	14/-	15/6	12/6	14/-	15/-	15/-

	Centigrade			Fahrenheit			
Range →	50° to 105°	— 10° to 110°	50° to 150°	30° to 100°	100° to 212°	20° to 230°	20° to 400°
Sub-division	0·2°	0·5°	0·2°	0·1°	0·2°	0·5°	0·5°
dozen .	£7 10 0	£5 10 0	£8 5 0	£8 15 0	£9 10 0	£6 5 0	£9 10 0
each .	14/-	10/-	15/-	15/6	17/6	11/6	17/6



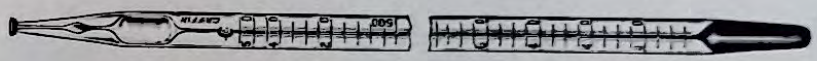
B 47-730.—Engraved Stem, Low Temperature.

B 47-730. THERMOMETERS, Chemical, Engraved Stem, Low Temperature. Diam. approx. 6 to 7 mm. In cylindrical card case.

	Centigrade			
Range →	− 40° to + 40°	− 80° to + 30°	− 120° to + 20°	− 200° to + 20°
Graduated ..	0·5°	1°	1°	1°
Filled with ..	Mercury	Toluene	Toluene	Pentane
Length approx.	30 cm.	35 cm.	40 cm.	43 cm.
each	17/6	£1 7 0	£1 15 0	£3 15 0



B 47-731.—High Temperature.



B 47-732.—High Temperature

B 47-731. THERMOMETER, Engraved Stem, High Temperature, reading to 550° C., approx. 7 mm. diam., 50 cm. long. Borosilicate glass, gas filled under high pressure. Engraved range **250° to 550° C.** in 1° C., with a zero mark at 0° C. In card case .. .. £ 2 10 0

B 47-732. Ditto, reading from **0° to 550° C.** in 1° C. In card case .. .. £ 2 0 0

B 47-733. Ditto, reading from **0° to 1000° F.** in 2° F. In card case .. .. .. £ 2 0 0

B 47-760. THERMOMETERS, Standard, Grade I, Chemical, Engraved Stem, highest accuracy, approx. 7 mm. diam., mercury filled. Each thermometer supplied in card case.

Range	Sub-division	Length	Unverified	With N.P.L. Certificate	Details of N.P.L. Verification		
					Tested at every	Corrections given to	Limit of accuracy of test
		cm.	£ s. d.	£ s. d.			
CENTIGRADE			*p*	*t*			
− 5° to 50° ..	0·2°	35	2 2 6	3 5 0	10°	0·01°	± 0·02°
− 5° to 50° ..	0·1°	38	2 6 0	3 10 0	10°	0·01°	± 0·02°
50° to 105° ..	0·2°	35	2 6 0	3 10 0	10°	0·01°	± 0·02°
50° to 105°	0·1°	38	2 15 0	3 17 6	10°	0·01°	± 0·02°
− 5° to 105° ..	0·2°	45	2 15 0	4 10 0	10°	0·01°	± 0·02°
− 5° to 205° ..	0·5°	45	4 0 0	6 0 0	20°	0·02°	± 0·05°
− 5° to 305° ..	0·5°	45	4 5 0	7 0 0	25°	0·05°	± 0·1°
− 5° to 360° ..	0·5°	45	4 12 6	6 15 0	50°	0·1°	± 0·2°
− 5° to 420° ..	1°	50	4 12 6	7 0 0	50°	0·1°	± 0·2°
0° to 550°	1°	50	6 5 0	9 10 0	50° (to 450° only)	0·1°	± 0·2°

Thermometers unverified will be supplied if type required is not specified on order.

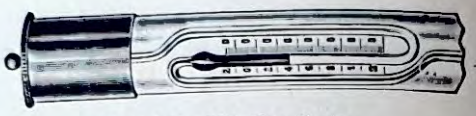
B 47-765. THERMOMETERS, Standard, Grade II, Chemical, Engraved Stem, high accuracy, approx. 8 mm. diam., mercury filled. Each thermometer supplied in card case.

Range	Sub-division	Length	Unverified	With N.P.L. Certificate	Details of N.P.L. Verification	
					Tested at every	Limit of accuracy of test
		cm.	£ s. d.	£ s. d.		
CENTIGRADE			*t*	*t*		
− 5° to 55° ..	0·1°	35	1 10 0	1 19 0	5°	± 0·05°
50° to 105° ..	0·1°	35	1 14 0	2 6 0	10°	± 0·05°
− 10° to 110° ..	0·2°	35	1 14 0	2 15 0	10°	± 0·05°
− 5° to 205° ..	0·5°	35	2 10 0	4 5 0	20°	± 0·2°
0° to 360° ..	0·5°	40	3 7 6	5 15 0	50°	± 0·5°
FAHRENHEIT						
0° to 120° ..	0·2°	35	1 14 0	2 2 0	10°	± 0·1°
20° to 220° ..	0·5°	35	1 19 0	2 15 0	20°	± 0·1°
20° to 300° ..	0·5°	35	2 8 0	3 17 6	50°	± 0·2°
30° to 400° ..	1°	35	2 15 0	4 15 0	50°	± 0·2°
30° to 600°	1°	40	3 0 0	5 10 0	100°	± 0·5°

Thermometers unverified will be supplied if type required is not specified on order.



B 47-775.



B 47-778—780, Top Scale.

B 47-775. THERMOMETER, Calorimeter, Beckmann, Enclosed Opal Scale of 6° divided in 0·01°, adjustable by means of the top bulb to any desired range within the limits of — 20° to 110° C., mercury filled. About 56 cm. long, 15 mm. diam., in strong card case — £ 3 15 0

B 47-778. Ditto, with auxiliary scale to the top bulb in order to facilitate setting the instrument to the desired range of temperature. The scale of 6° has **zero at bottom** for reading increase of temperature — £ 4 15 0

B 47-780. Ditto, as **B 47-778** but with scale having **zero at top** for reading decrease of temperature — £ 4 15 0

B 47-782. THERMOMETER, Calorimeter, Beckmann, Engraved Stem of 6°, divided in 0·01°, adjustable by means of enclosed opal auxiliary scale at top bulb to any desired range within limits of 0° to 100° C., mercury filled. About 67 cm. long, 8–9 mm. diam., graduations commencing 30 cm. from bulb, in strong card case — £ 5 5 0

B 47-785. N.P.L. Certificate for Beckmann Thermometers **B 47-775—782,** tested over any range of 5° C., at every 0·5° and corrections given to nearest 0·002° C.
each range of 5° *C.* — £ 2 10 0

When ordering Beckmann Thermometers with N.P.L. Certificate, please state :—(*a*) immersion, (*b*) working range(s) required to be tested, (*c*) zero-setting for each range, *e.g.* thermometer to be used over working range of 16-26° C. might have a zero for each 5° range = 15 and 20°.

Beckmann Thermometers with opal scales receive only a N.P.L. *Statement* and not a *Certificate.*

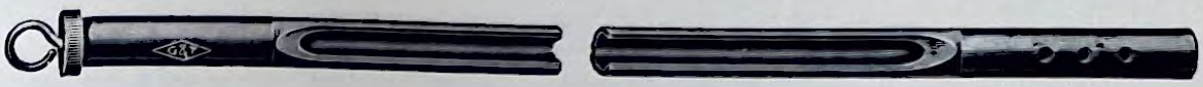


B 47-790.

B 47-790. THERMOMETERS, Bomb Calorimeter, Engraved Stem, B.S. 791—1938. Mercury filled bulbs of N.P.L. standard thermometric glass, expansion chamber at top. Maximum error at any point, ± 0·1° C. Maximum change in correction for any interval of 0·5°, ± 0·01° C. Diam. of stem, 11 mm. Length of scale, 30–35 cm. Overall length 65–70 cm.

These thermometers will, in general, be used at a fixed immersion of about 150 mm. Since it is the normal practice, however, to work with the calorimeter at a temperature close to that of the atmosphere surrounding it, the thermometers are specified for standardisation at total immersion. In calorimetry the absolute amount of the exposed stem correction is not of great importance, the results only being affected by the change in this correction between the initial and final temperatures.

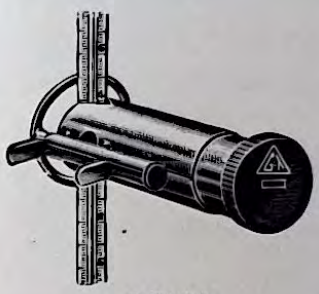
Schedule Mark and Range	Sub-division	Unverified £ s. d.	With N.P.L. Certificate £ s. d.	Details of N.P.L. Verification: Points Tested	Accuracy of Test	Corrections given to the nearest
Cal. 9° to 15° C.	0·01°	5 15 0	8 15 0	13	± 0·002°	0·001°
Cal. 12° to 18° C.	0·01°	5 15 0	8 15 0	13	± 0·002°	0·001°
Cal. 15° to 21° C.	0·01°	5 15 0	8 15 0	13	± 0·002°	0·001°
Cal. 18° to 24° C.	0·01°	5 15 0	8 15 0	13	± 0·002°	0·001°
Cal. 21° to 27° C.	0·01°	5 15 0	8 15 0	13	± 0·002°	0·001°
Cal. 24° to 30° C.	0·01°	5 15 0	8 15 0	13	± 0·002°	0·001°
Cal. 27° to 33° C.	0·01°	5 15 0	8 15 0	13	± 0·002°	0·001°
Cal. 8° to 20° C.	0·02°	4 2 6	6 2 6	13	± 0·005°	0·002°
Cal. 14° to 26° C.	0·02°	4 2 6	6 2 6	13	± 0·005°	0·002°
Cal. 20° to 32° C.	0·02°	4 2 6	6 2 6	13	± 0·005°	0·002°



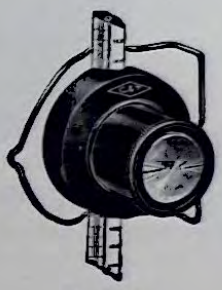
B 47-830—832.

CASES, Thermometer, Protective, 10 mm. diam., for protection of thermometers when in use, front cut away for scale reading. With screw top. Thermometers should be packed in a little asbestos yarn inserted in each end of case.

Length approx.	33	38	*cm.*
For thermometers length	30	35	*cm.*
B 47-830. Brass	*r* 8/6	9/6	*each*
B 47-832. Steel	*r* 10/6	11/-	*each*



B 47-850.



B 47-852.

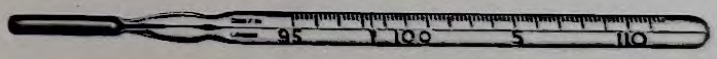


B 47-860.

B 47-859. MENISCUS READER, Magnifying, for thermometers, burettes, etc. In focussing drawtube, chromium-plated. Two pointers are fixed in the field of view. The thermometer is located in Vee-grooves, and the reader is held in position by a wire ring behind the thermometer controlled by a spring-loaded plunger, which can be operated with one hand for adjustment of position .. .. *r* 1 5 0

B 47-852. MENISCUS READER, Precision (*J. Sci. Instr.*, 1931, 8, 98), for thermometers, burettes, etc., up to 12 mm. diam. Designed to be used with the eye 20–30 cm. from the lens and thus to avoid eyestrain while giving greater comfort during observations. Provided with back and front sights to eliminate errors due to parallax. In velvet-lined, leatherette covered, snap-lid case .. .. *r* 2 5 0

B 47-860. GRADUATION FILLER, Jet Black, for restoring the legibility of graduation marks and figures of thermometers. etc. The compound is easily applied with a stick or cloth. The filler is rubbed in well and the excess wiped off with a piece of fairly stiff paper *bottle*, 10 *ml.* 0 1 9



B 47-935.

THERMOMETERS, Clinical, Engraved Stem, approx. 4 in. long, in metal cases. Each tested at N.P.L.

Type	2	1	½ *minute*
B 47-935. Ordinary Pattern	2/9	3/3	3/6 *each*
B 47-936. With Lens Front Tube	3/3	3/6	4/- *each*

B 47-937. N.P.L. Certificate for B 47-935—936 .. .. *each* *t* 0 2 0

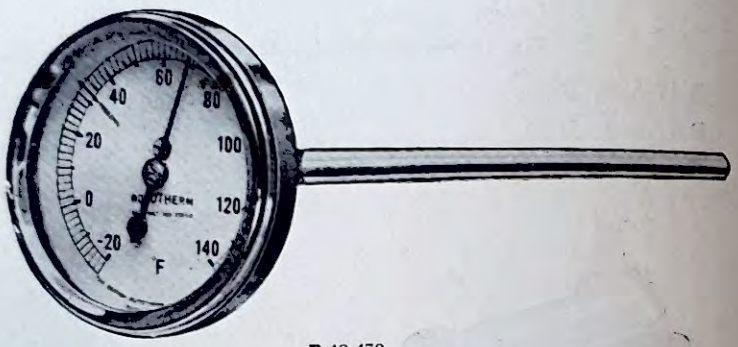
The General Index at the end of this Catalogue is a complete guide to its contents. Please consult it.



B 48-280.—For Projection Lantern.

B 48-280. THERMOMETER, Projection, Enclosed Transparent Scale, in glass tube approx. 15 mm. diam., 28 cm. long, mercury filled, Jena normal glass (*Foreign*), range 0° to 110° C. graduated in 1°. The figures on the scale are inverted in two senses in order to erect the projected image .. .. £ s. d. 0 8 0

B 48-470. THERMOMETER, Dial, Rototherm, bi-metallic, light immersion type, suitable for use in aquaria, sand baths, etc. White dial 2½ in. diam., with black figures, nickel-plated copper stem $\frac{5}{16}$ in. diam., 12 in. long. Available graduated 20-220° F., 0-300° F. or 0-160° C. £ s. d. *r* 1 19 3



B 48-470.

Please state range required when ordering.

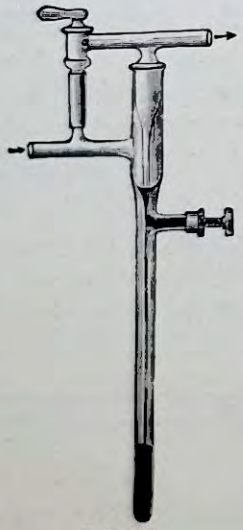
B 48-471. Ditto, for higher temperature ranges. Black anodised aluminium dial with engraved figures, martensitic iron stem.

Range	100–400° F.	100–550° F.	50–250° C.
	r £2 9 3	£3 0 3	£3 0 3 *each*

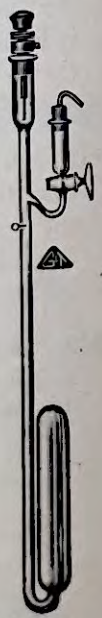
When ordering please state range required.



B 48-550



B 48-552.

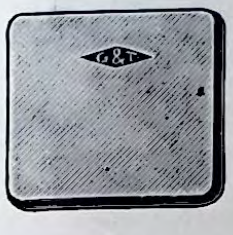


B 48-578.

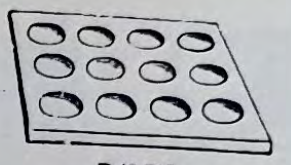
B 48-550. THERMOREGULATOR, Gas, Reichert, Mercury-filled, inlet tube for gas at top, which is ground-in to body. Outlet at side tube. Side arm with screw cemented in for fine adjustment of temperature at which thermostat operates. With **non-adjustable** by-pass. Overall height 14 in. .. .. £ s. d. *r* 1 7 0

B 48-552. Ditto, but with stopcock at top to enable size of by-pass flame to be adjusted. Overall height 14 in. .. .. *r* 1 12 0

B 48-578. THERMOREGULATOR, Electric, Toluene. One of the simplest and most satisfactory forms in common use. Cylindrical bulb about 6 × 1 in., platinum contact, side arm with stopcock and cup for coarse adjustment of range, and head with platinum contact, adjustable on screw for fine adjustment. Overall height about 20 in. **Unfilled** .. *r* 1 10 0



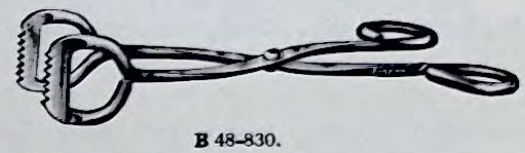
B 48-714.



B 48-716.



B 48-732—734.



B 48-830.

B 48-714. TILES, Porcelain, white, glazed both sides, square, for spotting and colour tests.

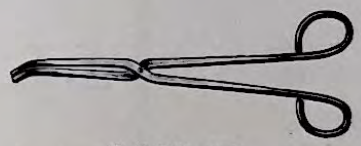
Sides	10	15	20	25 *cm.*
	tx 4/-	5/-	11/-	13/- *each*

B 48-716. TILE, Spotting, Porcelain, white, glazed, 11·5 × 8·5 cm., with 12 cavities .. *tx* £ 0 s. 9 d. 0

B 48-732. TILES, Porcelain, glazed half black and half white on one side, with cork cemented on reverse side, 6 × 6 in. .. .. *each* 0 3 6

B 48-734. Ditto, without cork .. .. *each* 0 2 6

B 48-830. TONGS, Laboratory, Pick-up, Fisher Pattern, stainless steel, about 7 in. long, with 1 in. serrated, stirrup-shaped jaws, which firmly hold even the thinnest paper, tubes 10 mm. or more diameter, and small beakers up to 150 c.c. capacity. Useful also for picking up weighing bottles, watch glasses, microscope slides, hot wire gauzes, etc.
each tx 3/- ; *dozen* 1 13 0



B 48-850—852.



B 48-878.

TONGS, Crucible, laboratory type, straight, made of stout wire, rolled flat at joint, securely riveted. Jaws corrugated on inside to give firm grip.

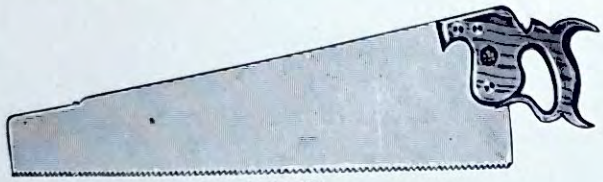
	Brass.	Light Wrought Iron.	Nickel.	Stainless Steel.	
			tx		
B 48-850. Length 6 in. ..	17/-	8/6	£1 14 0	£2 5 0	*dozen*
	1/7	10d.	3/3	4/3	*each*
B 48-852. Length 8 in. ..	£1 0 0	9/6	£2 5 0	£2 17 6	*dozen*
	1/10	11d.	4/3	5/6	*each*

TONGS, Crucible, laboratory type, with bow, made of stout wire, rolled flat at joint, securely riveted. Jaws corrugated on inside to give firm grip.

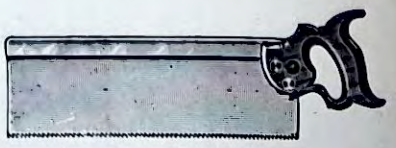
	Brass.	Light Wrought Iron.	Nickel.	Stainless Steel.	
			tx		
B 48-856. Length 6 in. ..	—	8/6	£1 14 0	£2 9 0	*dozen*
	—	10d.	3/3	4/6	*each*
B 48-858. Length 8 in. ..	£1 3 0	11/6	£2 5 0	£3 0 0	*dozen*
	2/3	1/1	4/3	5/6	*each*

TONGS, Crucible, laboratory type, 8 in. long, very best forged make, with accurately made lock-joint, giving smooth, even operation. Jaws corrugated inside to provide secure grip.

	Gunmetal.	Nickel-plated Iron.	Nickel Silver.	
B 48-875. Straight	£1 17 0	£2 9 0	£4 2 6	*dozen*
	3/6	4/6	7/6	*each*
B 48-878. With bow	£1 18 0	£2 12 6	£4 5 0	*dozen*
	3/6	4/9	8/-	*each*



B 48-980.



B 48-982.

B 48-980. SAWS, Hand, best Sheffield cast steel.

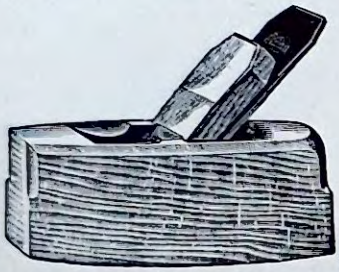
Length	20	22	24	26	*in.*
r	12/-	13/6	15/-	16/-	*each*

B 48-982. SAWS, Tenon, Iron Back, best Sheffield cast steel.

Length	8	10	12	14	*in.*
r	10/6	10/6	11/-	11/6	*each*



B 48-986.



B 48-992.



B 48-994.

		£	s.	d.
B 48-986. SAW, Pad, beech	*r*	0	2	0

B 48-988. Blades for above, best cast steel.

Length	8	10	12	*in.*
r	9/6	10/-	11/-	*dozen*

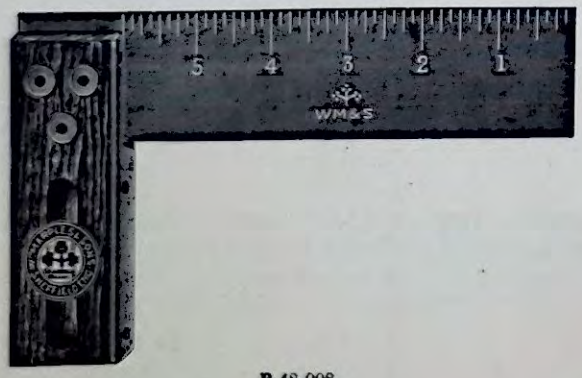
B 48-992. PLANES, Smoothing, Sheffield steel, double irons, beech blocks.

Width of iron	2	2⅛	2¼	*in.*
r	8/6	9/-	9/6	*each*

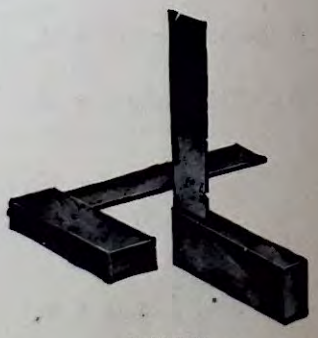
B 48-994. PLANES, Iron, Smoothing, with base ground and polished. Blade 2 in. wide *each* *t* 1 10 0



B 48-995.



B 48-998.



B 49-002.

		£	s.	d.
B 48-995. OIL CAN, round, with brass bottom and wide mouth	*r*	0	2	6
B 48-996. OIL, Clock, highly refined for lubricating fine mechanism	*bottle*	0	1	6

B 48-998. TRY SQUARES, Rosewood, with brass plated stock and blued steel blade graduated both sides inches and ⅛ in.

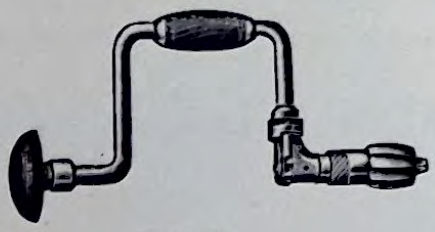
Length	4½	6	9	12	*in.*
r	3/9	4/9	6/-	7/6	*each*

B 49-002. SQUARES, Steel, engineers', made to an accuracy of 0·001 inch per foot, each in separate wood box.

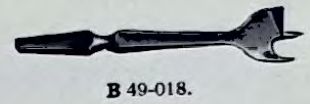
Length ..	2	3	4	5	6	8	10	*in.*
r	5/-	5/-	5/6	6/6	7/6	12/6	17/-	*each*



B 49-010.



B 49-012.



B 49-018.



B 49-022.

BRACES, Joiners', best quality. £ s. d.

B 49-010. Plain Brace, bright finish, 5 in. sweep, ball-bearing head .. .. *t* 0 14 0

B 49-012. Ratchet Brace, bright finish, 8 in. sweep .. .. *r* 0 16 0

BRACE BITS, Cast Steel, black finish.

Diam. ..	¼	⅜	½	⅝	¾	⅞	1	1⅛	1¼	*in.*
B 49-018. Centre Bits .. *r*	11d.	11d.	1/1	1/2	1/3	1/4	1/5	1/8	1/10	*each*

Diam. ..	..	..	⅛	3/16	¼	5/16	⅜	*in.*
B 49-020. Twist Gimlet Bits .. .. *r*			1/5	1/7	1/10	2/3	2/6	*each*
B 49-022. Turnscrew Bits .. .. *r*			—	—	11d.	11d.	11d.	*each*



B 49-026.



B 49-028.



B 49-030.



B 49-032.



B 49-038.



B 49-040.



B 49-044.

(Specifications and prices, p. 498)

B 49-026. SCREWDRIVERS, Cabinet, with oval beech handles.

Length of blade ..	4	5	6	8	10	12	*in.*
r	2/-	2/6	3/3	4/-	4/9	5/9	*each*

B 49-028. SCREWDRIVERS, Ratchet, with slide-in ferrule, which enables the blade to be either fixed, or set for right-handed or left-handed turning.

Length of blade	4	5	6	*in.*
r	3/6	4/9	5/-	*each*

B 49-030. SCREWDRIVERS, Electricians', with insulated handle, tested to 5000 volts.

Length of blade	5	6	7	8	*in.*
r	1/6	1/9	2/-	2/6	*each*

B 49-032. SCREWDRIVER, Pocket, steel, with revolving head and milled handle, for fine mechanical work. Approx. 3¼ in. long. To carry in pocket, reverse the blade, insert in handle and give slight turn of the chuck .. .. *r* £ 0 s. 1 d. 9

B 49-038. BRADAWLS, $\frac{1}{16}$ in. to $\frac{1}{8}$ in. diam., best quality round beech handles (Illustration, p. 497) .. .. *each* r **9d.** ; *dozen* £ s. d. **0 7 6**

B 49-040. GIMLETS, Twist, with square tang and boxwood head (Illustration, p. 497).

Diam.	$\frac{1}{8}$	$\frac{3}{16}$	$\frac{1}{4}$	*in.*
	r **8d.**	**9d.**	**1/-**	*each*

B 49-044. PINCERS, Tower, best quality, drop forged steel (Illustration, p. 497).

Length	6	7	*in.*
	Prices on application.		

B 49-046. GLUE POT, iron, with tinned inside lining.

Capacity	$\frac{1}{2}$	1	*pint*
	r **8/6**	**10/6**	*each*



B 49-046.

B 49-050. AERO GLUE, Croid, in tins.

Capacity	$\frac{1}{2}$	1	2	*lb.*
	t **1/6**	**2/9**	**5/-**	*each*

B 49-056. SECCOTINE .. .. *tube* £ s. d. t **0 0 11**



B 49-072.



B 49-076.

B 49-072. SPIRIT LEVELS, Hexagonal, brass mount, nickel-plated.

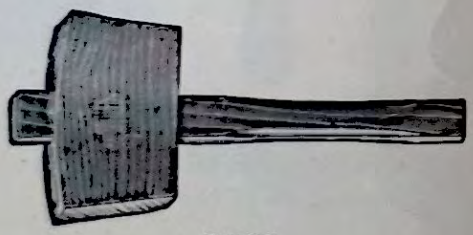
Length	2½	3½	*in.*
	r **2/6**	**3/3**	*each*

B 49-074. SPIRIT LEVELS, 6 in. long, beech-cased, brass top .. .. *each* £ s. d. r **0 2 0**

B 49-076. Ditto, 8 in. long, round tipped ends and brass top .. .. *each* r **0 3 0**



B 49-082.



B 49-088.

B 49-082. CHISELS, Firmer, best Sheffield cast steel, with round ash handles.

Width	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{7}{8}$	1	1¼	1½	*in.*
	r **1/7**	**1/8**	**1/9**	**1/10**	**2/-**	**2/-**	**2/3**	**2/6**	**3/-**	**3/9**	*each*

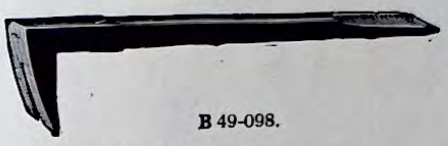
B 49-088. MALLETS, Joiners', best quality beech, with mortised handles.

Size of stock	4	5	*in.*
	r **3/-**	**3/9**	*each*

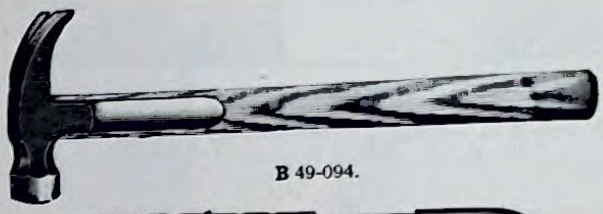
Please consult the General Index at the end of the Catalogue.



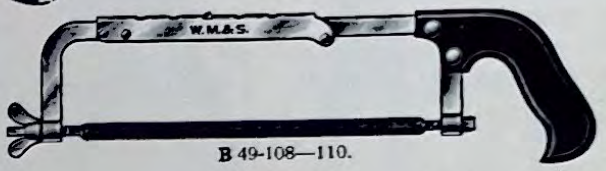
B 49-092.



B 49-098.



B 49-094.



B 49-108—110.



B 49-105.

HAMMERS, best quality.

Weight of head	6	8	10 oz.
B 49-092. **Joiners' or Warrington**	r 2/6	2/9	3/- *each*
B 49-094. **Canterbury Claw**	r 6/-	6/6	7/6 *each*

B 49-098. **CASE OPENERS**, forged from best steel. Length	12	14	16 *in.*
	r 3/9	4/6	5/- *each*

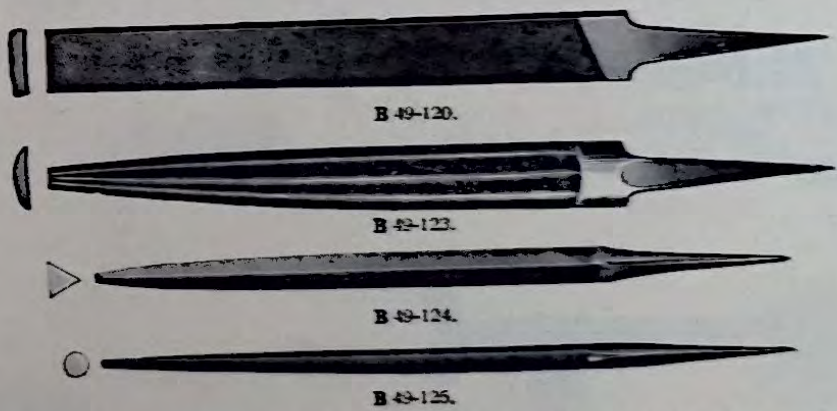
B 49-105. **COLD CHISELS**, best quality cast steel, 6 × ½ in. Four cuts available. Flat, Cross-cut, Diamond or Half-round .. .. *each* r 0 1 0

B 49-108. **HACKSAW**, steel back, sheath adjustment, black wood pistol handle, thumbscrew strainer, frame nickel-plated, for blades 8 to 12 in. .. .. r 0 6 6

B 49-110. **HACKSAW BLADES**, finest Sheffield steel. Length	8	9	10	12 *in.*
	r 3/-	3/6	3/9	4/6 *dozen*



B 49-115.



B 49-120.

B 49-123.

B 49-124.

B 49-125.



B 49-126.

RAWLPLUGS, a medium for making firm fixtures in all materials. Suitable for erecting shelving or physical apparatus on walls of tile, brick, plaster, wood, etc. Neat, invisible and very strong.

		£ s. d.
B 49-115. **Popular Outfit**	*each*	t 0 2 6
B 49-118. **Mechanics' Outfit**	*each*	t 0 9 0

FILES, best Sheffield, **without handles.**

Length ..	3	4	6	8	10 *in.*
B 49-120. **Hand, Bastard**	r 1/3	1/3	1/4	1/10	2/3 *each*
B 49-122. **Ditto, Smooth**	r 1/4	1/4	1/10	2/3	2/10 *each*
B 49-123. **Half-round** ..	r 1/2	1/4	1/4	2/-	— *each*
B 49-124. **Three-square** ..	r 1/2	1/2	1/7	2/-	— *each*
B 49-125. **Round**	r 1/-	1/-	1/2	1/4	— *each*

B 49-126. **FILE HANDLES**, hardwood, with brass ferrules. Size	Small.	Large.
	r 5/3	7/6 *dozen*



B 49-132.



B 49-133.

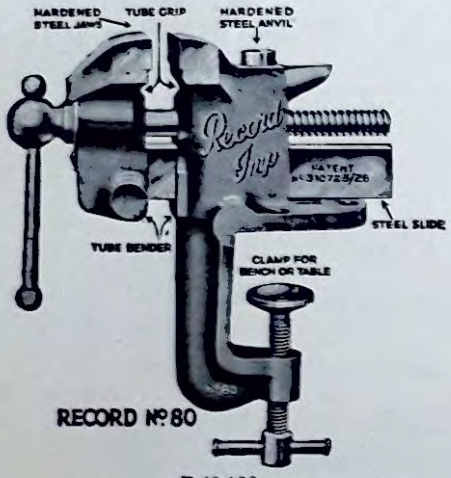
B 49-130. RASPS, Cabinet, Half-round, best Sheffield make.

Length	6	8	*in.*
	r 2/6	2/9	*each*

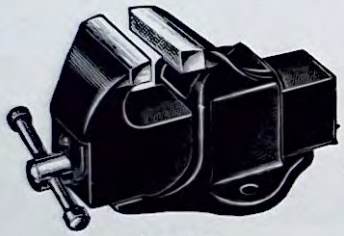
B 49-132. KNIFE, Laboratory, with steel blade approx. 4½ in. long, in wooden handle. Useful for cutting cork, cardboard, etc. £ s. d. *r* 0 2 6

B 49-133. SPANNERS, Adjustable, drop-forged steel, lever end.

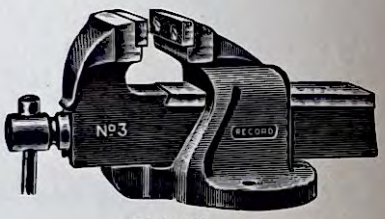
Length	7	9	11	12	14	*in.*
	r 5/6	7/-	9/-	9/6	15/-	*each*



B 49-136.



B 49-138.



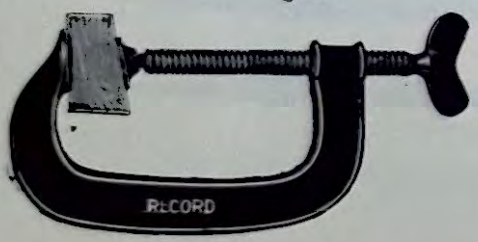
B 49-140.

B 49-136. VICE, Parallel, a sturdy and compact model, with screw to clamp to bench, for general work. Hardened steel jaws and anvil, steel slide and machine-cut square thread screw. Width of jaws, 2¼ in., opening 2½ in. £ s. d. *r* 0 13 6

B 49-138. VICE, Parallel, light pattern. Steel castings, steel screw, hardened jaws. Width of jaws, 2⅛ in., opening 2¼ in. Complete with fixing screws *r* 0 8 6

B 49-140. VICES, Parallel, with back jaw and base in one casting, detachable hardened steel jaws.

Width of Jaw.	Opening.	Weight.			
2¼ in.	2 in.	7 lb.	*each*	*r* 0 14	6
2½ in.	2¾ in.	9 lb.	*each*	*r* 0 16	6
3 in.	3¼ in.	12 lb.	*each*	*r* 0 19	6



B 49-146.



B 49-160.

B 49-146. G-CLAMPS, ribbed pattern, malleable iron frame, square threads, steel screw with swivel shoe which adapts itself to any angle of grip.

To take	2	3	4	6	8	10	12	*in.*
	r 3/3	3/9	5/6	7/6	10/6	13/-	17/6	*each*

B 49-160. DRILL, Hand, with nickel-plated three-jaw steel chuck, machine-cut gears, malleable iron frame, capacity 0–¼ in. round shank drills. **Without** drills £ s. d. *t* 0 12 0

B 49-162. Ditto, but with hollow wood handle containing 7 carbon steel twist drills *Price on application.*

B 49-172. DRILLS, Twist, carbon steel, straight shanks. Sizes rising by $\frac{1}{64}$ in.

Diameter	$\frac{1}{32}$ to $\frac{5}{32}$	$\frac{7}{64}$ to $\frac{5}{32}$	$\frac{1}{8}$ to $\frac{1}{4}$	$\frac{9}{32}$ to $\frac{1}{4}$	$\frac{17}{64}$ to $\frac{5}{16}$	*in.*
	r 8d.	10d.	1/1	1/3	1/6	*each*


B 49-180.


B 49-182.


B 49-183.


B 49-186.


B 49-188.


B 49-192.


B 49-194.

PLIERS, best Lancashire, black.

	Length	5	6	
B 49-180.	**Round Nose**	*r* 4/6	5/6	*each*
B 49-182.	**Flat Nose**	*r* 4/6	5/6	*each*
B 49-183.	**Long Taper** ("**Snipe**") **Nose**	*r* —	5/6	*each*
B 49-186.	**Combination**, with rimer and turnscrew	*r* —	4/-	*each*
B 49-187.	**Ditto, Electricians'**, with insulated handles	*r* —	5/-	*each*
B 49-188.	**Gas**, wrought steel, with wire cutter, rimer and turnscrew	*r* —	4/6	*each*
B 49-192.	**Taper nose**, turned down	*r* —	9/6	*each*

B 49-194. **SNIPS, Tinmen's**, for cutting sheet metal.

Length	8	10	
	r 4/9	6/6	*each*


B 49-202.


B 49-211.

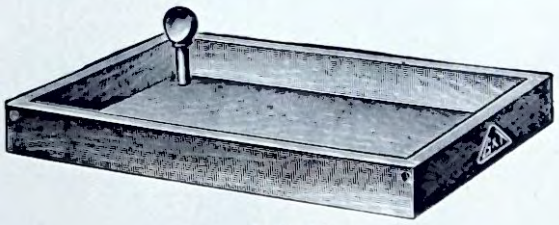
B 49-202. **SOLDERING IRONS, Straight Pattern.**

Weight of copper bit	4	8	16	oz.
	r 2/3	3/6	5/6	*each*

		£	s.	d.
B 49-211.	**SOLDERING IRON, Electric**, straight pattern, with oval tapered bit, weight 9¼ ozs., loading 65 watts, with flex and plug adapter	*t* 0	13	6
B 49-213.	**Ditto, "Pyrobit," Instrument Model**, with heating element inside the copper bit, giving high bit temperature with low rating (45 watts). Fitted with trumpet-shaped handle, designed to enable the iron to be held close to the bit and manipulated like a pencil. Total weight excluding flex, 6 ozs.	*t* 1	2	0

Please state voltage when ordering.

B 49-218.	**SOLDERING PASTE, Fluxite**, for use instead of spirits or resin, for all metals except aluminium. In 2 oz. tins	*each*	*t* 0	1	0
B 49-224.	**EMERY PAPER**, in sheets 12 × 10 in., Grades OO, O, FF, F, 1, 1½, 2, 2½, 3	*dozen*		0	2	9
B 49-226.	**Ditto, Durex**, in sheets 13½ × 9 in. Grades 4/0, 3/0, 2/0, 0, 1 (equivalent to Hubert's blue-back 4/0, 3/0, 2/0, 0 and 1)	*dozen*	*p* 0	3	6
B 49-228.	**EMERY CLOTH**, in sheets 11 × 8½ in., **twill, white back**, Grades OO, O, FF, F, 1, 1½, 2, 2½, 3	*dozen*		0	3	6
B 49-230.	**Ditto, flexible twill, blue back**, best quality, Grades OO, O, FF, F, 1, 1½	*dozen*		0	5	6
B 49-232.	**Ditto**, Grades 2, 2½, 3	*dozen*		0	7	0
B 49-234.	**GLASS PAPER**, in sheets 12 × 10 in., Grades OO, O, 1, 1½, F2	*dozen*		0	1	6
B 49-236.	**Ditto**, Grades M2, S2	*dozen*		0	2	9



B 49-375.



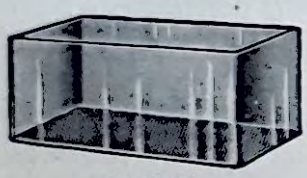
B 49-380.

B 49-375. TRAYS, Mercury, whitewood, 1 in. deep, with hole and peg in corner.

15 × 9	24 × 12	*in.*
p 9/-	13/-	*each*

B 49-380. TRIANGLES, Iron Wire, with Pipeclay Stalks.

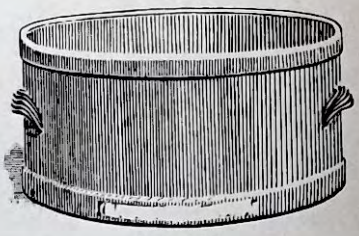
Inside size of triangle ..	1¼	1¾	2¼	2½	3¼	3¾	*in.*
Suitable for crucible No.	000	00	0	1	2/3	3/4	
	3/3	3/3	3/6	3/6	4/9	7/-	*dozen*
	4d.	4d.	4d.	4d.	6d.	8d.	*each*



B 49-430.



B 49-434.



B 49-438.

B 49-430. TROUGHS, Pneumatic, stout glass, rectangular.

Length ..	7	10	12	14	16	*in.*
Width ..	5	7	8	9	11	*in.*
Depth ..	5	7	8	9	11	*in.*
	8/6	12/6	17/6	£1 2 6	£1 10 0	*each*

B 49-434. TROUGHS, Pneumatic, stout glass, circular.

Diam. × depth ..	6 × 4	8 × 4	10 × 5	12 × 5	14 × 6 *in.*
	tx 4/6	6/6	11/-	15/-	24/- *each*

B 49-438. TROUGHS, Pneumatic, stoneware, circular.

Diam. × depth	6 × 3	11 × 5	15 × 8 *in.*
	3/6	10/6	35/- *each*

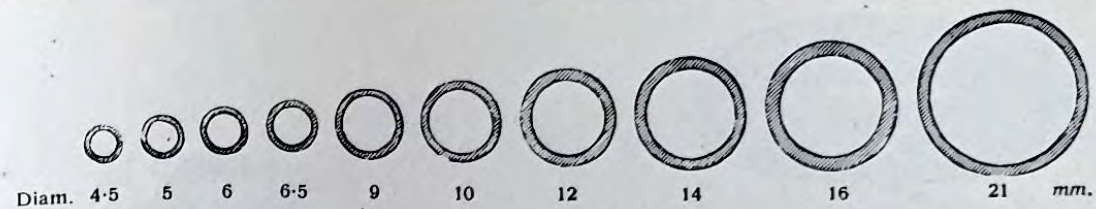
B 49-548. TUBES, Specimen, corked, flat bottom.

Length ..	1½	2	2	2	3	3	*in.*
Diam. ..	⅜	½	⅝	1	⅜	⅝	*in.*
	10/-	12/-	15/-	30/-	11/-	17/-	*gross*
	11d.	1/2	1/5	2/9	1/1	1/7	*dozen*
Length ..	3	4	4	4	5	6	*in.*
Diam. ..	1	½	¾	1	¾	1	*in.*
	32/-	15/-	22/-	35/-	35/-	55/-	*gross*
	3/-	1/5	2/-	3/3	3/3	5/-	*dozen*



B 49-548.

Griffin and Tatlock Limited from their five centrally situated Houses, provide a unique organisation for the supply of Complete Laboratory Equipment.

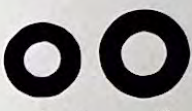


B 49-580.

The prices for tubing assume that reasonable tolerances are allowed. If special selection is required an extra charge is made.

B 49-580. TUBING, Glass, Soft Soda, small to medium diameters, free from lead, for bending and blowing, medium walled. In lengths up to maximum of about 4½ ft.

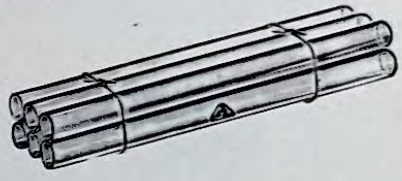
Diam. ..	under 2	2–3	3–4	5–10	11–25	26–30	31–35	*mm.*
Approx. ft./lb. ..		180	100	50–25	20–7	7–6	5–4	
	16/-	**6/6**	**3/-**	**2/3**	**2/3**	**2/6**	**3/-**	*lb.*



B 49-610.



B 49-612.



B 49-628.

	£	s.	d.
B 49-610. TUBING, Glass, Barometer. (*When ordering please state size above*) .. .. *lb.*	**0**	**4**	**6**
B 49-612. TUBING, Glass, Thermometer or Capillary. (*When ordering please state size above*) *lb.*	**0**	**4**	**6**

B 49-625. TUBING, Glass, Combustion, hardest potash glass, for high temperature work. Remains clear after repeated heatings.

Diam.	5–10	11–26	27–32	33–40	*mm.*
Approx. ft./lb.	40–20	20–7	6·5–5	5·5–3	
	r **8/-**	**7/-**	**8/-**	**10/-**	*lb.*

B 49-628. Ditto, thick wall, cut into lengths of 30 cm., ends fused.

Bore	13	16	19	*mm.*
	r **15/-**	**20/-**	**26/-**	*dozen*



B 49-691.

B 49-691. TUBING, Rubber, Black. Flexible, medium wall thickness. Suitable for either water or gas.

Bore ..	3/16	1/4	5/16	3/8	1/2	5/8	3/4	7/8	1	*in.*
	1/-	**1/9**	**2/3**	**2/9**	**6/-**	**9/-**	**14/-**	**15/-**	**17/6**	*yard*

B 49-695. TUBING, Rubber, Red, fine flexible quality, unaffected by changes of temperature and therefore very suitable for use in hot climates. Will withstand repeated sterilization.

Bore	3/16	1/4	5/16	3/8	1/2	5/8	*in.*
	10d.	**1/3**	**1/7**	**2/2**	**2/9**	**4/3**	*yard*



B 49-705—710.



B 49-715.

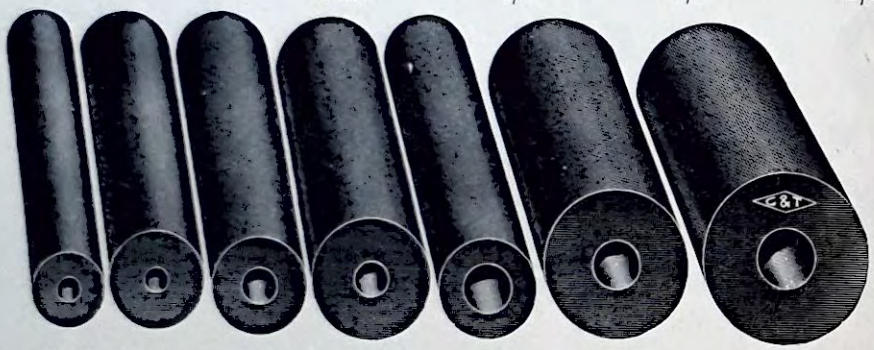
B 49-705. TUBING, Rubber, Bunsen Burner, Black, a heavily-loaded type, stout walled, which will not easily kink, $\frac{5}{16}$ in. bore .. .. *yard* — £ 0 s. 1 d. 9

B 49-710. TUBING, Rubber, Bunsen Burner, Red, stout walled, very best quality.

Bore	$\frac{1}{4}$	$\frac{5}{16}$ *in.*
	1/9	2/- *yard*
	1/6	1/9 *yard in* 60 *ft. lengths*

B 49-715. TUBES, Rubber, Bunsen Burner, Red, $\frac{1}{4}$ in. bore, with rolled ends to prevent splitting. Very suitable for gas connections.

Length	18	24	30	36 *in.*
	10d.	1/-	1/2	1/3 *each*

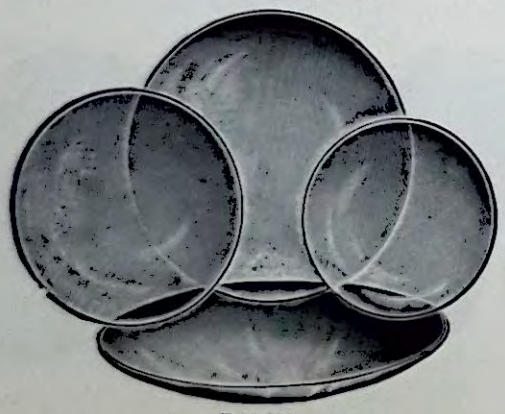


Dimensions $\frac{1}{8} \times \frac{3}{8}$ $\frac{1}{8} \times \frac{1}{2}$ $\frac{3}{16} \times \frac{1}{2}$ $\frac{3}{16} \times \frac{5}{8}$ $\frac{1}{4} \times \frac{1}{2}$ $\frac{1}{4} \times \frac{3}{4}$ $\frac{5}{16} \times \frac{7}{8}$ *in.*

B 49-725.

B 49-725. TUBING, Rubber, Pressure, Red, best quality, solid drawn.

Bore × diam.	$\frac{1}{8} \times \frac{3}{8}$	$\frac{1}{8} \times \frac{1}{2}$	$\frac{3}{16} \times \frac{1}{2}$	$\frac{3}{16} \times \frac{5}{8}$	$\frac{1}{4} \times \frac{1}{2}$	$\frac{1}{4} \times \frac{3}{4}$	$\frac{5}{16} \times \frac{7}{8}$ *in.*
	2/6	3/9	3/6	5/-	2/9	7/6	8/6 *yard*
	11d.	1/5	1/3	1/9	1/-	2/6	3/- *foot*



B 51-200.



B 51-245.

B 51-200. WATCH-GLASSES and CLOCK-GLASSES, thin white, with ground edge.

Diam. ..	$\frac{5}{8}$	$\frac{3}{4}$	1	$1\frac{1}{2}$	2	$2\frac{1}{2}$	3	$3\frac{1}{2}$ *in.*
	3/9	3/9	4/-	4/-	4/3	4/6	4/9	6/- *dozen*
	5d.	5d.	5d.	5d.	5d.	5d.	6d.	7d. *each*

Diam.	4	$4\frac{1}{2}$	5	6	7	8	9 *in.*
	8/-	9/-	10/-	14/-	24/-	28/-	35/- *dozen*
	9d.	10d.	11d.	1/4	2/3	2/9	3/3 *each*

B 51-245. WATCH-GLASS CLIPS, brass wire.

For watch-glass diam.	2	$2\frac{1}{2}$	3	4 *in.*
	11d.	1/2	1/4	1/8 *each*

Microchemistry

The field of micro-analysis as generally understood covers qualitative and quantitative determinations with minute quantities of material not amenable to exact treatment by classical means. Amounts of material usually of the order of 3–5 mgm. for organic material and 10 mgm. for inorganic material are employed. Semi-micro-analysis, of more recent origin, is based largely upon micro-methods but utilises samples ten times as heavy (up to 200 mgm.).

Of the methods described in the standard micro-analytical text books a number are now universally recognised as being accurate and not exceptionally difficult to carry out. Besides being of great value in research, they offer also undoubted opportunites for application to the field of routine testing, whether industrial or otherwise, and render available results in a fraction of the period required by the use of ordinary standard methods.

It is not only in quantitative analysis, however, that micro-methods have advanced. The qualitative determination of the elements and of compounds has also received considerable attention and has culminated in recent years in the systematic elaboration of " Spot Tests " (ultra-micro-analysis) by Feigl and other workers. These methods are not difficult to learn, the apparatus required is not expensive, and the rapidity with which detections and separations can be made is very attractive.

There is a widespread fallacy that, because micro-methods involve only minute quantities of material with apparatus of generally reduced dimensions, their use must of necessity be restricted to experts ; but it is the experience of competent instructors that the technique of many of the methods, particularly in the qualitative field, is well within the capacity of students at school, who in many ways find them simpler than corresponding analyses on the macro-scale and the accuracy of results returned is at least as great.

A recent book, Belcher and Wilson's *Qualitative Inorganic Microanalysis*, makes a valuable contribution to the literature of the subject and, since it is inexpensive, may be acquired by students for individual use.

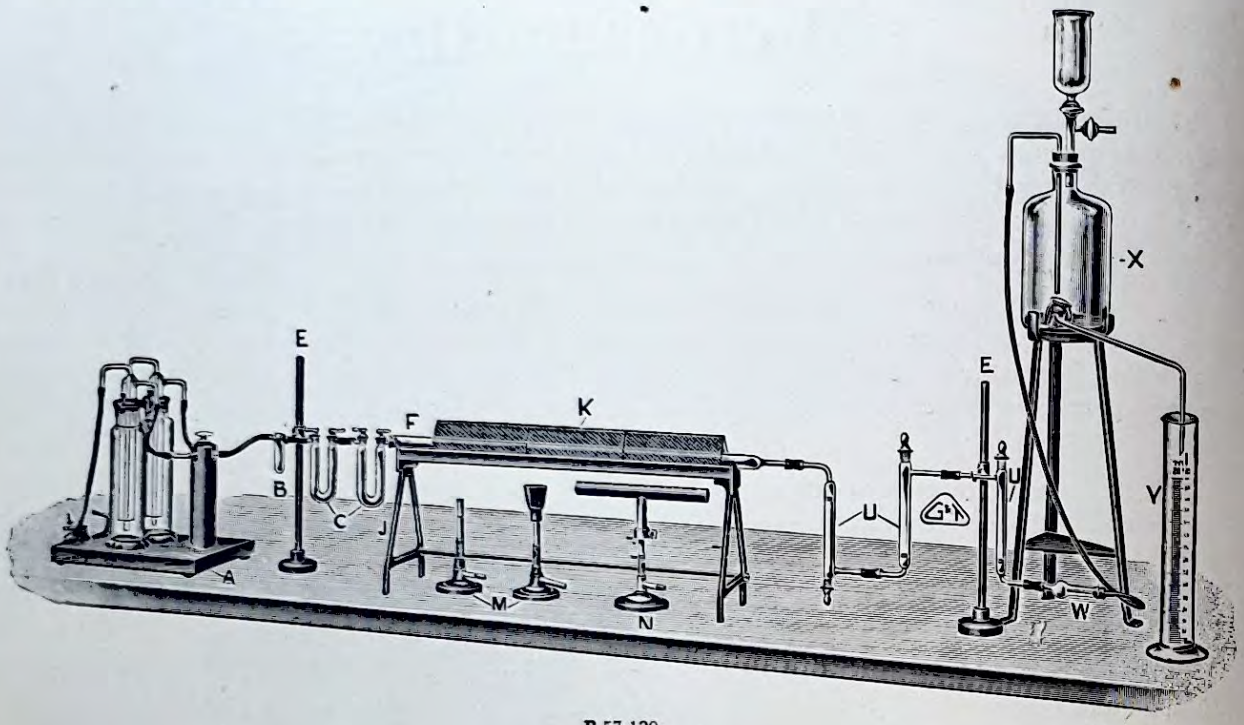
Training in the manipulations of microchemistry has a number of incidental advantages: general tidiness and cleanliness are engendered, rapidity and skill are developed, an understanding of the necessity for the sparing use of various chemicals is gained and methods may regularly be adopted which would be prohibited on a larger scale.

In semi-micro practice there are undoubtedly great possibilities and older classical practice is already being superseded by these newer methods. For educational purposes semi-micro processes offer many advantages. They require only a good analytical balance, and a little skill, to enable accurate determinations to be made. Moreover, they afford an excellent introduction to the more refined and delicate manipulations of true micro-chemistry. For purposes of research fuller investigation of substances may be made with limited quantities and a practical acquaintance with fundamentals of quantitative organic analysis may be acquired without undertaking the tedious methods previously essential.

The Semi-Micro Combustion Train, **B 57-120**, has been included as affording a good introduction to quantitative work, being simple and suited to giving accurate results in the hands of the average student. Elementary tests are now available for which the apparatus listed in the succeeding pages is eminently suitable. For classes which have passed beyond the elementary stage a comprehensive catalogue of 88 pages of micro-chemical apparatus is available and Heads of Departments are invited to make application for it.

KEY TO ABBREVIATIONS OF REFERENCES TO WORKS ON MICROCHEMISTRY

Abbreviation	Full Title
Belcher and Godbert	**Semi-Micro Quantitative Organic Analysis**, by R. Belcher and A. L. Godbert. 1945.
Belcher and Wilson	**Qualitative Inorganic Microanalysis**, by R. Belcher and C. L. Wilson. 1946.
Emich	**Microchemical Laboratory Manual**, by F. Emich. Translated by F. Schneider. 1932.
Feigl	**Qualitative Analysis by Spot Tests**, by F. Feigl. Translated by J. W. Matthews. 1937.
Pregl	**Quantitative Organic Micro analysis**, by F. Pregl. 4th English edition revised and edited by J. Grant. 1945.



B 57-120.

B 57-120. SEMI-MICRO COMBUSTION TRAIN, Roger-Mackay (*J. Soc. Chem. Ind.*, 1935, **54**, 46T). A simple method for the carbon-hydrogen analysis of organic compounds based on Pregl's adaptation of the Liebig train. Utilising 20–50 mgm. of material the technique is not so advanced as in micro-analysis but accurate results are readily obtainable with the use of an ordinary good analytical balance. The train is therefore well adapted for affording students practice in ultimate analysis.

Stainless steel combustion stand, glass parts, stands and necessary accessories, including treated rubber tubing. Including all component parts listed below. With assembly diagram .. .. *r* **16 10 0**

£ s. d.

Component Parts of B 57-120

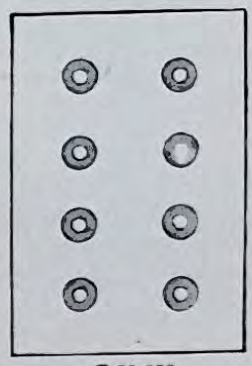
Corresponding letters are used in illustration and text

		£ s. d.
B 57-120 a.	**Pressure Regulator,** 2 bell gas regulator bottles with screwclips and three-way stopcock mounted together on oak stand .. .. *complete*	*r* **3 15 0**
„ „ **b.**	**Bubbler, Semi-Micro,** to contain sulphuric acid, into which tapered end of inlet tube dips, 60 mm. high	*r* **0 5 0**
„ „ **c.**	**U-tubes,** with ground-in stoppers, for calcium chloride and soda lime, 10 cm. high .. .. (2 supplied) *each*	*r* **0 11 0**
„ „ **e.**	**Stands with Hook** .. .. (2 supplied) *each*	*r* **0 8 6**
„ „ **f.**	**Combustion Tubes,** glass, 600 mm. long .. .. (2 supplied) *each*	*r* **0 7 6**
„ „ **g.**	**Combustion Boats, Porcelain,** 31 × 5·5 × 4 mm. .. .. .. (2 supplied) *each*	*tx* **0 1 6**
„ „ **j.**	**Combustion Stand, Stainless Steel,** rigid construction, 54 cm. long, with asbestos shield. Without gauzes	*r* **1 10 0**
„ „ **k.**	**Gauzes, Stainless Steel,** to form furnace tunnel .. .. *set of* 3	*r* **0 17 6**
„ „ **m.**	**Bunsen Burners,** two supplied, one with flame spreader .. .. *pair*	**0 8 0**
„ „ **n.**	**Tube Burner,** head 200 mm. long, adjustable for height	*r* **1 10 0**
„ „ **o.**	**Absorption Tubes, Roger-Mackay,** for use as calcium chloride or soda lime tubes (3 supplied) *each*	*r* **0 10 6**
„ „ **w.**	**Guard Tube,** to contain calcium chloride and soda lime, overall length 55 mm.	*r* **0 1 9**
„ „ **x.**	**Mariotte Bottle, Backeberg** (*Mikrochemie*, 1936, **21**, 135)	*r* **2 15 0**
„ „ **y.**	**Measuring Cylinder,** 250 ml.	**0 5 0**
„ „ **z.**	**Tubing, Rubber:** (i) Aged, 1 metre, and (ii) impregnated, six 15 cm. lengths .. *all*	*r* **0 15 0**


B 59-020.


B 59-030.


B 59-040.


B 59-050.

	£	s.	d.
B 59-020. SPOT TEST DROPPER, Mercury (Feigl, p. 12). Applicable also to delivery of aqueous solutions. Bottle, about 35 mm. diam., with tap, plug only partially bored through forming chamber which delivers drop on rotation .. .. *r*	0	11	0
B 59-030. SPOT TEST FILTER PIPETTE, Johnstone (*J. Soc. Chem. Ind.*, 1931, **50**, 182 T), for micro-filtration of turbid solution, *e.g.* on microscope slide by laying small trapezoid of filter paper on slide with larger edge touching drop. On pressing convex-ground tip of pipette on shorter edge of paper, clear filtrate rises by capillarity and collects in bulb without suction .. .. *r*	0	2	3
B 59-040. SPOT TEST FILTERING APPARATUS (Feigl, p. 8), for performing spot tests on filter layer, comprising Emich filter in suction tube containing micro-test tube .. .. *r*	0	3	0
B 59-042. Stand, for above. Nickelled brass. Heavy base 5 cm. diam. with spring clip .. *r*	0	7	0
B 59-045. SPOT TEST PAPER, Schleicher and Schüll, for use in carrying out spot test reactions. Texture allows rapid absorption of drops without undue spreading, generally giving zones more clearly defined than with porcelain plates. In sheets 22 × 14 cm. 100 *sheets* *t*	0	19	0
B 59-050. SPOT TEST PAPER, Schleicher and Schüll, Paraffin-Ringed, Yagoda (*Ind. Eng. Chem. Anal. Edn.*, 1937, **9**, 79 ; *Microchemie*, 1938, **24**, 117). To confine spot reactions to a small area and thereby to obtain maximum sensitivity. In sheets 22 × 14 cm. each containing 8 rings.			

Area of unimpregnated centre ..	10	50	100 *sq. mm.*
	t 15/-	15/-	15/- 100 *sheets*


B 59-060.


B 59-080.


B 59-085.


B 59-090.

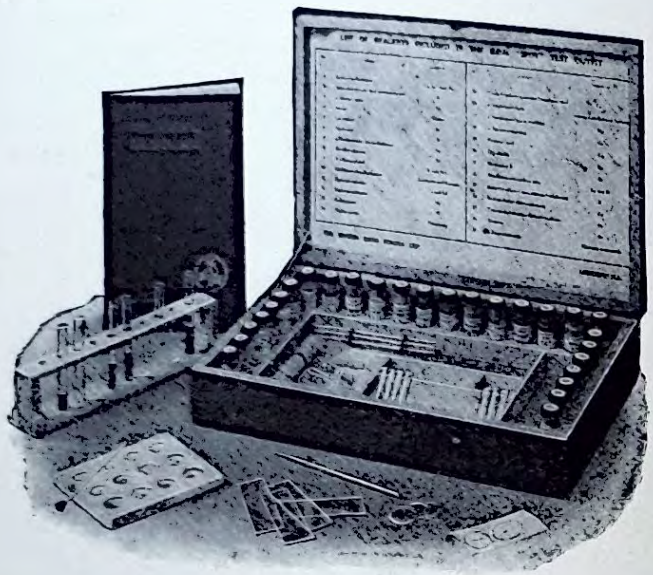

B 59-095.


B 59-120.

	£	s.	d.
B 59-060. SPOT TEST TUBES, Pavelka (Feigl, p. 4). For digestions, evaporation, solution of dried residues, etc. Glass, with small spout at bottom for removal of solution drop by drop .. .. *each r* 1/- ; *dozen*	0	10	6
B 59-080. SPOT TEST TUBES, Gas Reaction (Feigl, p. 10), with knob depending from the stopper. For absorption of evolved gas by drop of adherent reagent *each r* 2 9 ; *dozen*	1	10	0
B 59-085. Ditto (Briscoe-Matthews, p. 34), with hook for attachment of, *e.g.* litmus paper to detect evolution of ammonia or other gases. 0·1γ of ammonia can be estimated in 5 minutes .. .. *each r* 2 3 ; *dozen*	1	4	0
B 59-090. Ditto (Feigl, p. 11) (*cf.* Belcher and Wilson, p. 16), with funnel for support of impregnated filter paper. Useful where indifferent gases may be evolved in the presence of that being tested for, *e.g.* sulphur dioxide detection with dichromate *each r* 3 9 ; *dozen*	2	1	0
B 59-095. Ditto (Feigl, p. 11 ; Belcher and Wilson, p. 16), stoppered by loose fitting double cone with openings at each end. Lower end to contain drop of reagent rendering coloured reaction products easily visible. Specially adapted for chromyl chloride test for chlorides (Feigl., p. 153) .. .. *each r* 2/- ; *dozen*	1	2	0
B 59-120. STAND, for spot test gas reaction tubes **B 59-080–095.** Tripod, nickelled brass .. *r*	0	4	6

SPOT TESTS

Dropping Bottles, p. 429



B 59-140.

B 59-140. SPOT TEST OUTFIT, B.D.H., containing the following reagents and apparatus:— £ s. d.
27 tubes each containing 1 gram of the reagents shown in the table ; 1 porcelain spotting tile ; 3 graduated pipettes 0·5 c.c. ; 12 test tubes 3 × ¼ in. ; 1 test tube rack ; 72 capillary tubes 4 in. long ; 2 rubber bulbs for use with capillary tubes ; 12 absorbent papers for "spot" tests ; 12 microscope slides ; ¼ oz. cover glasses, ⅞ in. circles.

Complete in compact wooden cabinet about 14 × 9 × 2¾ in. with copy of *The B.D.H. Book of Organic Reagents for Analytical Use* .. .. *t* 3 10 0

This outfit provides a useful collection of twenty seven reagents and the apparatus required for their use, which should prove of particular value to chemists, and for demonstrating the technique of this branch of analytical chemistry. In designing the outfit, care has been taken to cover the widest possible range of metals and radicles together with the most useful reagents for each.

The tests which can be applied by means of organic reagents are of four types:—

Type (*a*) The production of "spot" colorations on absorbent paper or porcelain tiles.
Type (*b*) The formation of micro-crystals, the characteristics of which can be observed under a microscope.
Type (*c*) The development of colours in solution.
Type (*d*) The precipitation of insoluble compounds which can subsequently be identified or weighed.

Tests belonging to types (*a*) and (*b*) are qualitative only, but it is frequently possible to apply types (*c*) and (*d*) to quantitative measurements.

It may be well to note that "spot" test reagents are not necessarily specific for the substances they are used to detect, and the analyst should always consider any interfering factors arising from the presence of other material.

REAGENT CONTENTS OF B 59-140

Substance	Type of Test	Reagent for	Substance	Type of Test	Reagent for
Aurine-tricarboxylic acid (ammonium salt)	*c*	Al	Hexanitro-diphenylamine	*a*	K
α-Benzoin-oxime	*a, d*	Cu and Mo	Hydroquinone	*c*	Phosphates and Au
Brucine (*S1*)	*c*	Nitrates			
Cacotheline	*a*	Sn	7-Iodo-8-hydroxy-quinoline-5-sulphonic acid	*c*	Fe'''
Chromotropic acid (sodium salt)	*a*	Ti	o-Nitrobenzaldehyde	*c*	Isopropyl alcohol and acetone
p-Dimethylamino-benzal-rhodanine	*a, c*	Ag, Hg and Cu			
Dimethyl-glyoxime	*a, d*	Ni, Pd, Bi and Co	*p*-Nitrobenzene-azo-resorcinol	*a, c*	Mg
2 : 4-Dinitro-phenylhydrazine	*d*	Aldehydes and Ketones	3-Nitro-4-hydroxy-phenyl-arsonic acid (*S1*)	*b*	Cd
			α-Nitroso-β-naphthol	*a, d*	Co
Diphenyl-carbazide	*a, c*	Cr and Cd	Picrolonic acid	*b, d*	Ca
Diphenyl-carbazone	*a, c*	Hg	Quinalizarin	*a, c*	Be, Mg, Al and B
Diphenyl-thiocarbazone	*a, c*	Pb and Bi	Rhodamine B	*a*	Sb
Dithio-oxamide	*a*	Ni, Co and Cu	Rhodizonic acid (sodium salt)	*a, c*	Ba and Sr
Formaldoxime hydrochloride	*c*	Mn	Sodium diethyl-dithio-carbamate	*c*	Cu
Gallocyanine	*a*	Pb	Thiourea	*c*	Bi and Os



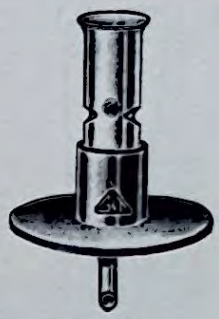
B 59-610.



B 59-615.



B 59-625—630.



B 59-635.

B 59-610. **MICRO-BEAKERS, Pyrex Glass** (Emich, p. 68). About 16 mm. diam. × 40 mm. high. Filter sticks project a convenient distance above beaker top, simplifying manipulation *each r* **10d.**; *dozen* — £ 0 s. 9 d. 0

Other sizes and capacities made to order.

B 59-615. **MICRO-BEAKERS, Pyrex Glass** (Emich, p. 30). With lip. For use with micro-filter funnels. About 16 mm. diam. × 40 mm. high .. .. .. *each r* **10d.**; *dozen* — £ 0 s. 9 d. 0

B 59-620. **Ditto, Transparent Silica**, without lip. About 22 mm. diam. × 41 mm. high. Capacity 10 ml. .. .. *each tx* £ 0 s. 12 d. 10

MICRO-BEAKERS, Griffin Form, squat, spouted.

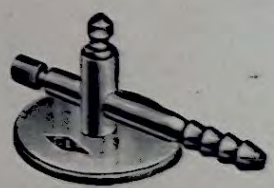
Capacity		5	10	15	20	*ml.*
B 59-625. **Pyrex Glass**	*tx*	13/4	13/4	13/4	13/4	*dozen*
	tx	1/3	1/3	1/3	1/3	*each*
B 59-630. **Transparent Silica**	*tx*	8/9	12/6	—	18/2	*each*

B 59-632. **MICRO-BEAKERS, Tall Form, Pyrex Glass**, unspouted. Sizes and prices as **B 59-625.**

B 59-635. **MICRO-BEAKER HEATER, Water bath** (Emich, p. 13). Flanged metal tube nickel-plated, to be placed in centre of rings on water bath and containing glass tube with reduced end and three re-entrant pips for supporting micro-beakers during heating *r* £ 0 s. 9 d. 6



B 59-650.



B 59-900.

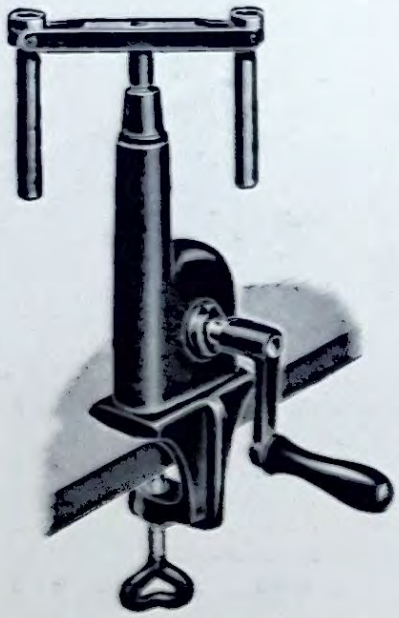


B 59-905.

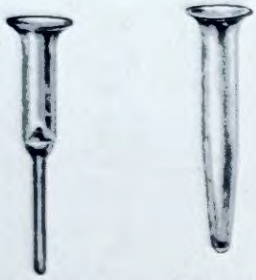
B 59-650. **MICRO-BEAKER STAND** (Emich, p. 12). Polished wood, with seven holes 18 mm. diam., to take micro-beakers, set of six holes for filter sticks, glass lined for cleanliness, and set of six holes for micro-centrifuge tubes. Base approx. 15 × 7·5 cm. .. .. *r* £ 0 s. 8 d. 6

B 59-900. **MICRO-BURNER**, with non-corrodible steatite jet giving perfect aeration, and needle valve for fine control. On circular base approx. 5 cm. diam., with riffled connection .. *r* £ 0 s. 18 d. 6

B 59-905. **MICRO-BURNER**, with non-corrodible steatite jet of special construction, giving a wide range of flames with good aeration. Needle valve for fine control. With stem for use on retort stand. Nickel-plated. Length 18 cm. .. .. *r* £ 0 s. 17 d. 6



B 59-950.



B 59-970.

B 59-975.



B 59-980.



B 59-995.

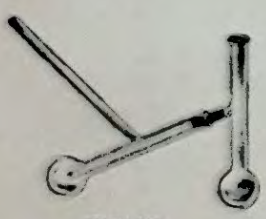
B 59-950. MICRO-CENTRIFUGE, Hand (Belcher and Wilson, p. 5), cast-iron casing, nickel-plated head. To take two micro-centrifuge tubes **B 59-970—975.** Accurately cut gears ; smooth running. With clamp to screw to edge of table .. .. *r* 3 5 0

MICRO-CENTRIFUGE TUBES, Glass, either with parallel tip of even bore to enable height of precipitates to be read for quantitative work, or conical shape for general work.

Capacity	0·5	1	2	*ml.*
B 59-970. Parallel tip	*r* 13/6	13/6	13/6	*dozen*
	r 1/3	1/3	1/3	*each*
B 59-975. Conical shape	*r* 8/-	8/-	8/-	*dozen*
	r 9d.	9d.	9d.	*each*

B 59-980. MICRO-CENTRIFUGE TUBE HEATER (Emich, p. 13 ; Belcher and Wilson, p. 9). Flanged metal tube to rest on rings in centre of water bath and fitted with conical glass support for holding micro-centrifuge tubes during heating. **Without** centrifuge tube *r* 0 11 0

B 59-995. HEATING BLOCK, Micro-Centrifuge, aluminium. For heating micro-centrifuge cones, small reaction vessels, etc. 2¼ × 2 in. diam. On tripod legs. Overall height approx. 4¼ in. With seven recesses approx. 2 mm. to 10 mm., to hold thermometer and tubes. **Without** thermometer or tubes .. .. *r* 0 17 6



B 61-350.



B 61-360.



Type A.



Type B.
B 61-365.



Type C.

B 61-350. MICRO-DISTILLATION FLASK, Pyrex Glass, 5 ml. capacity, with side arm. Side arm of one flask can be fitted into neck of another to make a complete distillation unit useful for qualitative organic analysis .. .. *each flask* *r* 0 3 0

B 61-355. Ditto, transparent silica, capacity 10 ml. .. .. *tx* 0 13 6

B 61-360. MICRO-DISTILLATION FLASK, Alber (*Mikrochemie*, 1929, **7**, 21). Designed for use in detection of glycerine, ethylene glycol and *d*-mannite, as well as for more general application. Side arm bent to act as condenser and receiver. Bulb 1 ml. capacity .. *r* 0 2 6

B 61-365. MICRO-DISTILLATION FLASKS, Fractionating, Stoppered (Pregl, p. 22), for fractionating 0·1–0·3 ml. mixture. Distillate condenses and collects in side tube and is removed with a pipette. With ground glass stoppers. Types B and C have constriction in vertical section to support porcelain fragments if required.

Type	A	B	C
	r 7/-	9/6	10/- *each*



B 61-500.

B 61-500. **FEATHER, Snipe** (Pregl, p. 102), for brushing down precipitates. Narrow, stiff feather cemented into thin glass handle 150 mm. long .. .. *r* 0 1 9



B 61-520.



B 61-525.



B 61-527.

B 61-520. **MICRO-FILTER BEAKERS, Pyrex Sintered Glass, Schwarz-Bergkampf** (Emich, p. 143). Of value in micro-determinations of organic **halogens** (*Mikrochimica Acta*, 1938, 3, 185). Outlet neck with sintered glass disc sealed in to form a beaker for precipitation and then to act as a filter under suction. If desired, outlet neck may be supported by a cork in inlet neck of a similar vessel. Body dimensions 27 × 27 mm. diam. external. Disc diam. 10 mm. Porosity Grade 4 .. .. *each tx* 0 15 9

For Porosities of Grades see page 445.

MICRO-FILTER CRUCIBLES, Royal Worcester Porcelain, No. 1/3M, with porous porcelain bottom and glazed porcelain sides. May be ignited in a muffle or heated directly in blow-pipe flame in an ignition dish (to prevent reduction of precipitate by reducing action of gases). Particularly suitable for fine grain precipitates such as barium sulphate, calcium oxalate, lead sulphate, copper sulphide, etc. Easily cleaned by boiling.

B 61-525. **Crucibles,** 15 × 15 mm. top diam. Disc diam. 12 mm. .. *each tx* 5/-; *dozen* 2 14 0

B 61-527. **Ignition Dishes** for use with **B 61-525** .. .. *each tx* 1/2; *dozen* 0 12 0



B 61-600.



B 61-605.



B 61-620.



B 61-634.

B 61-600. **MICRO-FILTER, Pregl** (Pregl, p. 88; Belcher and Godbert, p. 34), for filtering precipitates of silver halides, etc. Stem with constriction and bulb to support asbestos filter mat. Funnel approx. 35 mm. high .. .. *r* 0 2 6

B 61-605. **MICRO-FILTER** (Pregl, p. 88; Belcher and Godbert, p. 34), **Pyrex Sintered Glass.** For use according to Pregl, Fig. 51, in the determination of **halogens, phosphorus,** etc. Funnel with fused-in filter disc 10 mm. diam., of porosity Grade 1 (*see p.* 445). For closure by rubber stopper. Disc to be covered with thin layer of asbestos .. .. *tx* 0 7 9

B 61-620. **MICRO-FILTER, Immersion (Filterstick), Royal Worcester Porcelain** (Pregl, p. 27; Belcher and Godbert, p. 37). Extra long (70 mm.) stem, leaving a reasonable stem protrusion above the filter beaker and thereby facilitating manipulations. Disc 11 mm. diam. Constancy of weight unaffected by ignition .. .. *tx* 0 15 0

B 61-634. **FILTERSTICKS, King, Improved, Pyrex Sintered Glass.** The latest form, developed from that described in *Analyst*, 1933, 58, 345. Glass filterstick with sintered glass disc 10 mm. diam. surrounded by glass bell affording a firm fit for filtering wads. Rubber sleeve forming air-tight joint between bell and tube, which can be forced outwards to remove precipitate. Pyrex Grade No. 4 .. .. *each* 0 10 6



B 61-685.



B 61-700.



B 61-710.



B 61-750.

B 61-685. MICRO-FILTRATION APPARATUS. Convenient for collection of filtrate, when applying suction to filtersticks. Wood block with stout rubber sheet firmly cemented to it, supporting glass bell jar, approx. 10 cm. high, fitted with rubber bung and bent tubes for connection to vacuum and filterstick. **Without** beaker .. .. *r* **0 12 6**

B 61-700. MICRO-FLASKS, Round bottom, Pyrex glass.

Capacity	5	10	25	*ml.*
	tx **19/8**	**19/8**	**13/-**	*dozen*
	tx **1/10**	**1/10**	**1/3**	*each*

B 61-710. MICRO-FLASKS, Conical, Chance's Hysil glass.

Capacity	5	10	25	*ml.*
	tx **14/11**	**15/4**	**15/8**	*dozen*
	tx **1/5**	**1/6**	**1/6**	*each*

B 61-750. MICRO-GAS GENERATOR, Sutcliffe (*Chem. and Ind.*, 1943, 310), **Pyrex glass.** For generation of H_2S, CO_2, H_2, etc. Wide glass tube to contain solid reactant. Bulb on side arm to serve as acid reservoir. Ground-in stopcock. Overall height about 15 in. Readily portable, easy to clean. For recharging with acids and when not in use the apparatus is placed horizontally to rest on the bulb **2 5 0**



B 61-940.



B 61-960.



B 61-970.



B 61-980—982.

B 61-940. MICRO-WEIGHING BOTTLES ("**Pig**") (Pregl, p. 19), for weighing micro-combustion boats containing hygroscopic substances. Long glass extensions on bottle and ground hollow stopper to minimise heating when handling, two glass feet to maintain stability. Internal dimensions, 35 × 7 mm. diam. .. .. *each* **r 3 6**; *dozen* **1 18 0**

B 61-960. MICRO-WEIGHING BOTTLES, Liquid (Pregl, p. 97), particularly suited for weighing oils and viscous liquids. 5 × 3 mm. internal diam. with ground-in stopper *each* **r 2/-**; *dozen* **1 2 0**

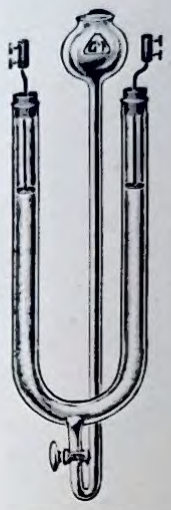
B 61-970. MICRO-WEIGHING TUBE SUPPORT (Belcher and Godbert, p. 23). Rests on pan of micro balance and holds absorption tubes during weighing. Advantageous where hooks on the bows are made difficult of access by a telescope on the sliding door, etc. Sheet aluminium, base approx. 50 × 20 mm. Weight approx. 2·5 gm. .. .. *r* **0 1 6**

B 61-980. COUNTERPOISES (Pregl, p. 14), for use in counterbalancing pieces of micro-apparatus in frequent use, by loading with shot. Micro-tare flasks, glass, numbered for ready identification, 35 mm. high .. .. *each* **r 1 3**; *dozen* **0 13 6**

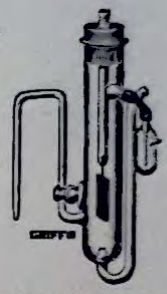
B 61-982. Ditto, Set of 6 of different weights, **for ready adjustment to various apparatus in** constant use .. .. *set of 6* **r 0 8 6**

B 61-984. Lead Shot, size No. 12, for above counterpoises .. .. *lb.* **r 0 3 6**

Physical Chemistry



B 85-320.



B 85-620—625.



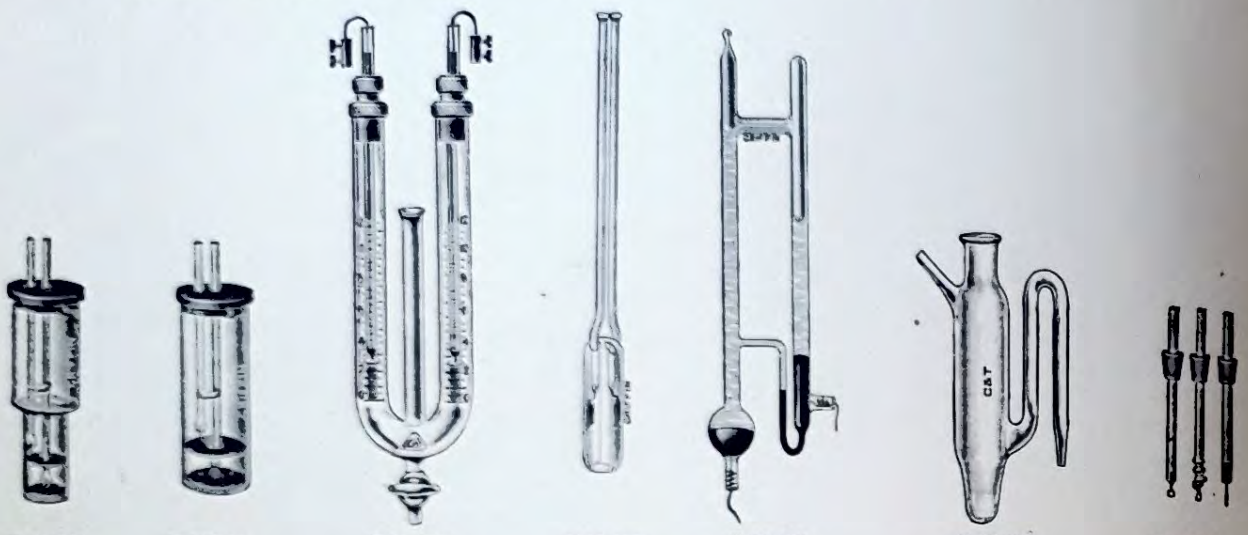
B 85-650.



B 85-660.

	£	s.	d.
B 85-320. CATAPHORESIS TUBE, Nernst-Hardy or Burton (Thomas: *Colloid Chemistry*, p. 206; Svedberg: *Colloid Chemistry*, p. 184; Friend: *Text-Book of Physical Chemistry*, Vol. I, p. 461). To illustrate the motion of colloid particles under the action of an electric field by applying a potential of 60–100 volts to electrodes in columns of water, etc., floating on a colloid solution (ferric hydroxide, etc.). U-tube, limbs 12 × 1·5 cm., filling tube attached to bottom of bend with funnel and tap, rubber stoppers and two mounted platinum electrodes .. .. *Price variable, approx.*	2	5	0
B 85-620. ELECTRODE VESSEL (Findlay: *Practical Physical Chemistry*, 7*th Edn.*, p. 218), for use in measuring the E.M.F. of a hydrogen concentration cell. Glass cell with gas inlet tube at bottom, outlet by side arm with detachable bubbler. Bent arm with tap for connection with electrolyte of external cell. **Without** platinum electrode	0	16	0
B 85-625. Electrode, Platinum foil, for above, with rubber stopper .. *Price variable, approx.*	0	8	6
B 85-650. CONDUCTIVITY CELL, Dipping type, for general use, cell constant 2–3 reciprocal cm. (actual value supplied with each cell). Blacked platinum electrodes each 1 sq. cm., 8 mm. apart, positioned by glass bridges. Cell about 145 mm. long, 22 mm. diam. With leads .. .. *ex*	3	10	0
B 85-660. OSCILLATOR, designed particularly for use with Measuring Bridge **A 86-440** in the conductivity of solutions (and in the measurement of small values of inductance and capacity). Output 1000 cycles/sec., avoiding polarisation and the use of telephones in locating balance point. In case 5½ × 4½ × 5 in. containing back-coupled triode oscillator with amplitude control to ensure pure wave form. Two pairs of terminals, one pair for output (approx. 2 volts), one pair for feeding bridge network at 50 cycles. Lead to A.C. mains. Input 100–150, 200–250 volts, consumption 10 watts .. .. .. *ex*	7	10	0

Griffin and Tatlock Limited from their five centrally situated Houses, provide a unique organisation for the supply of Complete Laboratory Equipment.



B 85-720. B 85-725. B 85-760. B 85-950. B 86-495. B 86-705. B 86-720.

NOTE.—**For elementary theory of conductivity and determination of cell constants see** Britton: *Conductometric Analysis*, pp. 3, 24; Glasstone: *Electrochemistry of Solutions*, 2nd Edn., pp. 55, 65; Reilly and Rae: *Physico-Chemical Methods*, 4th Edn., Vol. II, pp. 414 *et seq.*

For discussions on design of conductivity cells and elimination of shunt capacitance effects, etc., see Jones and Bollinger: *J. Am. Chem. Soc.*, 1931, **53**, 411.

Method of cleaning cells, its importance, and the short-circuiting of electrodes during that operation to obtain consistent results, see Morgan and Lammert: *J. Am. Chem. Soc.*, 1923, **45**, 1692.

For Conductivity Tables of different solutions employed as standards in conductivity work, see Kaye and Laby *Tables of Physical and Chemical Constants*, 9th Edn., pp. 97.

For Recent Survey and Review of Critical Investigations (17 refs.), **see** Harned and Owen: *Physical Chemistry of Electrolytic Solutions* (1943), p. 136.

B 85-720. CONDUCTIVITY CELL, Ostwald (Findlay: *Practical Physical Chemistry, 7th Edn.*, pp. 160, 167), for general use with electrolytes of **high conductivity**, or where only small amounts are available. Tube 9 × 3 cm. wider diam. with ebonite cap positioned by stop and carrying two bridged glass tubes supporting two platinum disc electrodes at a fixed distance apart. Hole for thermometer. Narrowed section of tube at lower end may be inserted in water bath. Approx. dimensions of platinum electrodes, each 0·66 sq. cm. area (a), 2·5 cm. apart (l). Cell constant (l/a) approx. 4 reciprocal cm. *Price variable, approx.* p 3 0 0

B 85-725. Ditto, Arrhenius (*ibid*; Mee: *Physical Chemistry*, p. 512). Straight type for use with electrolytes of **low conductivity**. Approx. dimensions of platinum electrodes, each 4·4 sq. cm. area, 1 cm. apart. Cell constant approx. 0·22 reciprocal cm. *Price variable, approx.* p 6 0 0

B 85-760. CONDUCTIVITY CELL, with Adjustable Cell Constant, covering a wide range of solutions. Glass U tube, each arm graduated from 0–120 mm. with draining cock and third limb for filling. Adjustable platinum electrodes each 1·5 sq. cm. area *Price variable, approx.* p 4 15 0

B 85-950. CONDUCTIVITY DIPPING CELL (Spencer: *Physical Chemistry*, 2nd Edn., Vol. II, p. 52). Useful for determinations on solutions of **medium conductivity**. By careful lowering into the electrolyte, contact with air and contamination by agitation of sediment is avoided. Rectangular platinum electrodes each approx. 0·5 sq. cm. area, 0·8 cm. apart, mounted in tube 2 cm. diam., with leads sealed through to mercury contact tubes. Cell constant approx. 1·6 reciprocal cm. Overall length 21 cm. *Price variable, approx.* p 2 0 0

B 86-495. ELECTROMETER, Capillary, Luther Enclosed Pattern (*cf.* Findlay: *Practical Physical Chemistry, 6th Edn.*, p. 196). With capillary and electrodes with two terminals. Overall length approx. 18 cm. Filled with mercury and dilute sulphuric acid and boiled out free from air. Sealed and ready for use 1 15 0

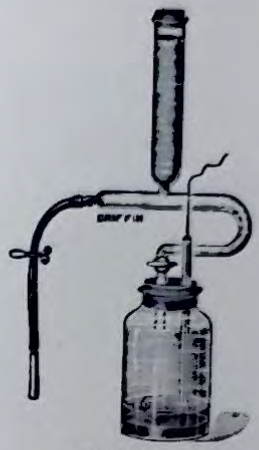
B 86-705. POTENTIAL VESSEL (Findlay: *Practical Physical Chemistry, 7th Edn.*, pp. 205, 209). About 16 cm. long, 1·5 cm. diam., with side tubes 2–3 mm. diam. 0 5 6

B 86-710. Ditto, approx. 60 cm. long, 3 cm. diam., but with stopcock on side tube .. 0 13 0

B 86-720. ELECTRODES, with rubber stoppers, for insertion into potential vessels.

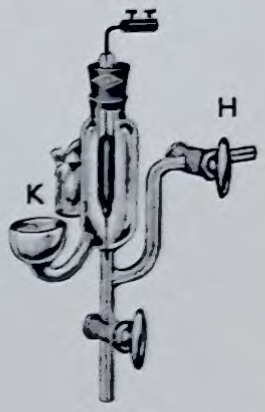
Type	Platinum Foil	Platinum Ring	Silver Spiral	Gold Foil	Zinc Rod	Copper Rod
1	13/6	7/-	6/6	13/6	4/6	4/6 *each*


B 86-740—742.


B 86-745.


B 86-775.

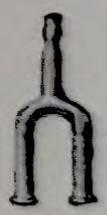

B 86-820.



B 86-860.

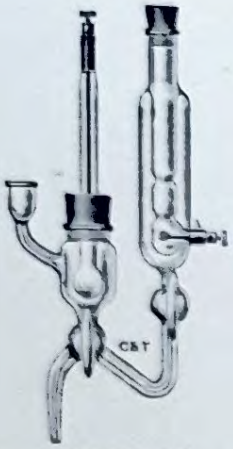
	£	s.	d.
B 86-740. CALOMEL ELECTRODE (*cf.* Findlay: *Practical Physical Chemistry. 7th Edn.*, p. 206), with stopcock in immersion tube and sealed-in platinum wire electrode. **Without** stand and clamp	0	14	6
B 86-742. Stand and Clamp, for above	0	13	6
B 86-745. CALOMEL ELECTRODE (Spencer: *Physical Chemistry, 2nd Edn.*, Vol. II, p. 122). A reliable form, avoiding contamination by diffusion. 8 oz. wide necked bottle with tightly fitting rubber stopper, ⊃-tube fitted with funnel and stopcock, platinum wire electrode sealed in glass tube, rubber tubing, clip and nozzle	0	18	6
B 86-775. CALOMEL ELECTRODE. A popular form. Vessel 90 mm. long by 25 mm. diam., with stopcock on side arm and on immersion tube. The platinum wire electrode is sealed in a glass tube with fitted terminal and a stopper ground to fit electrode vessel	1	15	0
B 86-820. HYDROGEN ELECTRODE, Hildebrand (Findlay: *Practical Physical Chemistry, 7th Edn.*, p. 223 ; *J. Am. Chem. Soc.*, 1913, **35**, 847). A convenient form for a great variety of work. The electrode is a square of platinum foil sealed to an inner tube. The jacket has a side tube for introduction of hydrogen and is fitted to the inner tube by means of rubber tubing. The hydrogen flows down the jacket and bubbles out at the bottom causing an oscillatory motion of the solution and alternately exposing the platinum electrode to the hydrogen and solution under test	0	10	0
B 86-860. HYDROGEN ELECTRODE, Lindsey (*Analyst*, 1932, **57**, 573). A most useful pattern for rapid routine *p*H determinations. Glass body with 2 stopcocks and side tube. Hydrogen enters by the tube H and escapes by the bubbler attached to the body of the electrode. The cup K is for filling and for entrance of the auxiliary electrode. With platinum electrode having a sealed-in mercury connection and with terminal	1	17	6


B 86-980.


B 87-105.


B 87-125.

	£	s.	d.
B 86-980. QUINHYDRONE ELECTRODE, Sand's. Glass U-tube about 3 in. long with overflow side tube ; capillary connecting tube with stopcock ; platinum foil electrode with sealed-in mercury connection, terminal and rubber stopper	1	0	0
B 87-105. AGAR BRIDGE TUBE, simple type, for connecting potassium chloride and solutions to be analysed	0	2	6
B 87-125. POTENTIOMETRIC BRIDGE TUBE, Pyrex Sintered Glass. An excellent substitute for the ordinary syphon tube in electro-chemical and potentiometric work. Suitable for calomel electrodes and similar purposes. Two sintered glass stems joined by a ∩-tube, dimensions 80 × 55 × 7 mm. diam., replace the usual filter paper wads .. .. *tx*	1	5	0



B 87-150—152.



B 87-330—335.

B 87-150. GLASS ELECTRODE SYSTEM, Morton (Findlay: *Practical Physical Chemistry, 7th Edn.*, p. 229). The system comprises a quinhydrone half-cell contained within a glass electrode, with a calomel half-cell reference electrode conveniently built into one unit. This construction is simple and robust and eliminates the electrical leakages experienced when separate mountings are adopted and therefore provides an electrode system capable of attaining high accuracy in measurement. The glass electrode is removable and may readily be interchanged with either quinhydrone, hydrogen, or antimony electrodes .. **3 10 0**

B 87-152. Glass Electrode Bulb, spare, with fused-on tube, for above. **Without** terminal .. **0 5 0**

B 87-154. Tubing, Glass, High Conductivity, for use in the manufacture of glass electrodes.

Diameter	5–6	7–9	10–12 *mm.*
Approx. No. of ft./lb. ..	50	40–30	25–18
	£1 15 0	**£1 14 0**	**£1 12 6** *lb.*

B 87-330. pH METER, Bench pattern, Cambridge. Range 0–14 *p*H in steps of 0·02 *p*H. Separate switch to enable instrument to be used as a millivolt potentiometer, range 0–1400 *m*V × 2 *m*V. With electrometer valve, consumption 0·1 amp., operated by a 12 volt accumulator supplying L.T., H.T. and grid bias, standard Weston cell, range switch, temperature compensating resistance (to be set to the measured temperature of the solution), and built-in galvanometer. In wood case 14 × 9 × 7 in., weight about 7 lb. Complete with **either** Morton **or** dip type glass-calomel electrode (*to be specified when ordering*), clip, spare sealed glass electrode, accumulator and 3 ft. connecting lead *tx* **50 0 6**

B 87-335. Ditto, but with self-contained mains unit for operation on standard A.C. voltage supply .. ..*tx* **59 16 0**

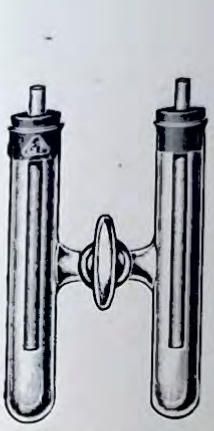
B 87-340. Electrode, Dip type, spare, for **B 87-330–335** .. ..*tx* **2 0 3**

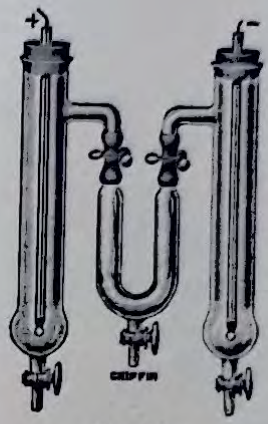
B 87-342. Electrode, sealed glass, spare for **B 87-330—335** .. ..*tx* **1 8 2**



B 87-600.

B 87-600. VELOCITY OF IONS APPARATUS, Lodge (Reilly and Rae: *Physico-Chemical Methods, 4th Edn.*, Vol. II, p. 408; Mee: *Physical Chemistry*, p. 527), by measuring the rate at which the colour of a faintly alkaline phenolphthalein jelly solution is discharged by hydrogen ions under a measured fall of potential. Suitable for students' use. Glass tube about 40 cm. long fitted with corks, right angle bends and platinum electrodes mounted on glass tubes **2 0 0**


B 88-105.


B 88-115.


B 88-120.


B 88-370.


B 88-380.

B 88-105. TRANSITION TEMPERATURE CELL (Reilly and Rae: *Physico-Chemical Methods, 2nd Edn.*, p. 301), for determining the transition temperature of one hydrate into another hydrate of the same salt. H-shaped cell about 8 cm. high, with stopcock between limbs. With rubber stoppers and cylindrical zinc rod electrodes .. .. £ 1 0 0

Method of Use.—One limb of the cell contains a saturated solution of $ZnSO_4 7H_2O$, the other a saturated solution of $ZnSO_4 6H_2O$, both in presence of their salts, and reaching above the junction. When the tap is open a current will generally flow on completing the circuit, since the arrangement constitutes a concentration cell except at the transition temperature.

To determine this, therefore, place the apparatus with the tap closed in a thermostatic bath at 25° C. for half an hour. Open the tap and measure the E.M.F. Repeat after 15 mins. to ensure that saturation has occurred. Then raise the temperature 5° and repeat, continuing thus at 5° intervals. Plot a Temperature—E.M.F. graph. It will be found that zero E.M.F. is reached at 39° C. above which temperature, the sign changes.

B 88-115. TRANSPORT NUMBER APPARATUS, Findlay (Findlay: *Practical Physical Chemistry, 7th Edn.*, p. 189). Symmetrical, allowing the solution round each electrode and the intermediate solution to be removed for analysis. Two tubes each approx. 18 cm. long with bulb at bottom and fitted with stopcock, with side arms connected by rubber tubing with clips, to a U-tube fitted with stopcock at bottom of bend. Mounted electrodes supported by rubber stoppers with vent-hole are required. **Without** electrodes .. 1 4 0

B 88-120. Cathode Limb (*ibid.*), with cup to contain mercury cathode, supported by rubber stopper with vent-hole. For substituting one limb of the Findlay Transport Number Apparatus **B 88-115**, where liberated metallic ions cause evolution of gas 0 14 6

B 88-125. Electrodes, mounted in glass tubes, for **B 88-115**. **Without** rubber stopper.

Type	Cadmium	Copper	Silver (long or short)	Zinc
	8/6	4/6	6/6	3/6 *each*

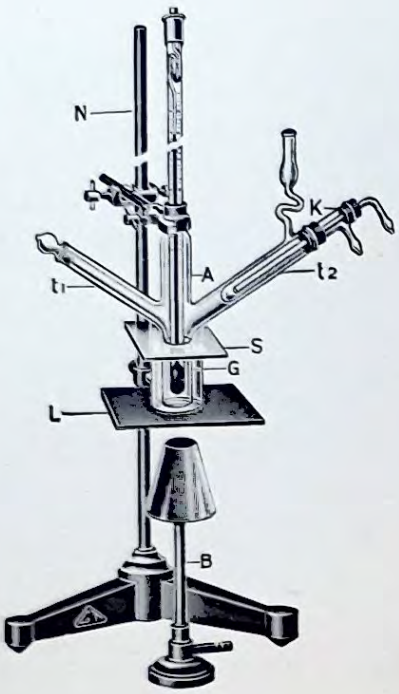
NOTES.—On passing current through an electrolyte the change of concentration at the electrodes is unequal, *i.e.* the velocities of the positive and negative ions differ. Analysis of the electrolyte surrounding the electrodes gives a measure of the ionic velocities from which, if the total quantity of electricity consumed is known, the transport numbers may be calculated. With the apparatus **B 88-115** the concentration of that portion of electrolyte in the U-tube is unaffected by diffusion or ionic migration during the time of the experiment and may be kept separate by closing the clips. The whole apparatus may be filled with N/10 silver nitrate solution, in which case two silver electrodes will be needed. After the passage of current, titrations are made on silver nitrate solution drawn through the cock from the region of the exposed anode. If used in conjunction with the limb **B 88-120**, an amalgamated zinc rod (soluble anode) is used.

B 88-370. MELTING POINT TUBES, Thiele, Pyrex Glass (*Analyst*, 1907, **32**, 277; *J. Chem. Education*, 1945, **22**, 111), with loop for circulation of sulphuric acid or other heating liquid by convection, thus avoiding stirring .. .. *each* 3/11; *dozen* 2 6 3

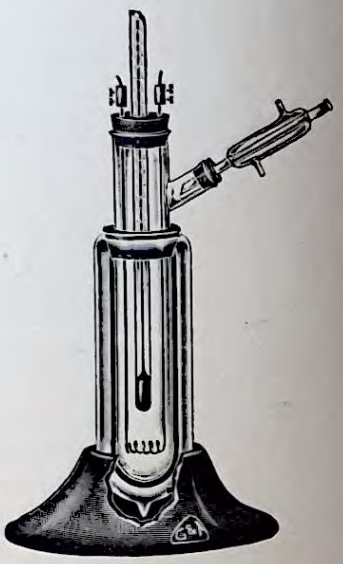
B 88-380. MELTING POINT FLASKS, Gibson, Pyrex Glass. As used in the Chemistry Dept., Guy's Hospital Medical School. A convenient form providing easy support of the capillary by means of a side tube on 50 ml. flask. End of capillary rests against thermometer bulb, immersed in sulphuric acid. Generally used with burner as employed for Marsh arsenic test. **Without** thermometer and capillary tube .. .. *each* 3/6; *dozen* 1 18 0



B 88-460.



B 88-500.



B 88-525.

B 88-460. MOLECULAR WEIGHT APPARATUS, Ebullioscopic, Walker-Lumsden (Spencer: *Physical Chemistry, 2nd Edn.*, Vol. I, p. 111; Clowes and Coleman: *Quantitative Chemical Analysis, 14th Edn.*, p. 507). A modification of the Landsberger apparatus of molecular weight determination having the advantage that only one quantity of substance has to be weighed out. Readings are made by varying the volume of solvent, rendering determinations rapid. Boiling tube graduated 0–30 ml. in 1 ml., with small hole above bulb and inlet tube perforated at bottom for introduction of vapour of solvent boiling in 750 c.c. conical flask. Glass jacket 20 cm. high with outlet for connection to condenser. As illustrated, with rubber stoppers but **without** thermometer .. .. £ s. d. 1 7 6

Thermometer, for above, 50–105° C. in 0·1°, white enamel back. *See* **B 47-675.**

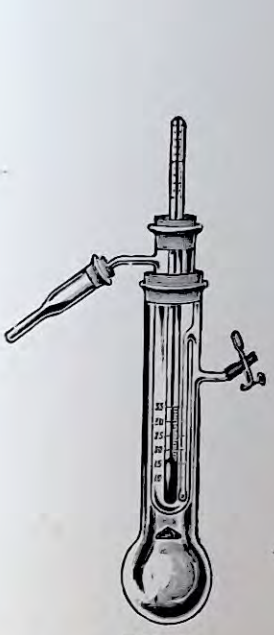
B 88-500. MOLECULAR WEIGHT APPARATUS, Ebullioscopic, Beckmann (Friend: *Text-Book of Physical Chemistry*, Vol. I, p. 421). An improved form of the classical Beckmann apparatus for determining molecular weight by elevation of the boiling point. Boiling tube A, with side arm t_1, for introducing sample and side tube t_2, carrying condenser K; cylindrical glass shield, G, with mica cover, S, for screening of thermometer and exclusion of draughts; asbestos millboard, L; burner, B, with chimney; beads (or garnets on request) to prevent superheating. The whole clamped to a stand, N, as shown. **Without** Beckmann thermometer .. .. £ 4 10 0

B 88-525. MOLECULAR WEIGHT APPARATUS, Ebullioscopic, Beckmann, Electrically heated (Findlay: *Practical Physical Chemistry, 7th Edn.*, p. 138; Rae and Reilly: *Physico-Chemical Practical Exercises*, p. 100). Designed for more rapid and accurate results than are possible with the gas heated types. In particular superheating of the liquid is minimised by the internal heating. Recommended more especially for dealing with non-electrolytic solutions. Silvered Dewar cylinder 200 × 40 mm. internal diam., with inner tube and rubber stopper, condenser side arm, platinum spiral to dissipate about 20 watts, joined to copper leads enclosed in glass tubes and with terminals. Mounted on polished wood foot. **Without** condenser or Beckmann thermometer 5 5 0

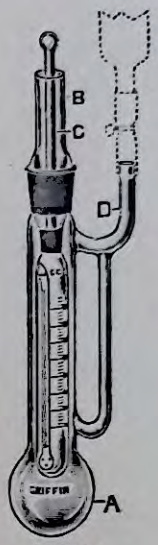
Beckmann thermometer for **B 88-500–525** .. .. .. *See* **B 47-778.**

Condenser, all glass, 20 cm., for **B 88-525** .. .. .. *See* **B 22-180.**

A great variety of Apparatus for all branches of Physics, Chemistry and Biology is made in our own factories and approved by rigid inspection in our own Test Rooms.



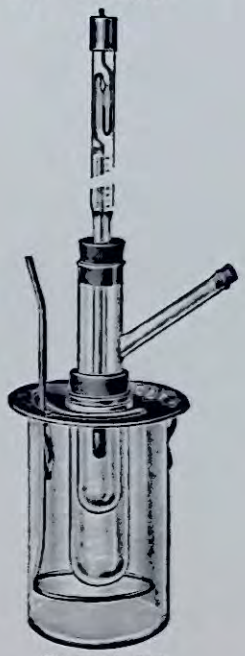
B 88-570.



B 88-580.



B 88-590—595.



B 88-715—717.

B 88-570. MOLECULAR WEIGHT APPARATUS, Ebullioscopic, McCoy (Findlay: *Practical Physical Chemistry, 7th Edn.*, p. 142 ; Reilly and Rae: *Physico-Chemical Methods, 2nd Edn.*, p. 434). for the determination of molecular weight by elevation of boiling point. The outer tube serves as a boiling tube and vapour jacket. Vapour enters the solution in the inner tube by the narrow sealed-in tube and a condenser should be connected to the upper side tube. Graduated 10–35 ml. **Without** Beckmann thermometer .. .. £ 1 15 0

Beckmann thermometer, for above .. .. *See* **B 47-778.**

B 88-580. MOLECULAR WEIGHT APPARATUS, Ebullioscopic, Menzies (Reilly and Rae: *Physico-Chemical Methods, 2nd Edn.*, p. 434), for measuring the difference between the vapour pressure of a pure solvent and a solution, and for determining the molecular weight of a solute. Boiling jacket about 27 cm. unstoppered length, to hold pure solvent, fitted with side arm for connecting to reflux condenser. Inner test-tube, supported by ground joint, graduated 15–55 ml. and closed by ground glass plunger ; integral leading-in tube, graduated in mm., serving to introduce vapour of boiling solvent from jacket and act as manometer. Test tube to contain pure solvent at first and then solution. No thermometer is required in this method. **Without** condenser 2 5 0

B 88-590. MOLECULAR WEIGHT APPARATUS, Menzies-Wright (Rae and Reilly: *Physico-Chemical Practical Exercises*, p. 102), Pyrex glass. Designed to secure a more perfect equilibrium between the liquid and vapour phases. Pyrex glass body having graduated bulb, inner tube vapour jacket, upper part condenser. With lift pump and with special differential water-filled thermometer with stem graduated in mm. Complete, as illustrated, with ground-in side tube for introduction of solute 7 0 0

B 88-592. Thermometer only for above, graduated, filled, boiled, evacuated and sealed .. 2 0 0

B 88-595. Lift Pump, Improved, for above, highly efficient pattern, with solid glass convolutions tied together by glass reinforcing rods. 1 1 0

In this apparatus the solvent and solute are placed in the bulb at the base, and the lift pump is hung on the upturned bulb of the differential thermometer, which is then lowered into the apparatus. When ebullition commences, the vapour and liquid phases are expelled by the pump over the lower thermometer bulb, the upper bulb being surrounded by the vapour of the pure solvent. From the differential thermometer readings the difference in boiling point between the solution and solvent may be obtained.

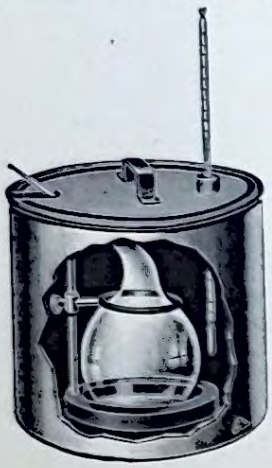
B 88-715. MOLECULAR WEIGHT APPARATUS, Cryoscopic, Beckmann (Findlay: *Practical Physical Chemistry, 7th Edn.*, p. 126 ; Clowes and Coleman: *Quantitative Chemical Analysis, 15th Edn.*, p. 449), for determination of molecular weights by lowering of freezing point. Cooling bath with ring-shaped stirrer and nickel-plated cover supporting air jacket in which is freezing tube 18 cm. long, having side arm for introduction of sample. **Without** thermometer or platinum stirrer for freezing tube 3 10 0

B 88-717. Freezing tubes, spare, for above .. .. *each* 0 3 0

Beckmann thermometer for above .. .. *See* **B 47-780.**

Cyclohexanol as a solvent for the cryoscopic determination of molecular weights. (Wilson & Heron : *J. Soc. Chem. Ind.*, 1941, **60**, 108). Because of its very high Raoult constant, large depressions of melting point are obtained, and a Beckmann thermometer is unnecessary. Cyclohexanol can readily be purified, and is not as hygroscopic as phenol or acetic acid.

VAPOUR DENSITY



B 88-770—780.

B 88-770. VAPOUR DENSITY APPARATUS, Dumas (Smith: *Intermediate Physics*, p. 238). Adjustable weighted support for glass bulb; enamelled iron water bath, 6 in. diam., copper cover with asbestos cement top and handle, apertures for thermometer and neck of glass bulb. **Without** thermometer and bulb *p* 3 5 0

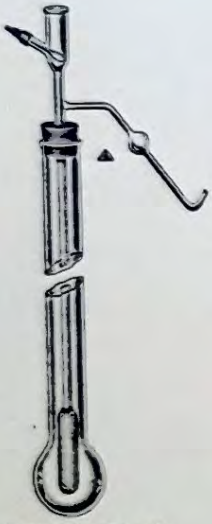
B 88-780. VAPOUR DENSITY BULBS, Dumas (*cf.* Clowes and Coleman: *Quantitative Chemical Analysis*, 14*th Edn.*, p. 513). Of light glass, 200 ml. capacity, for vaporising liquid. Neck drawn out for sealing off .. *each* 2/-; *dozen* 1 2 0



B 88-780.



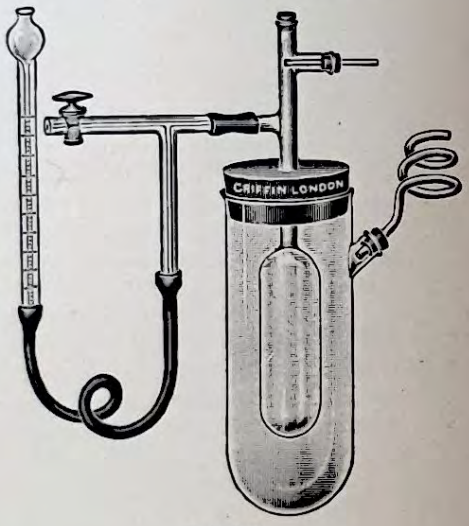
B 88-790—792.



B 88-840+855 a, b.



B 88-855 d.



B 88-870.

B 88-790. VAPOUR DENSITY APPARATUS, Dumas, Improved (Mee: *Physical Chemistry*, p. 35). Useful for making determinations at elevated temperatures. Cylindrical vaporising bulb 14 × 3 cm. diam., supported by rubber bung in glass vapour bath, fitted with condenser and thermometer to 210° C. in 1° 1 15 0

B 88-792. Bulbs, Vaporising, Spare, for above .. .. *each* 2/6; *dozen* 1 6 0

B 88-840. VAPOUR DENSITY APPARATUS, Victor Meyer, Improved (Walker: *Introduction to Physical Chemistry*; Findlay: *Practical Physical Chemistry*, 7*th Edn.*, p. 50). A convenient and widely used apparatus. Vaporising tube with bulb 150 ml. capacity, delivery arm with safety bulb and side tube with flattened glass rod to retain stoppered bottle with sample until release by rotation of rod is required. By this means loss of gas on withdrawal of stopper to introduce bottle, as in earlier forms, is avoided. **Without** outer jacket. (**B 88-855 a-c**) 0 7 6

Component and Extra Parts for B 88-840

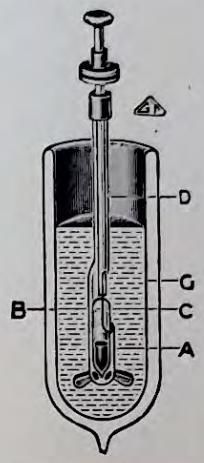
		£	s.	d.
B 88-855 a.	**Outer Jacket** only, soda glass, 65 cm. × 4 cm. diam.	0	8	0
" " b.	Ditto, Pyrex glass .. .. *tx*	0	10	6
" " c.	Ditto, Copper	0	17	6
" " d.	**Bottles, Vapour Density,** for introducing liquid samples into Victor Meyer tubes. External diam. 4 mm. Length, including ground-glass stopper, 3 cm. .. .. *dozen*	0	9	6

B 88-870. VAPOUR DENSITY APPARATUS, Lumsden (Reilly and Rae: *Physico-Chemical Methods*, *2nd Edn.*, p. 542; Mee: *Physical Chemistry*, p. 32). Bulb about 100 ml. capacity, jacket 22 × 4·5 cm., spiral air condenser, capillary T-piece with reference mark, tap and manometer tube divided in mm. for 20 cm. Complete with rubber tubing and corks 2 5 0

The Victor Meyer and the Lumsden methods are similar except that in the former, determinations are carried out at constant pressure and in the latter at constant volume. The inner bulb is heated to constant temperature with the stopcock open; the substance is then introduced in a small bottle (**B 88-855 d**), the stopcock closed and the difference in level then read on the graduated tube when equilibrium has been attained.



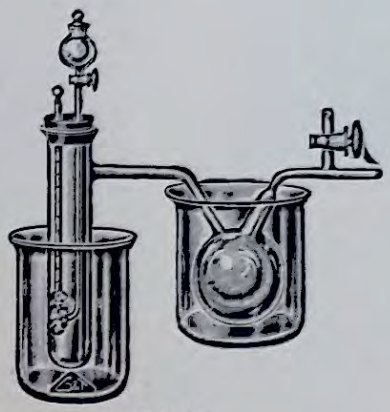
B 88-940.



B 88-960.



B 89-300.



B 89-625.



B 89-705.

B 88-940. REACTION VELOCITY APPARATUS (Findlay: *Practical Physical Chemistry, 7th Edn.*, p. 263). The velocity of decomposition is determined by the amount of gas evolved from, *e.g.* benzene diazonium chloride, in a given time. Decomposition tube with side arm for connection to a gas burette; stirrer for mechanical rotation, with mercury seal .. £ 2 5 0

B 88-960. HEAT OF REACTION APPARATUS, Yorke (*Chem. and Ind.*, 1946, 17). Stirrer, comprising a glass bulb fitted with glass vanes, tubular spindle and pulley with sleeve for holding in clamp, and inner sliding rod for breaking capsule. **With** 1 dozen uncharged capsules, but **without** Dewar Vessel. (**A 42-940**) .. .. £ 1 5 0

B 88-962. Ditto, on stand with clamps for flask, stirrer and thermometer £ 3 0 0

B 88-964. Capsules, spare, thin walled, for above .. .. *dozen* £ 0 0 10

This apparatus is designed to allow two unmixed reactants to be brought to the same temperature in the same vessel, before the reaction is started. The device comprises a hollow stirrer A having at its end a bulb, through an aperture B in the side of which, there can be introduced one reactant in a sealed, thin-walled, capsule C. After equilibrium thermal conditions have been attained, the capsule can be broken *in situ* by means of the plunger G. The apparatus has proved useful in measuring heats of reaction, etc.

B 89-300. MOLECULAR SURFACE ENERGY APPARATUS (Findlay: *Practical Physical Chemistry, 7th Edn.*, p. 86). By reading the height or rise of liquids in a capillary tube data are furnished for determining the molecular surface energy and the association factor. Glass vessel 15 cm. high, containing capillary divided in mm. With short tube for forcing liquid up capillary by air pressure .. .. £ 0 11 6

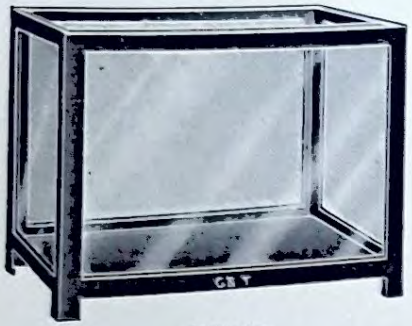
B 89-625. VAPOUR PRESSURE APPARATUS, Ramsay and Young (Reilly and Rae: *Physico-Chemical Methods, 4th Edn.*, Vol. II, p. 9; Friend: *Text-Book of Physical Chemistry*, Vol. I, p. 76). A dynamic method also applicable to the determination of the boiling point of a pure liquid. Tube 10 × 1½ in., fitted with thermometer — 5° to 105° C. in 0·1° C., bulb covered with cotton wool, tap funnel with drawn-out stem, rubber stopper and side tube, oil bath; globular condenser 200 ml., having exit tube with tap for air inlet; cooling bath .. .. £ 2 5 0

The apparatus is designed to overcome the difficulties of raising the temperature of the liquid under examination without superheating. The liquid is placed in the tap funnel and delivered in drops to the covering of the thermometer bulb, where vaporisation takes place, the bath temperature being maintained about 20° C. above the anticipated boiling point. The apparatus is exhausted and the boiling point (or vapour pressure as read on a manometer) determined for the different pressures indicated on the manometer.

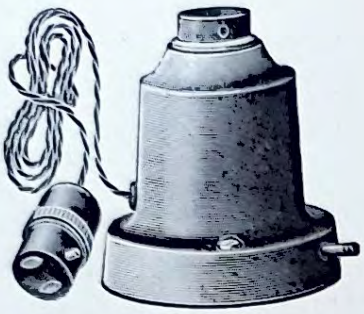
B 89-705. TENSIMETER, Cumming (Spencer: *Physical Chemistry, 2nd Edn.*, Vol. I, p. 215, Vol. II, p. 198; Lowry and Sugden: *Class Book of Physical Chemistry*, p. 151). An apparatus for measuring vapour pressures of crystals, etc., and may be applied to determine the transition point of hydrates. Observation of the dew point furnishes data for determination of vapour pressure; molecular weight determinations may also be made. Tube 15 × 5 cm. diam. to contain sample; stopcock on side arm for connection to exhaust pump. Silver thimble, to carry thermometer — 5° to 105° C. in 0·2°, and with two bent tubes for evaporation of ether by bubbling air, to cause deposition of dew from vapour of sample. **Without** thermometer .. .. £ 3 10 0

Thermometer — 5° to 105° C. in 0·2° for above .. .. *See* **B 47-675.**

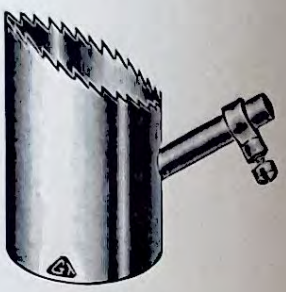
Biology



B 96-010.



B 96-025.



B 96-040.

B 96-010. AQUARIA, stoutly constructed, with strong welded steel frame, glass sides and slate bottom.

Size	A	B	C	D	
Length × width × depth	18 × 12 × 12	24 × 12 × 12	30 × 15 × 15	36 × 18 × 18	*in.*
	t £4 10 0	£6 0 0	£9 10 0	£12 15 0	*each*

Larger sizes made to order.

Glass Troughs, suitable also for aquaria .. .. *see* **B 49-430—434.**

	£ s. d.
B 96-025. AERATOR, Aquaria, electrically operated, for use on 200–240 v. A.C. mains only. New pattern differs from illustration	*t* 2 0 0
B 96-029. DIFFUSERS, for use in aerating aquaria. Hollow Bakelite cube, with felt washer and stem about 1½ in. long, for rubber tubing connection .. *each t* 1/8 ; *dozen*	0 18 0



B 96-030.

B 96-030. HEATERS, Aquaria, coiled coil heating element, in glass tube, submersible, for use in maintaining aquaria at temperature for tropical fish, etc. Heaters can be strung together to build up any required loading. A 25 watt heater will maintain a 1 gallon aquarium at about 60° F. in a room temperature of 40° F. A 50 watt heater would maintain it at about 70° F. Tube length 12 in. for 25 and 50 watt, 14 in. for 75—120 watt, 18 in. 50 watt.

Loading ..	25	50	75	100	120	150	*watts*
	t 12/6	12/6	12/6	12/6	14/-	14/-	*each*

B 96-032. Thermostats, for above, adjustable.

To carry up to	150	250	*watts*
Please state voltage when ordering.	*t* 15/-	25/-	*each*

	£ s. d.
B 96-040. CYLINDER, Collecting, for filamentous algæ. Strongly made of zinc and brass, 5 in. high, with sloping serrated edge. Can be attached to stick by means of screw. Useful where difficulties attend the use of hooks or net. With closed bottom	*t* 0 6 6
B 96-042. Ditto, with perforated bottom	*t* 0 6 6



B 96-060.

COLLECTING STICKS AND EQUIPMENT.

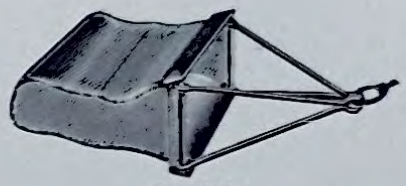
B 96-060. CANES, length 30 in., with screw fittings at each end, enabling a number of canes to be screwed together. **Without** handle .. .. *each* *t* 0 5 0

		£ s. d.
B 96-065 a.	**Nets, circular,** 6 in. diameter. .. .. *each*	*t* 0 4 0
„ „ b.	**Nets, circular,** 8 in. diam., on brass ring, complete with tube .. .. .. *each*	*t* 0 11 0
„ „ c.	**Grapnel,** brass, flat pattern with 24 feet cord and frame	*t* 0 8 0
„ „ d.	**Rigid Hook,** stainless steel, oval pattern, for use amongst weeds	*t* 0 5 6

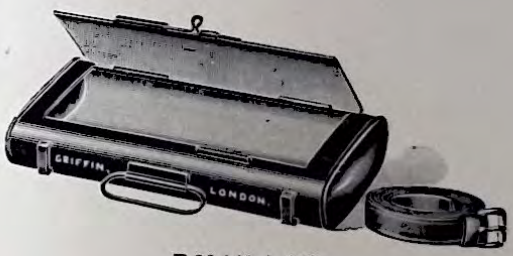
Other accessories, prices on application.


B 96-105.

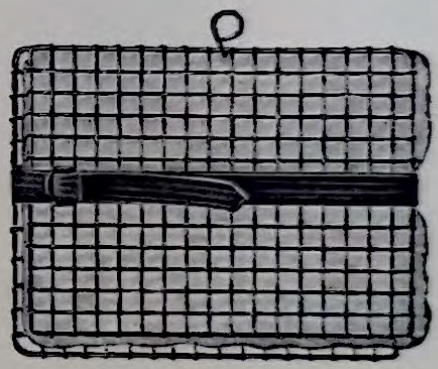

B 96-115.


B 96-120.

	£	s.	d.
B 96-105. WATER NET, diam. 8 in., strong canvas bag, brass socket. **Without** stick .. *t*	0	3	6
B 96-107. Ditto, suitable for Daphnia, Tadpoles, etc. D shape, folding, 12 in. across, strong canvas bag, brass socket, to fit **B 96-060. Without** stick .. .. *t*	0	7	6
B 96-115. TOW NET, for Plankton collecting, diam. 11 in. at mouth, tapering bag of fine muslin net with reinforced seams and metal receiver, with bayonet catch .. .. .. *t*	1	10	0
B 96-120. DREDGE, width across mouth 12 in., strong galvanised frame with heavy canvas and net bag. **Without** cord .. .. *t*	2	0	0
B 96-125. Ditto, light pattern, triangular, side 8 in., with canvas net and 12 yards stout cord on frame .. .. *t*	1	10	0



B 96-140 + 142.


B 96-150.


B 96-175.

B 96-140. COLLECTING CASES (Vascula), finished black enamel outside, coated aluminium inside to prevent rust, with handle, and loops for shoulder strap.

Size	A	B	C
Dimensions	11 × 5½	13 × 6½	15 × 7½ *in.*
	p 15/-	17 6	22 6 *each*

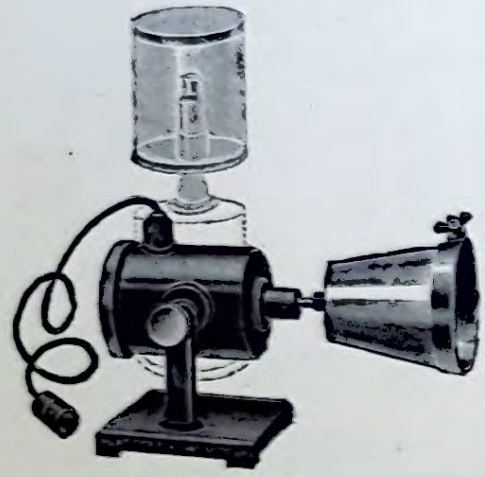
	£	s.	d.
B 96-142. Shoulder Straps, Leather, for above .. .. *each p*	0	4	6
B 96-150. PRESS, Botanical, 7 × 9 in., wire frame, with thick absorbent cotton wool and one strap. Preserves the colours of flowers and leaves .. .. *t*	0	5	0
B 96-152. Ditto, 14½ × 12 in., with two webbing straps and supply of drying paper .. *t*	0	13	6
B 96-170. ENVELOPES, 2½ in., square, with gummed flap, for seed collection *per* 100	0	1	6
B 96-175. FERN TROWEL (Pupa Digger), long solid steel curved blade with wood handle, in leather sheath .. .. *p*	0	8	6
B 96-177. Ditto, cheaper quality, without leather sheath .. .. *p*	0	3	6

BOTANY

		£	s.	d.
B 96-190. PAPER, black, glazed, for specimens. Sheets 20 × 30 in.	*quire*	0	9	0
B 96-195. Ditto, drying, thick. Sheets 18 × 11 in. double	*quire* r 4/6 ; *ream*	3	10	0
B 96-200. Ditto, mounting, white, thick. Sheets 17½ × 11 in. double	*quire* r 2/6 ; *ream*	2	5	0
B 96-205. Ditto, parchment, waterproof. Sheets 20 × 30 in.	*sheet* r 8d. ; *quire*	0	15	0
B 96-210. Ditto, waxed, for wrapping fresh specimens. Sheets 20 × 30 in.	*sheet* r 8d. ; *quire*	0	15	0

B 96-215. CARDS, mounting, white, stout.

Dimensions	12 × 10	18 × 12½ *in.*
	r 6/-	18/- *dozen*



B 96-250—252.



B 96-265.



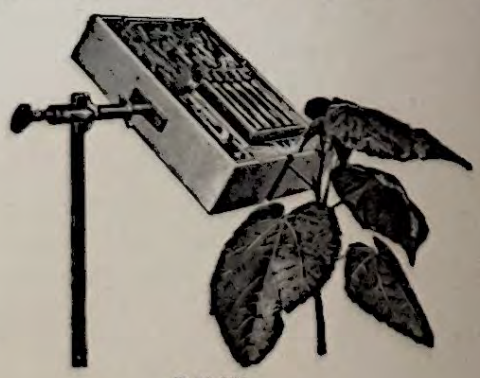
B 96-270.

	£	s.	d.
B 96-250. CLINOSTAT, electric (*cf.* Ganong: *Textbook of Botany*, p. 176), for experiments with seedlings and cut shoots on geotropism and phototropism. Self-starting motor 200–250 volts A.C. adjustable to any angle from vertical to horizontal, mounted on heavy base, 5 in. diam. cork disc with celluloid cover and removable fitting carrying small bottle for cut shoots. Safety device to prevent damage to motor when attaching or removing cork disc	t 4	10	0
B 96-252. Plant Pot Cover, aluminium, for thumb pots, with socket to fit motor spindle of **B 96-250,** interchangeable with cork disc	t 0	8	6
B 96-265. PHOTOSYNTHOMETER (Ganong: *Textbook of Botany*, p. 24). For demonstrating the absorption of carbon dioxide by green plants in light, with the equivolumetric release of oxygen. Glass plant chamber on stand with ground-in stopper and stopcock, one ground-in tube graduated 0–10 ml. in 0·1 ml., with stopcock (combined capacity of assembly 102 ml.), 2 reagent tubes with rubber tubing and clips. **Without** burette stand and cylinder ; with instructions	r 3	0	0

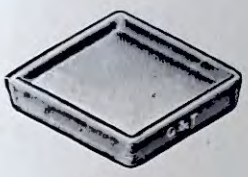
Method.—Introduce 10 ml. CO_2 into graduated tube removed from plant chamber (amount determined by displacement of water). Place 2 ml. leaves in chamber, assemble apparatus and expose to bright light for 4 hours. Analyse for CO_2 in tube by fixing reagent tube containing KOH solution to end (under water). After absorption, immerse in water, as shown on left, to obtain reading. Similarly for oxygen, using pyrogallol.

B 96-270. LIGHT SCREEN (Ganong: *Textbook of Botany*, p. 20), pill-box pattern, covering part of leaf, but allowing the CO_2 of the air freedom of access. To show that the effect of light in photosynthesis is strictly local. The parts exposed to sunlight give a blue coloration with iodine solution, indicating the synthesis of starch from sugars and carbon dioxide. Before applying test extract chlorophyll with warm alcohol	t 0	5	0

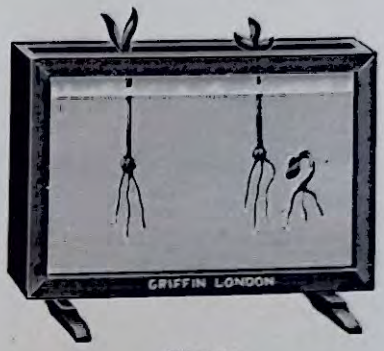
B 96-275. LIGHT SCREEN (*cf.* Bower: *Botany of the Living Plant*, p. 113), covering wholly leaves of moderate size, consisting of box, adjustable for height and angle, divided into two compartments open at bottom, and covered in such a manner that direct light can be excluded and yet air can enter freely. With support for attaching to tripod stand and five solutions for simultaneous use as light screens to different wavelengths, *e.g.* red, yellow, green, blue, violet .. .. £ 5 10 0



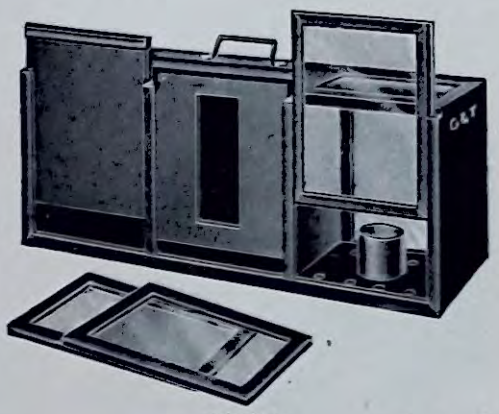
B 96-275.



B 96-302.



B 96-310.



B 96-315.

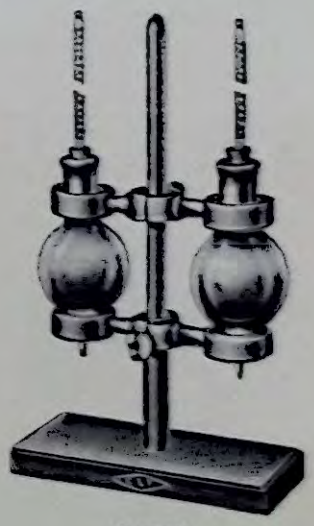
	£	s.	d.
B 96-302. GERMINATING DISHES, square, thick porous earthenware, with rim, 2⅝ in. side. *dozen*	0	10	0
B 96-310. GERMINATOR (*cf.* Cavers: *Botany for Matriculation, 3rd Edn.*, p. 53), designed to show the proper depth to plant seeds. Zinc frame with glass front and back, 15 in. long, 8 in. high, ¾ in. between glass. Metal shields are provided for each window to exclude light during germination	2	15	0
B 96-315. GERMINATING CHAMBER, Combination Dark (*cf.* Fritsch and Salisbury: *Botany 2nd Edn.*, p. 209), for phototropic experiments on seedlings. 7 in. high, divided into 3 compartments, each with a glass pot for seedlings. The first compartment is fitted with a sliding opaque shutter, the second a shutter with slot to admit light from one direction only, and the third allows free access of daylight for use as a control. Additional shutters, one each of blue and orange, are provided for use with light from which certain wave-lengths have been removed .. .. *p*	3	15	0



B 96-325—327.

	£	s.	d.
B 96-325. RESPIROMETER, Ganong (Thomas: *Plant Physiology*, p. 256), for accurately and conveniently showing and measuring the oxygen uptake in typical respiring material, *e.g.* germinating seeds. With stand	2	5	0
B 96-327. Ditto. Glass parts only	0	15	0

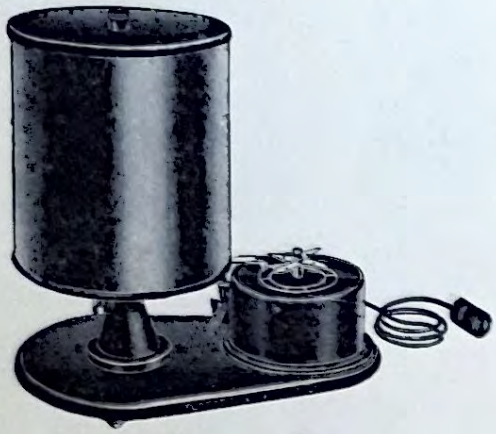
Place 2 ml. respiring material (determine by water displacement in a graduated jar) in the bulb, and a 10% solution KOH in the manometer, adjust the level to the 100 ml. mark. The stopper, which has a small air hole, is turned momentarily to adjust the air pressure to atmospheric. The volume of the apparatus above the liquid level is 102 ml. (including the 2 ml. material). Close air hole. CO_2 produced by respiration is absorbed by the KOH solution and the solution ascends the graduated tube up to the 80 ml. mark. Adjust liquid levels again. 20% air (oxygen) is assimilated.



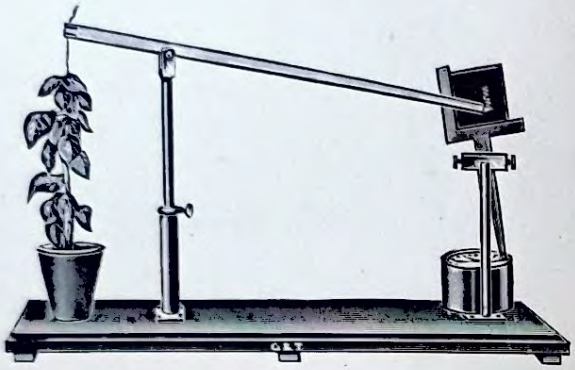
B 96-330.

	£	s.	d.
B 96-330. CALORISCOPE, Ganong (*Text-Book of Botany*, p. 170). To demonstrate the **heat of respiration** of seeds, living tissues, etc. Two, 250 ml. spherical, vacuum-jacketed vessels (Dewar flasks) with internally-silvered walls, are mounted between adjustable rings on a stand. The vessels are provided with rubber stoppers and two thermometers — 5° to + 50° C. in 0·1° C.	3	15	0

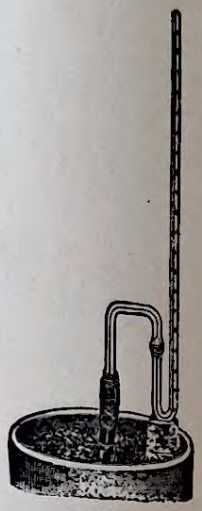
The apparatus may be used to demonstrate the heat developed in respiration ($C + O_2 \rightarrow CO_2$). The vessels being vacuum jacketed and little heat therefore being lost by radiation or conduction, the heat developed in respiration manifests itself as a rise in temperature of the respiring material. Germinating seeds should be placed in one vessel and seeds, killed either by treatment with mercuric chloride solution or by immersion in boiling water, in the other vessel. The two thermometers will then, after a time, indicate different temperatures; that in the germinating seed vessel being the higher. If the seeds be killed by immersion in boiling water the difference of reading between the two thermometers will probably not be as great as if the seeds had been killed by treatment with $HgCl_2$ solution. This is because fermentative processes may supervene and cause a rise of temperature which, however, will not be as great as that due to respiration.



B 96-335.



B 96-345.



B 96-350.

£ s. d.

B 96-335. AUXANOMETER, electric, Farmer pattern, with recording drum 6 in. diam. × 6 in. high, mounted on baseplate with self-starting 200–250 v. A.C. electric motor. Adjustable vanes on the top of the motor can be set to actuate the drum through a small angle every 15, 20, 30 or 60 mins. With flex and adapter .. .. *t* 7 5 0

B 96-340. Recording Lever, for use with **B 96-335**, with writing point, and hooks, pivoted at centre and adjustably mounted on metal upright, with heavy metal base. For comparison purposes it is possible to use several recording levers at once .. .. *t* 1 11 6

B 96-345. AUXANOMETER, electric (Fritsch and Salisbury: *Botany, 2nd Edn.*, p. 199 (Modified); *Science Masters' Book*, Part II, p. 202), for measuring and recording the growth of plants. Light metal lever, giving magnification × 5, on pillar, adjustable for height, long arm fitted with writing point makes a trace on a smoked glass plate held in a frame. The plate is caused to move laterally every hour or half-hour by a 200–250 volt A.C. motor. The apparatus can readily be dismantled for storage .. .. *t* 5 10 0

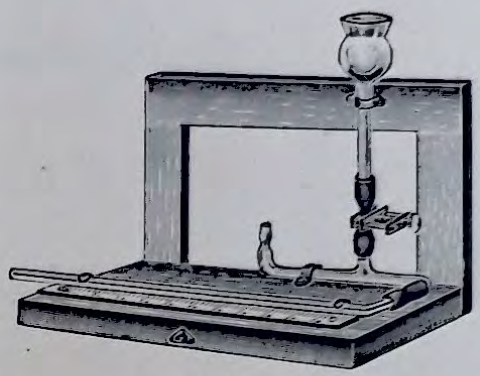
The short arm of the lever is attached to the plant by silk thread, the long arm moves downwards as the plant grows. The glass plate may be a standard 3¼ × 3¼ in. lantern slide cover glass. The records obtained can be made permanent by spraying with gum fixative, and bound as lantern slides for retention for reference.

B 96-350. ROOT PRESSURE MANOMETER (Lowson: *Text-Book of Botany, 7th Edn.*, p. 179; Fritsch and Salisbury: *Botany, 2nd Edn.*, p. 156). Graduated manometer is attached by means of rubber tube or insulating tape to the cut stem of a plant growing vigorously in wet soil 0 8 6

A great variety of Apparatus for all branches of Physics, Chemistry and Biology is made in our own factories and approved by rigid inspection in our own Test Rooms.


B 96-370.


B 96-375.

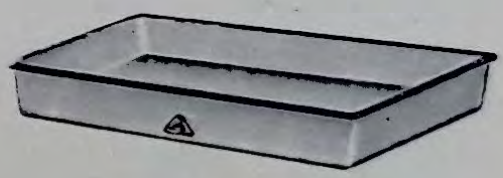

B 96-380.


B 96-385.

	£	s.	d.
B 96-370. POTOMETER TUBE, Darwin, fitted with 2 rubber bungs .. *each* 2/6 ; *dozen*	1	7	0
B 96-375. POTOMETER, Farmer (Wyeth: *Elementary General Biology, Part I,* p. 140), consisting of funnel with stopcock, glass tube of narrow bore fitted with scale, and wide-mouthed bottle with rubber bung .. .. *r*	0	16	0
B 96-380. POTOMETER, Thoday (*Science Masters' Book, Series II,* Pt. II, p. 86). Horizontal glass potometer tube, with vertical open end to take plant shoot, thistle funnel connected to side arm by rubber tubing with screw clip. Other end of potometer is attached by means of rubber tubing to a capillary tube about 1 mm. bore with millimetre scale. Mounted on wood stand 9 × 6 in., with back board about 6 in. high, to which the shoot can be attached	1	0	0
B 96-385. POTOMETER, Ganong (Lowson: *Text-Book of Botany, 7th Edn.,* p. 183), for the quantitative determination of transpiration by the measurement of the water absorbed by a cut shoot. Complete with stand	2	10	0


B 96-390+395.


B 96-525.


B 96-530.

	£	s.	d.
B 96-390. PLANT POT COVER (Ganong: *Text-Book of Botany,* p. 45 ; Wyeth: *Elementary General Biology, Pt. I,* p. 138). A metal shell for transpiration experiments, by weighing. Evaporation from the soil surface is prevented by means of rubber sheet which can be drawn to any desired tightness by a screw nut. Suitable for 4 in. diam. pot. **Without** rubber sheet .. .. *r*	0	8	6
B 96-395. Rubber Sheet, for above .. .. *square foot*	0	3	0

B 96-525. DISSECTING DISHES, enamelled steel, white.

Length overall ..	8	10	12	14 *in.*
	18/-	30/-	43/-	62/6 *dozen*
	1/8	2/9	4/-	5/9 *each*

B 96-530. DISSECTING DISHES (Instrument Trays), heavy gauge steel, white enamelled inside and out, straight sided, depth 2 in.

Dimensions ..	8 × 6	10 × 8	12 × 10	16 × 12	18 × 14 *in.*
	5/-	5/6	6/-	8/6	9/6 *each*



B 96-560.



B 96-565.



B 96-570.



B 96-580.



B 96-540.

B 96-535. CORKS, weighted, for dissecting dishes.

Size of cork	$4\frac{3}{4} \times 2\frac{3}{4}$	$6\frac{1}{4} \times 3\frac{3}{4}$	$7\frac{1}{2} \times 4\frac{1}{4}$	$9 \times 5\frac{1}{4}$	*in.*
Suitable for dish length ..	8	10	12	14	*in.*
	2/6	**2/9**	**3/6**	**5/6**	*each*

B 96-540. DISSECTING BOARDS, Hardwood, for rats, guinea pigs, rabbits, etc. Strongly made, of well-seasoned wood, with raised edge all round, rubber feet on base and hook in each corner on top.

Dimensions ..	9 × 9	12 × 12	18 × 12	22 × 15	24 × 18 *in.*
	10/-	**12/-**	**14/6**	**21/-**	**27/-** *each*

		£	s.	d.
B 96-560. NEEDLES, Dissecting, steel, needle point, in round wood handle, **without** ferrule	*dozen* 4/- ; *gross*	2	5	0
B 96-562. Ditto, best quality, with ferrule	*dozen* 4/6 ; *gross*	2	9	0
B 96-565. Ditto, with lancet point (Borradaile type)	*each* 1/6 ; *dozen*	0	16	0
B 96-570. SEEKERS, straight, blunt, steel, in round wood handle ..	*each* 5d. ; *dozen*	0	4	0
B 96-575. Ditto, best quality, with ferrule	*each* 7d. ; *dozen*	0	6	0
B 96-580. SEEKERS, bent, in round wood handle	*each* 7d. ; *dozen*	0	6	0
B 96-585. Ditto, best quality, with ferrule	*each* 8d. ; *dozen*	0	7	0
B 96-600. FORCEPS, Wood, 12 in. long, for removing specimens from preserving fluid	*each*	0	5	0



B 96-615.

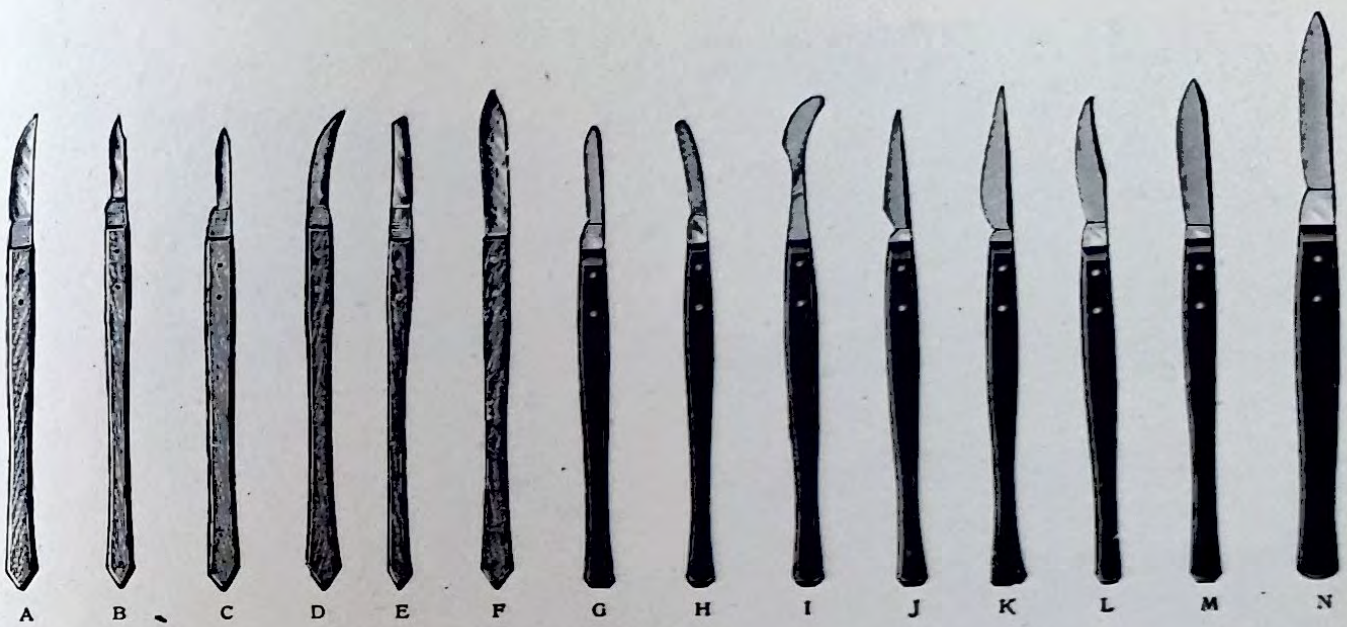


B 96-620.

B 96-615. DISSECTING PINS, for pegging out specimens on dissecting boards. Blade $2\frac{1}{4}$ in. With wooden handle shaped to facilitate the application of pressure .. *each* 8d. ; *dozen* 0 7 0

B 96-620. DISSECTING STANDS, suitable for bees and other small insects *each* 3/3 ; *dozen* 1 15 0

The General Index at the end of this Catalogue is a complete guide to its contents. Please consult it.



B 96-800.

B 96-800. SCALPELS, best quality Sheffield steel, with ebonised handles.

Pattern ..	A	B	C	D	E	F	G	
	4/-	3/6	3/6	4/-	4/-	3/6	3/6	*each*
Pattern ..	H	I	J	K	L	M	N	
	4/-	4/-	4/-	4/-	4/-	3/6	4/-	*each*

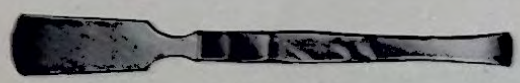
B 96-802. Ditto, with solid steel handles, nickel-plated. Shapes and sizes as **B 96-800.** (*Pattern N only stocked. Other shapes to order*) .. .. *each* £ s. d. 0 4 0

B 96-805. SCALPELS, good quality, with ebonised handles, for students' use, as **B 96-800,** pattern N.

Blade length approx.	1½	2	*in.*
	42/6	45/-	*dozen*
	4/-	4/3	*each*



B 96-810.



B 96-815.



B 96-820.

B 96-810. SCALPEL RACKS, nickel-plated.

For	6	12	*scalpels*
	2/3	4/-	*each*

B 96-815. SECTION LIFTERS, straight, nickel-plated, ebonised handle.

Width	1	1·5	2	*cm.*
	3/6	4/-	4/6	*each*

B 96-820. Ditto, bent, nickel-plated, with ebonised handle .. .. *each* £ s. d. 0 3 0



B 97-010.



B 97-015.



B 97-020.



B 97-022.



B 97-025.

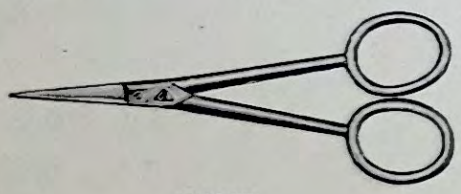


B 97-040.

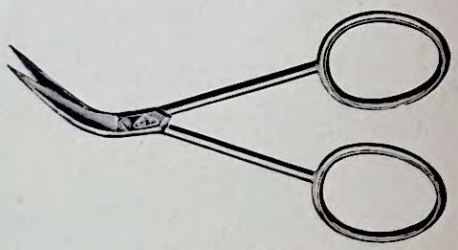
B 97-010. FORCEPS, Stainless Steel, fine points, **straight.**

Approx. length	5	6	*in.*
	£1 17 6	£2 4 0	*dozen*
	3/6	4/-	*each*

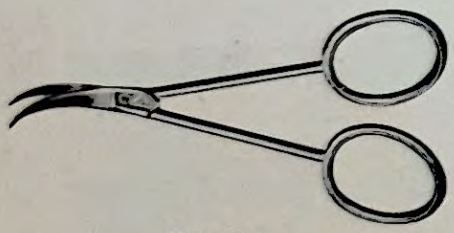
	£	s.	d.
B 97-015. FORCEPS, Stainless Steel, fine points, **bent,** approx. length 4½ in. *each* 3/6 ; *dozen*	1	17	6
B 97-020. FORCEPS, Stainless Steel, blunt points, strong, length approx. 5 in. *each* 3/6 ; *dozen*	1	17	6
B 97-022. FORCEPS, nickel-plated steel, curved broad ends, as used in Schools of Tropical Medicine. Length 4½ in. .. .. *each* 4/- ; *dozen*	2	4	0
B 97-025. FORCEPS, Bone, nickel-plated, 5½ in. long, for small bones .. .. .. *each*	1	5	0
B 97-040. CHAIN HOOKS, set of 3	0	1	9



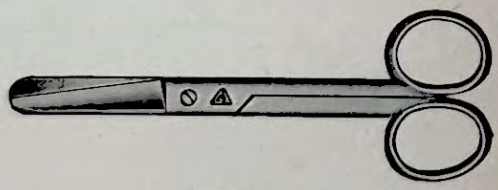
B 97-055.



B 97-062.



B 97-060.

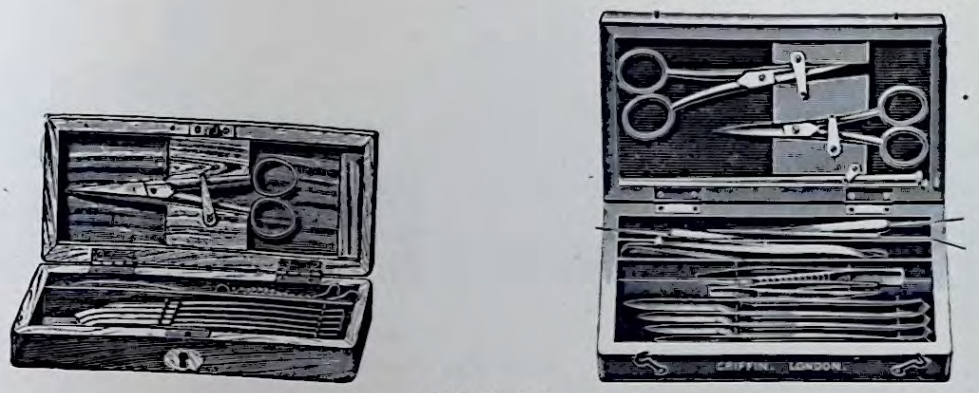


B 97-065.

B 97-055. SCISSORS, Dissecting, nickel-plated steel, fine points, straight, open shanks.

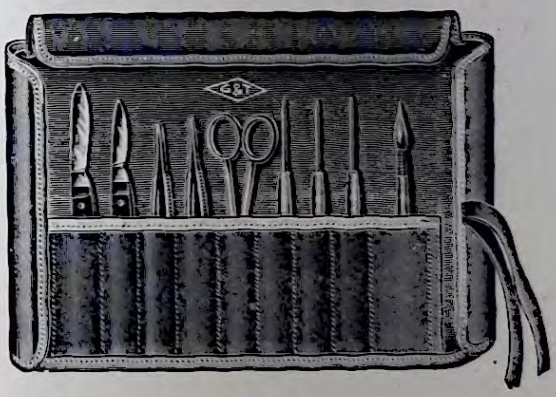
Approx. length	4	5	*in.*
	£4 2 6	£4 7 6	*dozen*
	7/6	8/-	*each*

	£	s.	d.
B 97-060. Ditto, fine points, curved up, length approx. 4½ in. .. .. *each* 8/- ; *dozen*	4	7	6
B 97-062. Ditto, fine points, bent to side, length approx. 4½ in. .. *each* 5/- ; *dozen*	2	15	0
B 97-065. SCISSORS, Dressing, nickel-plated steel, blunt rounded ends, closed shanks, approx. length 5 in. .. .. *each* 4/6 ; *dozen*	2	10	0

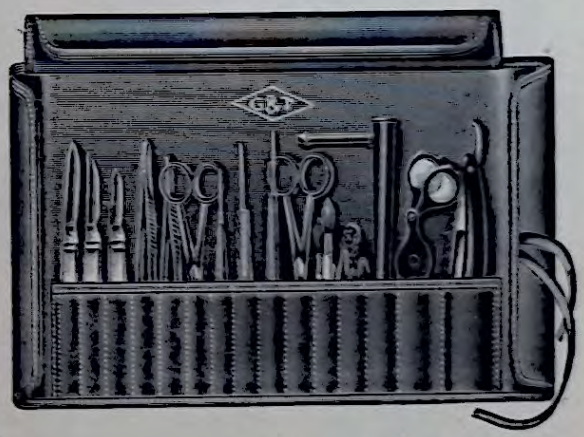


B 97-080—087.

	£	s.	d.
B 97-080. DISSECTING SET, No. 1, in polished wood case containing 3 scalpels, 1 pair forceps, 1 pair scissors and 2 needles	1	15	0
B 97-082. Ditto, No. 2, containing 4 scalpels, 1 pair each forceps straight and curved, 1 pair each scissors straight and curved, and 2 needles	2	5	0
B 97-085. Ditto, No. 3, containing 6 scalpels, 1 pair each forceps straight and curved, 1 pair each scissors straight and curved, 1 section lifter and 2 needles	2	15	0
B 97-087. Ditto, No. 4, containing 3 scalpels, 2 pairs straight forceps, 1 pair bent forceps, 2 pairs straight scissors, 1 pair curved scissors, 2 needles, 1 hook in handle, 1 razor, 1 strop, and 1 section lifter	3	10	0



B 97-110.



B 97-120.

	£	s.	d.
B 97-105. DISSECTING SET, No. 5, in khaki drill roll, containing ebony handled scalpel, one pair scissors, two needles and one pair forceps with fine points	1	1	0
B 97-110. Ditto, No. 6, in khaki drill roll, containing two ebony handled scalpels, two pairs forceps, fine and blunt points, one pair scissors straight points, one seeker, two needles, and one camel-hair brush	1	10	0
B 97-115. Ditto, No. 7, in khaki drill roll, containing two all-metal scalpels, two pairs forceps, fine and blunt points, two pairs scissors straight and curved points, one razor, one seeker, two needles, and one single lens hand magnifier	2	0	0
B 97-120. Ditto, No. 8, in khaki drill roll, containing three all-metal scalpels, two pairs scissors straight and curved points, two pairs forceps fine and blunt points, one razor, one seeker, two needles, one blowpipe, one chain hooks, one double-lens hand magnifier, and two camel-hair brushes	2	15	0

Dissecting Sets in boxes or khaki rolls, containing any combination of instruments, made to order.



B 97-135.

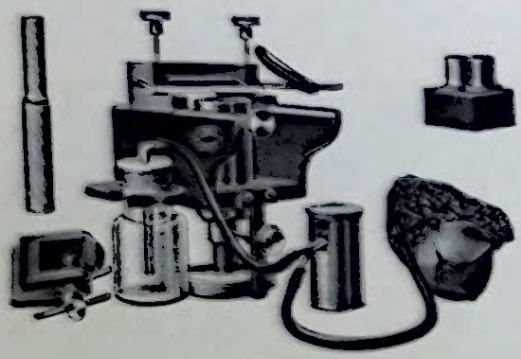


B 97-140.

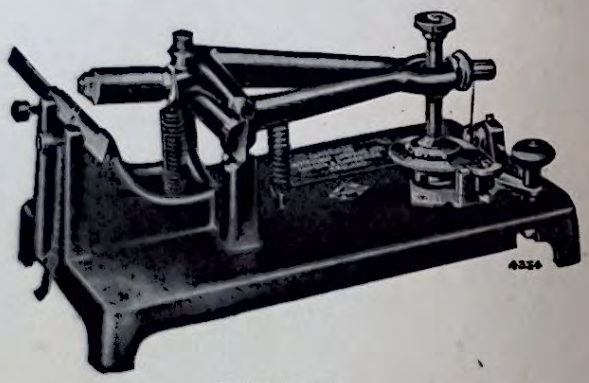


B 97-145.

	£	s.	d.
B 97-135. MICROTOME, Hand, Brass, of solid but simple construction. External diam. 1 in., well diam. $\frac{5}{8}$ in., table diam. 3 in.	1	15	0
B 97-140. MICROTOME RAZOR, best Sheffield quality, ground flat one side, in cardboard case	0	5	0
B 97-145. RAZOR HONE (oil stone), in case, 8 in. long	0	4	6
B 97-150. RAZOR STROP, natural velvet hide leather, and prepared canvas back. Clutch fitting at top and padded leather handle at base .. .. (*a*) *p*	0	8	0

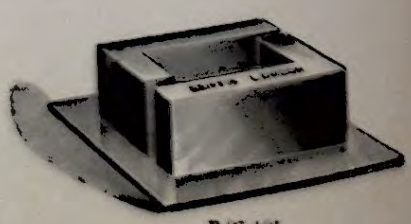


B 97-165.



B 97-175—177.

	£	s.	d.
B 97-165. MICROTOME, Cathcart, all metal, suitable for cutting specimens embedded in pith, carrot or paraffin, and including ether freezing attachment. The instrument is secured to the bench by two adjustable screw clamps. The knife holder runs on a geometric slide and, by means of adjustable screws, accommodates a flat-sided razor. The thickness of the section is controlled by a hand-operated micrometer screw fitted with click mechanism each notch of which equals 10 μ. Complete with razor .. .. .. *tx*	5	10	0
B 97-175. MICROTOME, Rocking, Cambridge, to cut sections from 0·002 mm. to 0·024 mm. thick. On heavy enamelled base about 14 × 7 in., with simple object holder, orientating object holder and knife .. .. *tx*	19	5	3
B 97-177. Knife, spare, for B 97-175 .. .. *tx*	1	4	0
B 97-195. MOULDS, Embedding, L-shaped, stout brass, with zinc base plate, for casting paraffin blocks up to $1\frac{1}{2} \times 1\frac{1}{2} \times \frac{1}{2}$ in. .. .. .. *pair*	1	2	0
B 97-205. PITH, for embedding *bundle* 1/9 ; *dozen bundles*	0	19	0



B 97-195.


B 97-460.


B 97-465.


B 97-475.


B 97-495.

B 97-460. BOXES, Specimen, tin, circular, with glass tops.

Diam. × depth ..	1¼ × ⅜	1½ × ½	1¾ × ⅝	2 × ¾	2¾ × 1⅛	*in.*
p	4/-	4/6	5/-	6/6	7/-	*dozen*
p	5d.	5d.	6d.	8d.	8d.	*each*

B 97-462. BOXES, Pill, cardboard, circular, with lid, purple outside, lined white inside.

No.	0	1	2	3	4	5	
Diam.	1	1¼	1½	1¾	2	2¼	*in.*
Height	7/16	½	7/16	⅝	¾	⅞	*in.*
p	16/-	17/-	19/6	20/-	24/-	30/-	*gross*
p	1/6	1/7	1/10	2/-	2/3	2/9	*dozen*

B 97-465. BOXES, Specimen, rectangular, cardboard with glass tops, white inside.

Length	2½	3¼	4	5	5⅞	6	*in.*
Width	1½	2	2½	3¼	3⅞	4	*in.*
Depth	¾	1	1¼	1⅝	1⅞	2	*in.*
r	9/-	10/6	13/6	15/-	16/6	18/-	*dozen*

B 97-470. Ditto, square, cardboard with glass tops, white inside.

Length × width ..	2½ × 2½	3¼ × 3¼	4⅛ × 4⅛	5 × 5	*in.*
Depth	1¼	1⅝	1¾	2	*in.*
p	10/6	13/6	16/6	18/-	*dozen*

B 97-475. COLLECTING BOXES, Zinc, oval, corked both sides, 2 in. deep. Can also be used as relaxing boxes.

	Small	Medium	Large	
r	5/-	6/-	8/6	*each*

B 97-480. RELAXING TINS, with fluid.

	4½ × 6	6 × 9	*in.*
p	5/-	7/-	*each*

B 97-485. POSTAL BOXES, wood, rectangular, corked both sides, approx. 3 × 3 × 2 in. *each* *p* £ 0 s 5 d 6

B 97-490. COLLECTING BOXES, glass bottomed, cardboard, circular. Nest of 7, from 1–3 in. diam. .. .. *p* 0 9 0

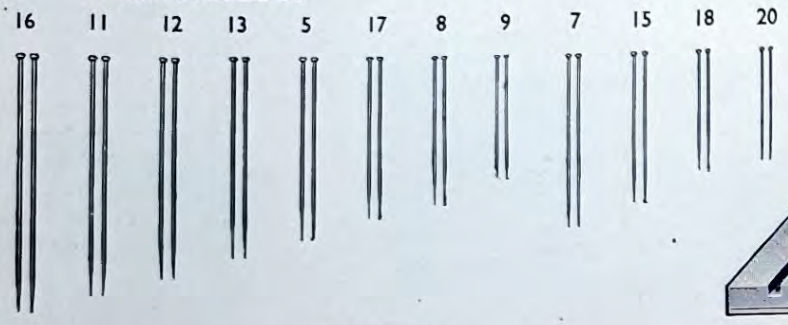
B 97-495. COLLECTING CASES, suitable for pocket, fitted with 5 corked glass tubes 2½ × ½ in., for insects .. .. *each* *p* 0 1 6

B 97-497. COLLECTING TUBES, for coleoptera, 1½ × 1 in., with plastic caps, enabling the cork to be removed with one hand .. .. *dozen* *p* 0 2 6

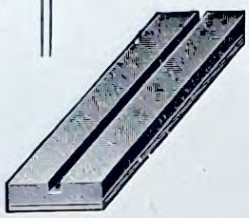
B 97-505. BUTTERFLY NET, four joint folding ring, fitted with bag .. .. *p* 1 0 0

B 97-510. Ditto, non-folding, fitted with metal Y and bag .. .. *p* 0 8 0

A large selection of Cabinets of individual Butterflies, Moths, Insects and Beetles can be supplied. Biological Life Histories are also available. Enquiry is invited.



B 97-550—552.



B 97-575.



B 97-595.

PINS, ENTOMOLOGICAL, either silvered or enamelled black. Illustrations are approx. full size. Pins shown to the right of No. 9 are thinner than the pin of the same length to the left.

No.	16	11	12	13	5	17	
B 97-550. Silvered	1/10	1/10	1/10	1/10	3/-	3/9	*oz.*
B 97-552. Enamelled black	3/3	3/3	3/3	3/3	4/6	5/3	*oz.*

No.	8	9	7	15	18	20	
B 97-550. Silvered	4/-	5/6	4/-	5/6	10/6	14/-	*oz.*
B 97-552. Enamelled black	5/6	7/-	5/6	7/-	12/-	15/6	*oz.*

	£	s.	d.
B 97-560. PIN BOXES, mahogany, with lid and fastener, dimensions 6×2×1 in. with six divisions *each p*	0	9	6
B 97-565. FORCEPS, Insect, curved stainless steel, length 4 in. for pinning *each p*	0	7	6
B 97-570. Ditto, straight, fine points *each p*	0	2	9

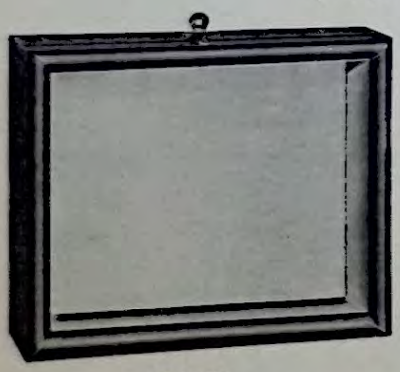
B 97-575. SETTING BOARDS, for insects, flat, corked and papered.

Width	1	1½	2	2½	3	4	*in.*
p	1/6	2/-	2/6	3/-	3/9	4/6	*each*

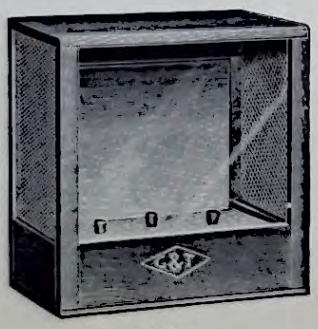
B 97-580. SETTING NEEDLES, in handles *each* 6d.; *dozen*	0	5	0

B 97-595. STORE BOXES, for insects; wood frame, three-ply tops and bottoms. Lined with cork composition; camphor cell; dustproof, depth 2¾ in.

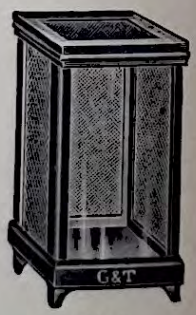
Dimensions	8 × 6	10 × 8	13 × 9	14 × 10	16 × 11	17½ × 12	*in.*
p	13/6	16/6	19/-	23/-	25/-	28/-	*each*



B 97-605.



B 97-635.



B 97-640.

B 97-605. EXHIBITION CASES, glass covered, dustproof framed, cork lined and fitted with brass rings to hang on wall. Equally suitable for exhibition or instructional purposes.

Dimensions	10 × 8 × 2	13 × 9 × 2	14 × 10 × 2	16 × 14 × 2	18 × 18 × 2	*in.*
t	13/6	16/-	17/6	19/6	22/-	*each*

B 97-610. CORK, Sheet, compressed, for lining cabinets and store boxes.

	12 × 4 × ⅛	12 × 4 × 3/16	*in.*
	3/-	5/-	*dozen*

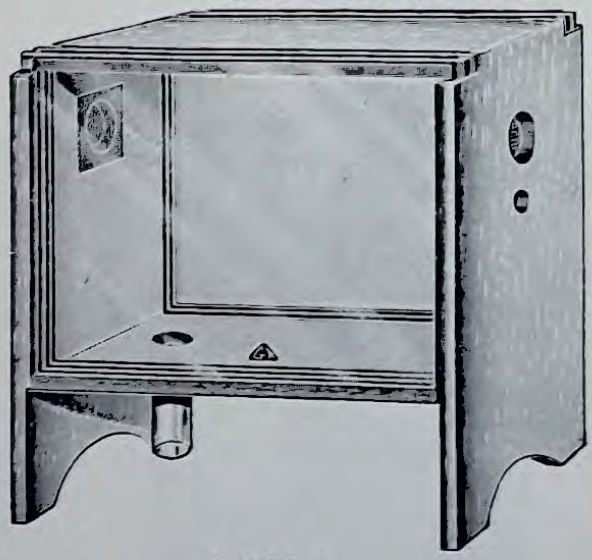
	£	s.	d.
B 97-615. TAPE, ADHESIVE, transparent, ¾ in. wide *roll (a)* 3d.; *dozen rolls*	0	1	9
B 97-620. GUM, for mounting Coleoptera *bottle p*	0	0	10
B 97-630. LARVA REARING CAGE, Wood, with perforated sides, glass front, and door at rear *p*	0	15	0
B 97-635. Ditto, with metal tray for containing damp moss *p*	0	18	6
B 97-640. LARVA REARING CAGE, 5 × 5 × 9 in. high, with glass front and three perforated zinc sides, base and top removable, the whole packing into a small space for easy transport *p*	0	17	6



B 97-645.



B 97-655.



B 97-680.

B 97-645. LARVA REARING CYLINDER, stout glass cylinder 9 × 4½ in., reversible, with perforated zinc at top and bottom. To stand on a household jar .. .. *t* **0 10 6**

B 97-655. VIVARIA, zinc, green enamelled, glass top and sliding perforated back, solid bottom.

Length × width × depth	10 × 6 × 6	12 × 9 × 9	14 × 12 × 12	18 × 13 × 13 *in.*
	p **20/-**	**22/-**	**27/-**	**45/-** *each*

B 97-660. Ditto, large, 30 × 18 × 12 in., metal framed with glass front, sides and top, lower part of perforated zinc. With centre partition forming two compartments each with perforated zinc door ; top lifts off .. .. *p* **9 15 0**

B 97-680. NEO VIVARIUM (Biorum), Vaughan-Roberts, combination vivarium, larvarium, vesparium, wormery, beetle rearer and formicarium. Wood box on end supports, with glass front and back, constructed as follows:—Inner chamber constituting a larvarium, inner surfaces of the wood ends roughened to provide an easy grip for larvæ ; 2 in. diam. ventilation holes covered with fine gauze ; glass tube 3 in. deep × 1 in. diam. let flush into base to contain damp Sphagnum Moss to sustain plant food.

Size glass front and back	9 × 7	12 × 10 *in.*
Inner chamber, front to back	5	7 *in.*
	£3 0 0	**£4 5 0** *each*

The inner chamber can be used as a vesparium, the wasps' nest being suspended from the top. A small hole (normally closed with a cork) in one side provides an exit for Tree Wasps, and a "tunnel" is supplied for inserting into the hole for Ground Wasps.

Proceeding outwards from the inner chamber, two further glass sheets are fitted, front and back, thus providing chambers ⅛ in. wide, closed at the top with wood strips. These spaces are useful for darkening the inner chamber for wasps, bees and nocturnal larvae by inserting sheets of matt black paper ; for experimenting on the influence of colour by the insertion of coloured gelatine sheets ; and as a formicarium, in which case the cage is laid on its back, food being introduced by removing the wood strip.

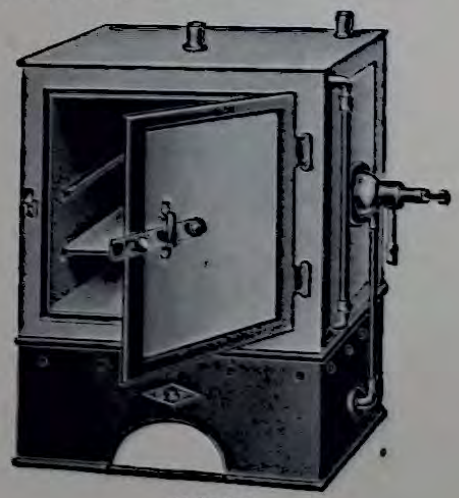
A third enclosure ⅜ in. wide is formed by a further glass sheet, also closed at the top by a wood strip. This space can be filled with damp moss to provide shade for the formicarium, enabling the cage to be placed in the classroom window. It can also be used for keeping Geotrudes, Melolontha and other larval beetles that burrow ; or as a wormery, when filled with layers of various kinds of soils, sands, etc., the worms' "agricultural" activities can be observed.

When used as a formicarium, coleopterarium or vermarium, the cage should be kept dark by means of sheets of matt black paper, partly to discourage algal growths in the soil, but chiefly because the inmates are normally photophobic.

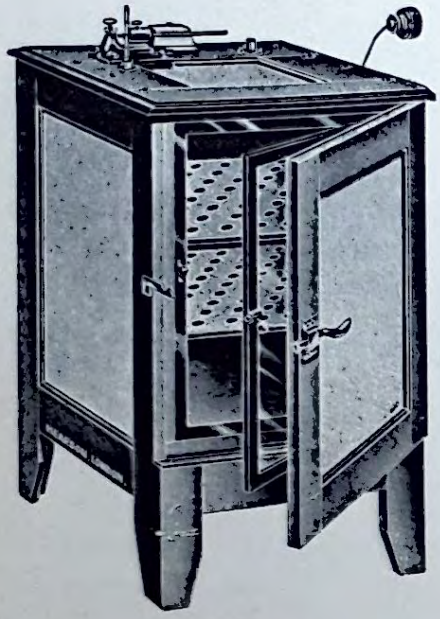
B 97-695. INCUBATORS, gas heated, suitable for students' use. Constructed throughout of stout copper and insulated with asbestos on outside to minimise radiation loss. Fitted with water gauge tube, tubulure for thermometer, and capsule regulator to maintain temperature at 37° C. within ± 1° C. The interior is fitted with runners enabling the shelves to be used in various positions for varying sizes of culture apparatus. Mounted on sheet iron burner screen with gas burner.

Size.	Inside Dimensions. Height.	Width.	Depth.	No. of Shelves.	£ s. d.
A	10	8	8 in.	1 ..	.. *p* **12 0 0**
B	12	10	10 in.	1 ..	.. *p* **13 15 0**
C	14	12	12 in.	2 ..	.. *p* **17 10 0**
D	16	14	14 in.	2 ..	.. *p* **21 0 0**

The capsule on above apparatus can be arranged for any temperature up to 80° C. if desired.



B 97-695.



B 97-700.

B 97-700. INCUBATORS, Hearson, electrically heated, water jacketed. Outside casing of toned oak, panelled in Asbestone and well lagged. The water jacket is of heavy gauge copper, inner door of metal-framed glass. The heating elements are of the strip type and are arranged beneath the base of the water tank. They may be easily and quickly replaced when necessary. Fitted with **automatic temperature regulator** to control temperature at 37° C. Complete with thermometer, wall plug and flexible lead.

Size.	Inside Dimensions. Height.	Width.	Depth.	No. of Shelves.	£ s. d.
A	7	6	6 in.	1	.. *t* 14 17 0
B	12	9	9 in.	1	.. *t* 23 17 0
C	14	12	12 in.	1	.. *t* 28 16 0
D	18	15	15 in.	2	.. *t* 35 2 0

B 97-705. Heating Elements, Spare, for above.

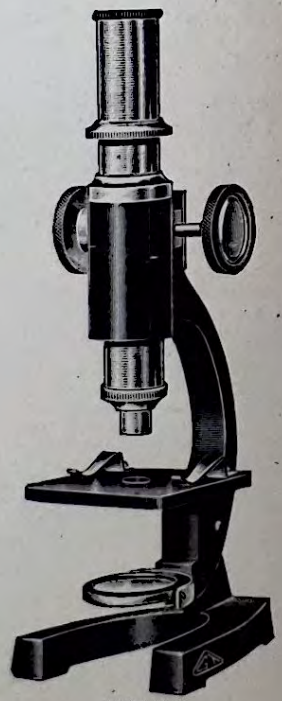
Size ..	A	B	C	D	
Set of ..	2	2	3	5	
	t 12/8	12/8	19/-	31/8	*set*



B 97-800.



B 97-805.

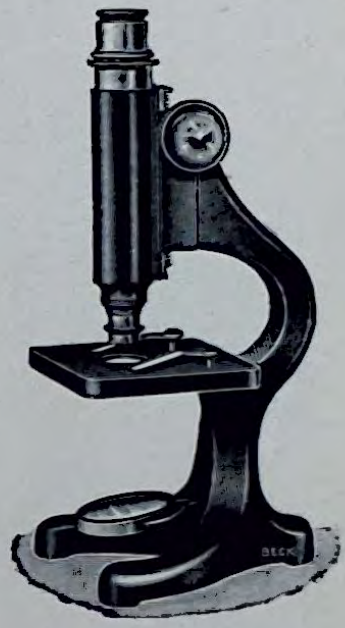


B 97-810.

B 97-800. MICROSCOPE, Student's. Magnification × 44, height 5 in. Sliding tube focusing, inclinable stand, plane silvered mirror. Body and base castings stoved black enamel finish, tube and other fittings, bright nickel plated .. .. *t* 1 15 0

B 97-805. Ditto, specification as **B 97-800**, but magnification × 70, height 6 in. .. .. *t* 2 5 0

B 97-810. Ditto, specification as **B 97-800** but magnification × 100, height 7½ in., rack and pinion focusing, complete with supply of microscope slides, cover slips, glass tube and pair of forceps, in fitted polished wood case with lock and key .. .. *t* 3 15 0



BECK MICROSCOPE, LONDON No. 10

The No. 10 miscroscope is a simple instrument suitable for general industrial and educational purposes, where the highest powers are not employed. Stand, solid cast base with non-inclinable handle-shaped limb, coarse rack and pinion focusing, square stage fitted with clips, adjustable drawtube, plano-concave mirror held in gimbals, the whole finished in acid-resisting stoved black enamel. A cylindrical substage can be added for the accommodation of iris diaphragm and substage condenser.

B 97-840. Set 10A, magnifications 62–110.

	£ s. d.	£ s. d.
(*a*) **Stand**, with square substage	0 0 0	
(*b*) **2 Eyepieces**, 42 mm. (× 6) and 25 mm. (× 10)	*tx* 1 15 0	
(*c*) ⅔ **in. (16 mm.) Objective**, N.A. 0·17, without box	*tx* 1 18 6	
		tx 10 18 0

B 97-850. Set 10B, magnifications 62–285.

(*a*) **Stand**, with square substage	0 0 0	
(*b*) **Eyepiece**, 42 mm. (× 6)	*tx* 0 17 6	
(*c*) ⅔ **in. (16 mm.) Objective**, N.A. 0·17, without box	*tx* 1 18 6	
(*d*) ⅛ **in. (4 mm.) Objective**, N.A. 0·65, without box	*tx* 5 4 6	
		tx 14 15 0

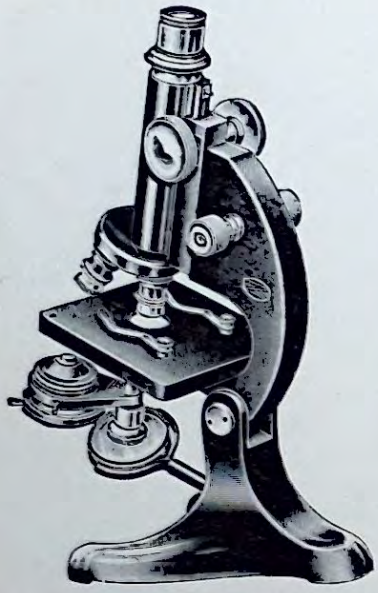
B 97-860. Set 10C, magnifications 62–490.

(*a*) **Stand**, with square substage	0 0 0	
(*b*) **2 Eyepieces**, 42 mm. (× 6) and 25 mm. (× 10)	*tx* 1 15 0	
(*c*) ⅔ **in. (16 mm.) Objective**, N.A. 0·17, without box	*tx* 1 18 6	
(*d*) ⅛ **in. (4 mm.) Objective**, N.A. 0·65, without box	*tx* 5 4 6	
(*e*) **Double Nosepiece**	*tx* 1 13 8	
		tx 17 6 0

Extras for London Microscopes B 97-840—860

B 97-865 a. **Oak case**, with lock and key	*tx* 1 18 6
„ „ b. **Cylindrical substage**	*tx* 0 12 8
„ „ c. **Iris Diaphragm**	*tx* 0 16 6
„ „ d. **Abbe Condenser and iris diaphragm**	*tx* 2 15 0

A great variety of Apparatus for all branches of Physics, Chemistry and Biology is made in our own factories and approved by rigid inspection in our own Test Rooms.



BECK MICROSCOPE, LONDON Nos. 29 A and B

A series covering the requirements for all general work, including medical purposes, for teaching and research. This microscope is of the latest design embodying many improvements in construction which make it most convenient in use and capable of withstanding constant and hard wear. The instrument is so made that various accessories can be added from time to time, as the necessity arises and the instrument thus built up from a simple stand to a complete form for use with the highest powers. The stand is generously designed with convenient and reliable focusing adjustments. The stage is of large size and various substages are fitted. The objectives and eyepieces are of the highest quality giving critical optical performance. An oak case with lock and key is included in the price.

B 97-880. Set 29A (2), magnifications 62–285.

	£ s. d.	£ s. d.
(*a*) **Stand**, with tubular substage, iris diaphragm	0 0 0	
(*b*) **Eyepiece**, 42 mm. (× 6)	*tx* 0 17 6	
(*c*) **⅔ in. (16 mm.) Objective**, N.A. 0·17, without box	*tx* 1 18 6	
(*d*) **⅙ in. (4 mm.) Objective**, N.A. 0·65, without box	*tx* 5 4 6	
(*e*) **Double Nosepiece**	*tx* 1 13 0	
		tx 26 17 0

B 97-890. Set 29B (1), magnifications 62–490.

	£ s. d.	£ s. d.
(*a*) **Stand**, with swing-out focusing substage	0 0 0	
(*b*) **2 Eyepieces**, 42 mm. (× 6) and 25 mm. (× 10)	*tx* 1 15 0	
(*c*) **⅔ in. (16 mm.) Objective**, N.A. 0·17, without box	*tx* 1 18 6	
(*d*) **⅙ in. (4 mm.) Objective**, N.A. 0·65, without box	*tx* 5 4 6	
(*e*) **Abbe Condenser** and iris diaphragm	*tx* 2 15 0	
(*f*) **Triple Nosepiece**	*tx* 1 19 6	
		tx 32 9 0

B 97-900. Set 29B (2), magnifications 62–900.

	£ s. d.	£ s. d.
(*a*) **Stand**, with swing-out focusing substage	0 0 0	
(*b*) **2 Eyepieces**, 42 mm. (× 6) and 25 mm. (× 10)	*tx* 1 15 0	
(*c*) **⅔ in. (16 mm.) Objective**, N.A. 0·17, without box	*tx* 1 18 6	
(*d*) **⅙ in. (4 mm.) Objective**, N.A. 0·65, without box	*tx* 5 4 6	
(*e*) **1/12 in. (2 mm.) Objective**, N.A. 1·0, oil immersion	*tx* 7 3 0	
(*f*) **Cedar Oil Bottle**, with dipper, ground-on cap and supply of oil	*tx* 0 5 6	
(*g*) **Abbe Condenser** and iris diaphragm	*tx* 2 15 0	
(*h*) **Triple Nosepiece**	*tx* 1 19 6	
		tx 39 17 6

B 97-910. Set 29B (3), magnifications 62–900.

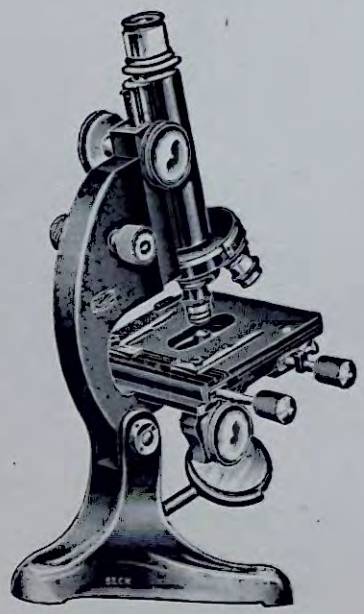
	£ s. d.	£ s. d.
Set 29B (2) as above	*tx* 39 17 6	
(*a*) **Detachable Mechanical Stage**	*tx* 11 11 0	
		tx 51 8 6

Extras for London Microscopes B 97-880—910

	£ s. d.
B 97-915 a. **Hardwood Case**, screwed, for tropical climates, in place of oak case	*extra tx* 1 7 6
„ „ b. **Graduations to Draw-tube**, in millimetres	*tx* 0 8 6

BECK MICROSCOPE, LONDON No. 29K

This stand is similar in design to those described on the preceding page, except that the mechanical stage is of a very convenient pattern. It is of the built-in type which gives a travel of 75 mm. in the horizontal and 27 mm. in the vertical direction. It is fitted with scales and verniers and is a very convenient form of mechanical stage for examining large specimens and for searching over an entire slide. The instrument is available fitted with various forms of substage, making it eminently satisfactory for pathological and histological work.



B 97-930. Set 29K (1), magnifications 62–490.

	£ s. d.	£ s. d.
(*a*) **Stand,** with mechanical stage and rack and pinion focusing substage and with graduated draw-tube, in oak case	0 0 0	
(*b*) **2 Eyepieces,** 42 mm. (× 6) and 25 mm. (× 10)	*tx* 1 15 0	
(*c*) ⅔ **in. (16 mm.) Objective,** N.A. 0·17, without box	*tx* 1 18 6	
(*d*) ⅙ **in. (4 mm.) Objective,** N.A. 0·65, without box	*tx* 5 4 6	
(*e*) **Abbe Condenser** and iris diaphragm	*tx* 2 15 0	
(*f*) **Double Nosepiece**	*tx* 1 13 0	
		tx 55 17 6

B 97-940. Set 29K (2), magnifications 62–900.

	£ s. d.	£ s. d.
(*a*) **Stand,** with mechanical stage and rack and pinion focusing, substage and with graduated draw-tube, in oak case	0 0 0	
(*b*) **2 Eyepieces,** 42 mm. (× 6) and 25 mm. (× 10)	*tx* 1 15 0	
(*c*) ⅔ **in. (16 mm.) Objective,** N.A. 0·17, in box	*tx* 1 18 6	
(*d*) ⅙ **in. (4 mm.) Objective,** N.A. 0·65, in box	*tx* 5 4 6	
(*e*) 1/12 **in. (2 mm.) Objective,** N.A. 1·0, oil immersion with **Cedar Oil Bottle**	*tx* 7 8 6	
(*f*) **Abbe Condenser** and iris diaphragm	*tx* 2 15 0	
(*g*) **Triple Nosepiece**	*tx* 1 19 6	
		tx 64 1 6

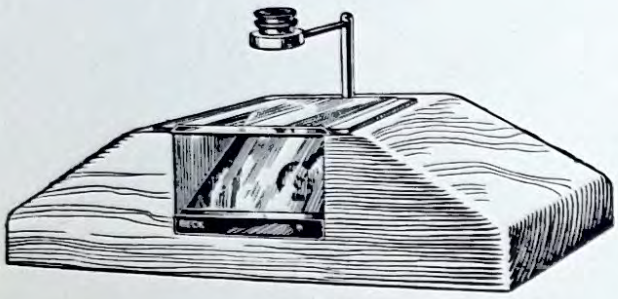
B 97-950. Set 29L (3), magnifications 62–1275.

	£ s. d.	£ s. d.
(*a*) **Stand,** with built-in mechanical stage, rack and pinion focusing and centring substage, in oak case	0 0 0	
(*b*) **3 Eyepieces,** 42 mm. (× 6), 25 mm. (× 10) and 17 mm. (× 15)	*tx* 2 12 6	
(*c*) ⅔ **in. (16 mm.) Objective,** N.A. 0·28, in box	*tx* 3 6 0	
(*d*) ⅙ **in. (4 mm.) Objective,** N.A. 0·85, in box	*tx* 6 12 0	
(*e*) 1/12 **in. (2 mm.) Objective,** oil immersion, N.A. 1·3	*tx* 10 4 6	
(*f*) **Dark Ground Illuminator,** high power, in substage fitting	*tx* 3 18 6	
(*g*) **Stop** for 1/12 in. objective	*tx* 0 5 6	
(*h*) **Achromatic Condenser,** N.A. 1, with iris diaphragm and swing-out tray, green and ground glass screens	*tx* 10 3 6	
(*k*) **Triple Nosepiece**	*tx* 1 19 6	
		tx 84 0 0

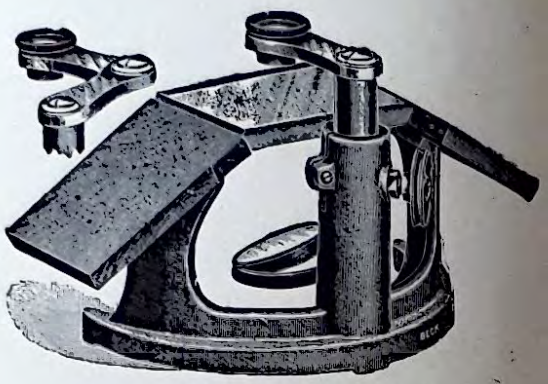
B 97-960. Set 29M (3), magnifications as **Set 29L (3),** but with centring and swing-out substage *tx* 87 11 6

Extra for London Microscopes B 97-930—960

	£ s. d.
B 97-965 a. Hardwood case, screwed, for tropical climates, in place of oak case	*extra tx* 1 18 6



B 98-010.



B 98-020 + 035 a.

THE CORNEX DISSECTING MICROSCOPE.—For class use this simple dissecting microscope will be found satisfactory. It is very rigid and strong, and the magnification is sufficient for ordinary botanical and entomological dissection. For naturalists' work and for such purposes as the recognition of diseases in bees and other insects it will be found equally useful.

It is constructed from a solid block of wood 10 × 3½ in. and in use will be found very convenient. The sides of the block are cut away at an angle so as to form rests for the hands. A glass stage is provided upon which to place the objects, illuminated by a mirror set at an angle of 45°.

The lenses are carried in a fitting provided with a focusing motion and arranged so that the lens is movable over the stage plate.

With the lenses supplied, magnifications of 7 and 14 are obtained. These lenses can be used either separately or combined, the higher power being obtained with the two lenses together, the lower power when used separately.

	£	s.	d.
B 98-010. Microscope, Dissecting, Beck Cornex, complete with two magnifiers .. .. *tx*	1	10	6

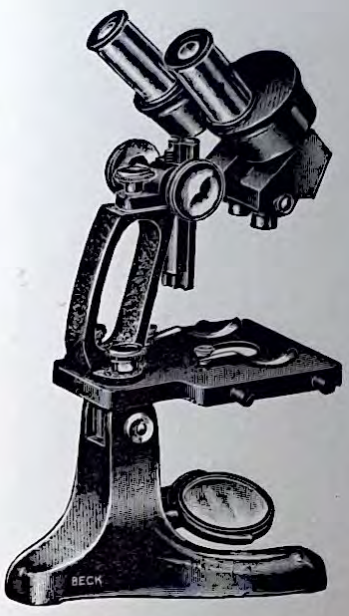
THE CRESCENT DISSECTING MICROSCOPE.—The design and construction of this instrument have been specially considered with a view to perfect rigidity. Many dissecting microscopes are made on the lines of an ordinary microscope stand, that is with a small base, a pillar and a stage, with the addition of hand rests. Such a construction is unsuitable for dissecting as the weight of the hands upon the rests has a tendency to upset the instrument. In the Crescent dissecting microscope the base is a heavy casting on three projecting feet, with two uprights to support the hand rests and stage. The supports are directly under the hand rests, so that weight and pressure upon them have no tendency to tip the instrument. A pillar is provided holding a rod, adjustable over a distance of 3 in. by rack and pinion, and carrying a swinging arm for holding lenses. Hardwood hand rests, plate glass stage, substage mirror silvered one side, opal glass reverse side. Instrument supplied with single-jointed arm, but double-jointed arm also available. Overall dimensions 11 × 5 × 5 in.

	£	s.	d.
B 98-020. Microscope, Dissecting, Beck Crescent, stand only, with single-jointed arm. **Without** lens .. .. *tx*	5	14	0
B 98-025. Ditto, but fitted with double-jointed arm. **Without** lens .. .. *tx*	6	15	6

Accessories for Microscopes B 98-020–025

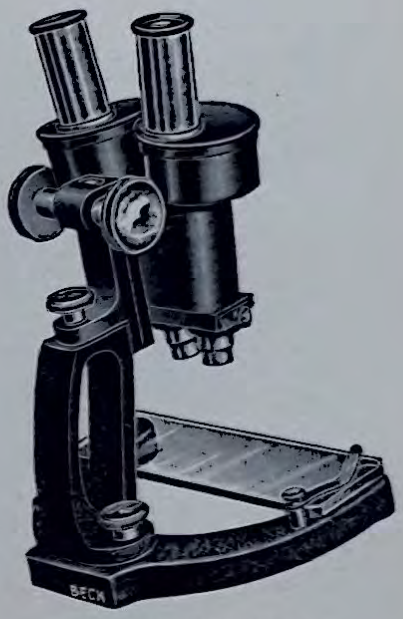
	£	s.	d
B 98-030 a. Magnifier, single lens × 5 .. .. *tx*	0	11	6
„ „ b. **Ditto, achromatic,** lens × 5 .. .. *tx*	2	1	6
„ „ c. **Ditto,** lens × 12 .. .. *tx*	2	4	0
„ „ d. **Ditto,** lens × 20 .. .. *tx*	2	8	6

BECK GREENOUGH BINOCULAR MICROSCOPE



B 98-050 + B 98-095 a, e, h.

An instrument specially suited for dissection work and for magnifications up to about 200. It is valuable also for viewing certain classes of object especially those whose surfaces have cavities and projections. It consists of two microscopes inclined to each other. By this method, true stereoscopic relief is obtained and the image, being also erect, produces a natural view. The advantages of this can be readily appreciated, especially for dissection. The microscope can be mounted on a variety of stands, each suitable for different work, and any stand can also be supplied with eyepieces inclined at a convenient angle for comfort in working. The interpupillary distance is adjustable by rotation of the prism boxes. The objectives are mounted in pairs upon slides which, by means of their dovetail edge, are readily attached and interchanged in the corresponding slide on the nosepiece of the body.



B 98-070 + B 98-095 a, e.

	£	s.	d.
B 98-050. MICROSCOPE, Greenough Binocular, on stand with stage and base. **Without** case and optical fittings .. ..tx	27	9	6
B 98-060. Ditto, but with hand rests. **Without** case and optical fittings .. .. ..tx	28	17	0
B 98-070. MICROSCOPE, Greenough Binocular, on horseshoe stand, as illustrated. **Without** case and optical fittings .. ..tx	23	11	0
B 98-080. MICROSCOPE, Greenough Binocular, on stand to clamp on to edge of bench, with raising, lowering and extending adjustments, suitable for examining large surfaces or materials in large dishes, aquaira, etc. **Without** case and optical fittings .. ..tx	28	2	0
B 98-090. Ditto, mounted on heavy table base instead of stand to clamp to bench. **Without** case and optical fittings .. ..tx	27	1	0

Accessories for Greenough Binocular Microscopes B 98-050—090

	£	s.	d.
B 98-095 a. Pair of Objectives, 59 mm. .. ..tx	5	3	0
„ „ **b. Ditto,** 49 mm. .. ..tx	5	3	0
„ „ **c. Ditto,** 32 mm. .. ..tx	6	12	0
„ „ **d. Ditto,** 16 mm. .. ..tx	8	1	6
„ „ **e. Eyepieces,** × 6, × 10 or × 15 .. .. *pair* tx	1	15	6
„ „ **f. Eyepieces,** wide field, × 10 or × 15 .. .. *pair* tx	5	10	0
„ „ **g. Spot Lens** for dark field illumination .. ..tx	2	4	0
„ „ **h. Inclined Head.** Comprising prism to reflect incident beam through an angle into inclined eyepiece tubes, making for convenience in use. Without objectives and eyepieces *extra* tx	7	9	6
„ „ **j. Case** for Microscopes **B 98-050** and **B 98-060** .. ..tx	2	8	0
„ „ **k. Case** for Microscopes **B 98-070** .. ..tx	1	13	0

Magnification Table for Beck Greenough Binocular Microscope

Focal length of objectives	Working distance	× 6 eyepiece 42 mm. focal length	× 10 eyepiece 25 mm. focal length	× 15 eyepiece 17 mm. focal length
59 mm.	80 mm.	10	16	28
49 mm.	50 mm.	20	32	56
32 mm.	30 mm.	35	60	100
16 mm.	17 mm.	70	120	200

BECK OBJECTIVES

B 98-100. Achromatic Objectives. Corrected for a tube length of 160 mm. Supplied in a metal box with the exception of A and B.

Type	English Designation	Focal Length	Numerical Aperture	Approximate Magnifying Power						Price
				With Eyepiece			Add for each 20 mm. extension of Drawtube			
				× 6 42 mm.	× 10 25 mm.	× 15 17 mm.	× 6 42 mm.	× 10 25 mm.	× 15 17 mm.	£ s. d.
	inch	mm.								tx
A	2½	60	·07	7	13	20	3	5	7	1 7 6
B	2	50	·08	10	20	27	3	6	8	1 7 6
C	1½	32	0·12	25	45	65	4	6	8	2 1 6
D	1½	32	0·15	25	45	65	4	6	8	4 5 6
E	⅝	16	0·17	62	110	155	8	12	8	1 18 6
F	⅝	16	0·28	62	110	155	8	12	18	3 6 0
G	¼	8	0·54	115	200	285	20	30	40	6 1 0
H	¼	4	0·85	285	490	690	40	60	80	6 12 0
I	¼	4	0·65	285	490	690	40	60	80	5 4 6
M	1/12	2	1·0	530	900	1275	60	100	150	7 3 0
N*	1/12	2	1·3	530	900	1275	60	100	150	10 4 6

* Oil immersion.

BECK EYEPIECES

B 98-120. Eyepieces, Huygenian, made to fit easily in R.M.S. No. 1 standard 0·917 in. diam. They are designated by their focal length and their magnifying power is given for the least distance of distinct vision—250 mm.

Focal length	42	25	17 *mm.*
Power	× 6	× 10	× 15
tx	17/6	17/6	17/6 *each*

B 98-130. Eyepiece, Huygenian, with Pointer, for demonstration purposes. Focal length 25 mm., magnifying power × 10 .. .. *tx* £ 1 s. 7 d. 6

BECK DARK GROUND ILLUMINATORS

B 98-140. High Power, Focusing, in non-centring substage fitting .. .. *tx* 9 18 0

B 98-145. Ditto, in centring substage fitting .. .. *tx* 12 2 0

B 98-150. High Power, Non-Focusing, in non-centring substage fitting .. .. *tx* 3 18 6

B 98-155. Ditto, in centring substage fitting .. .. *tx* 5 19 6

BECK SUBSTAGE CONDENSERS

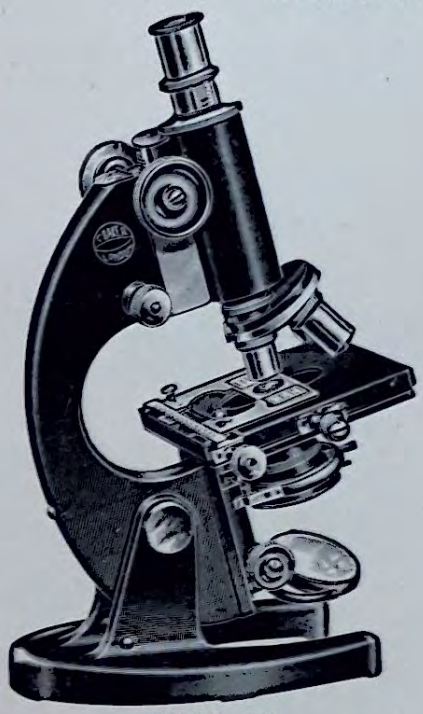
B 98-160. Abbe Condenser, with iris diaphragm and swing-out tray for colour screens or patch stops, with green and ground-glass screens .. .. *tx* 2 15 0

B 98-165. Patch Stops, set of 3, for **B 98-160** .. .. *tx* 0 11 0

B 98-170. Achromatic Condenser, N.A. 1, in fitting with iris diaphragm and swing-out tray, green and ground-glass screens .. .. *tx* 10 3 6



B 98-200—210.



B 98-230—240.

B 98-200. MICROSCOPE, Baker, BLM.3E. Magnifications 53–406. Advanced students' model, stand fitted with rack and pinion focusing, swing-out substage and non-corrosive stage $4\frac{1}{2} \times 4\frac{1}{2}$. Set comprises:—

	£	s.	d.	£	s.	d.
(*a*) Stand in wood case	..*tx* 24	4	0			
(*b*) Abbe condenser with iris	..*tx* 3	6	0			
(*c*) Triple nosepiece	..*tx* 1	19	8			
(*d*) Objective, $\frac{2}{3}$ in.	..*tx* 2	17	3			
(*e*) Objective, $\frac{1}{6}$ in.	..*tx* 5	4	6			
(*f*) Eyepiece, × 5	..*tx* 0	17	8			
(*g*) Eyepiece, × 10	..*tx* 0	17	8			
				tx 39	6	9

B 98-210. Ditto, magnifications 53–900. Set comprises:—

	£	s.	d.	£	s.	d.
(*a*) Stand in wood case	..*tx* 24	4	0			
(*b*) Abbe condenser with iris	..*tx* 3	6	0			
(*c*) Triple nosepiece	..*tx* 1	19	8			
(*d*) Objective, $\frac{2}{3}$ in.	..*tx* 2	17	3			
(*e*) Objective, $\frac{1}{6}$ in.	..*tx* 5	4	6			
(*f*) Objective, $\frac{1}{12}$ oil immersion	..*tx* 10	17	3			
(*g*) Eyepiece, × 5	..*tx* 0	17	8			
(*h*) Eyepiece, × 10	..*tx* 0	17	8			
				tx 50	4	0

B 98-220. MECHANICAL STAGE, to fit microscopes **B 98-200—210.** Attachable to stage by a single screw. With rack and pinion controls for both horizontal and vertical movements, enabling the whole of a 3 × 1½ in. slip to be examined *Price on application.*

B 98-230. MICROSCOPE, Baker, BLM.3B. Magnifications 50–1000. Research model, stand fitted with rigidly built-in mechanical stage with movements of 60 mm. in the horizontal, and 30 mm. in the vertical directions. Swing-out centring substage with rack and pinion focusing, divided draw-tube. Set comprises:—

	£	s.	d.	£	s.	d.
(*a*) Stand in mahogany case	..*tx* 39	1	0			
(*b*) Abbe condenser with iris	..*tx* 3	6	0			
(*c*) Triple nosepiece	..*tx* 1	19	8			
(*d*) Objective, $\frac{2}{3}$ in.	..*tx* 2	17	3			
(*e*) Objective, $\frac{1}{6}$ in.	..*tx* 5	4	6			
(*f*) Objective, $\frac{1}{12}$ in. oil immersion	..*tx* 10	17	3			
(*g*) Eyepiece, × 5	..*tx* 0	17	8			
(*h*) Eyepiece, × 10	..*tx* 0	17	8			
				tx 65	1	0

B 98-240. Ditto, magnifications 50–1000 as **B 98-230** but fitted with achromatic condenser and dark ground illuminator .. ..*tx* 76 15 8

THE MICROID MICRO-PROJECTOR

An inexpensive projector and drawing apparatus for biological and other subjects

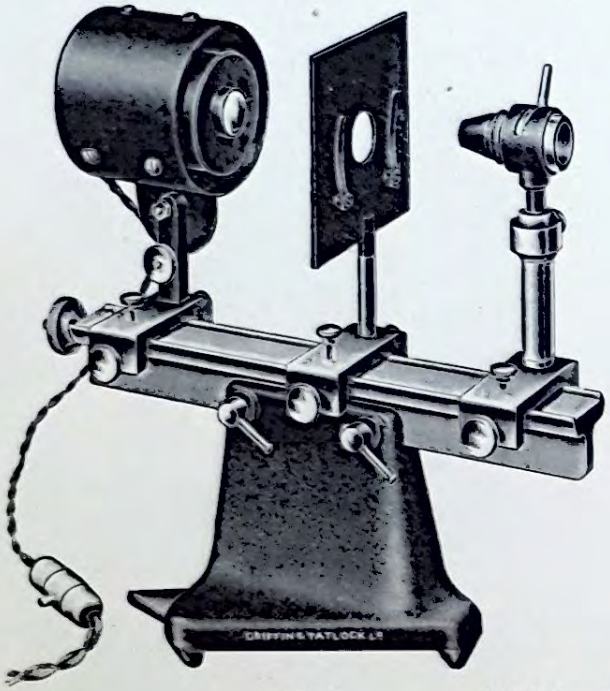


Fig. 1. B 98-250.

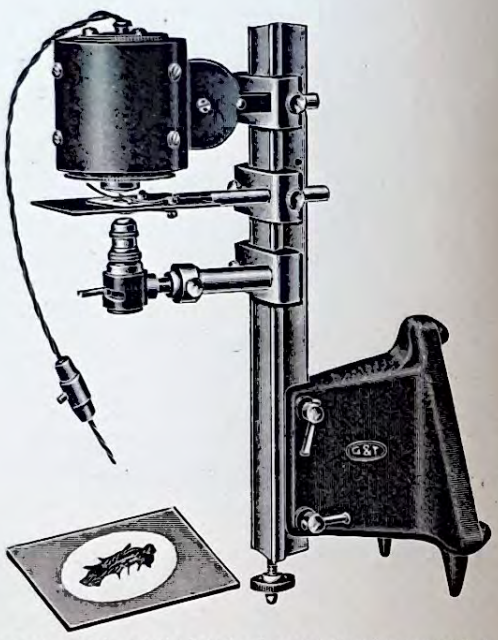


Fig. 2.—Projector arranged for vertical projection as a drawing apparatus.

The Microid Micro-projector has an unusually efficient optical system, and its mechanical adjustments are simple and precise. The illumination is obtained through carefully selected condenser lenses from a low-voltage lamp, which can be operated conveniently from the mains either by a transformer or a suitable resistance. Mounted slides, live specimens, animalculæ, etc., are projected with remarkable definition and intensity and, in addition, the instrument may be used in two positions (*see* Figs. 1 and 2) as a drawing apparatus. The instrument is assembled from parts of the Microid Universal Projector, fully described on pp. 125—131.

	£	s.	d.
B 98-250. MICROID MICRO-PROJECTOR, complete with base, bed 12 in. long, lamphouse, two sliding feet, objective holder, sliding foot with integral pillar for objective holder, slide holder, flex and switch. **Without** lamp or objective	11	9	0

Accessories for B 98-250

Lamp, for above, 24 watt, 6 or 12 volts, straight filament, gas filled, S.B.C. fitting *see* **A 58-495**
Objective, Microscope.—Achromatic, 1 in. focal length, with standard R.M.S. thread. This is made in large quantities and is offered at a specially low price .. .. *see* **A 51-120** *part* 10
Ditto.—$\frac{2}{3}$ in. focal length .. .. *see* **A 51-120** *part* 11
Ditto.—$\frac{1}{3}$ in. focal length .. .. *see* **A 51-120** *part* 12
Trough.—Mounted on 3 × 1 in. glass slide. Can be used as a cooling trough in micro-projection or filled with pond water, etc. for projection of animalculæ .. .. .. *see* **A 51-120** *part* 13

TABLE GIVING APPROXIMATE PICTURE SIZES AND MAGNIFICATIONS

A = Approximate diameter of picture in feet.
B = Approximate magnification using objective in first column.
C = Approximate magnification using objective in first column together with a bi-concave lens.

Focal Length of Objective	Screen Distance in Feet																	
	1			3			5			10			15			20		
Inches	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
1	0·30	7·2	9·6	1·1	26	35	1·85	44	58	4·0	90	120	5·7	140	185	7·0	180	290
$\frac{2}{3}$	0·41	13	16	1·25	40	53	2·0	68	90	4·2	135	185	6·0	210	280	8·3	270	390
$\frac{1}{3}$	0·37	30	40	1·16	85	120	1·85	143	205	4·0	290	440	5·7	440	650	7·0	580	850

The above data has been determined experimentally and, while figures have been given for magnifications with high powered objectives at comparatively great screen distances, it is not to be expected that the intensity of illumination will, in such cases, be very high. The limiting distance of projection with adequate illumination must be decided by reference to the type of specimen and the particular conditions under which it is being projected.

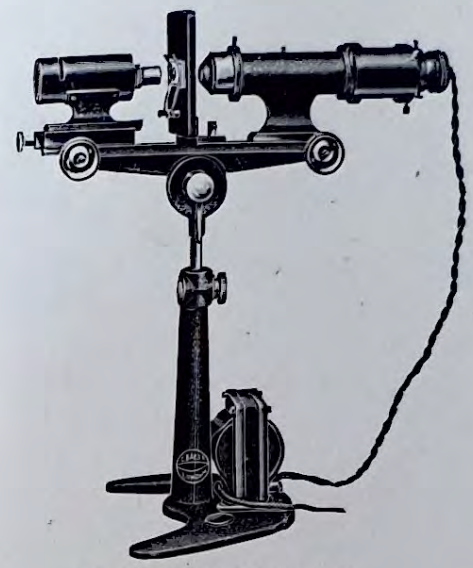


Fig. 1. B 98-270 + 275 a, k.

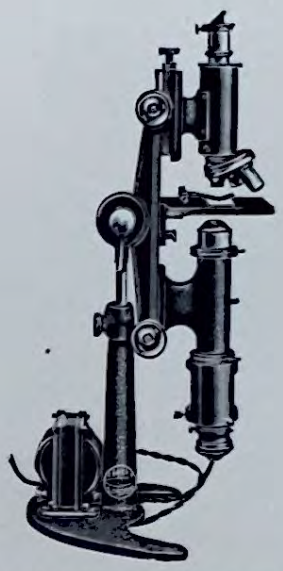


Fig. 2. B 98-270 + 275 a, b, c, d, g, h, and k.

This micro-projector can be used either horizontally or vertically. In the horizontal position, (fig. 1) it projects directly on to a screen, or with the right-angled prism attachment, on to the bench for drawing purposes and demonstration. In the vertical position (fig 2), the prism attachment can be used for projection of liquid specimens. Using a 2 in. objective, as in fig. 1, the projector will give a 5 ft. 6 in. image of a $\frac{1}{2}$ in. specimen at a distance of 12 ft. With a $\frac{1}{6}$ in. objective and × 10 eyepiece, a 3 ft. disc can be obtained at a distance of 6 ft. This represents a magnification of 400 diameters, but can be usefully employed only in a fully darkened room. The change from low to medium or high power magnification is facilitated by the use of a triple nosepiece. Illumination is provided by means of a special filament, 6 volt, 5 amp., E.S. lamp. A transformer and resistance are available to operate the projector from the mains.

SPECIFICATION

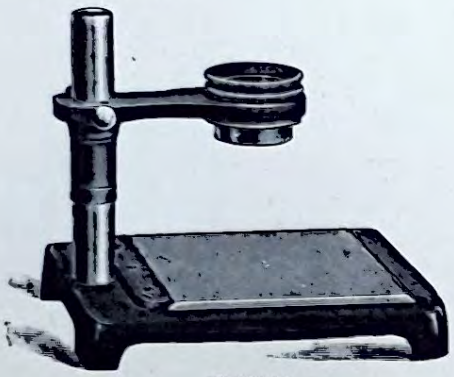
Rigid stand with cut-away base to hold rod adjustable over a distance of 12 in. Mounted on the rod is a metal bed 10 in. long, carrying a microscope body, slide holder and substage condenser fitted with a lamphouse. Microscope body fitted with rack and pinion focusing and smooth fine adjustment and provided with slot to accommodate colour filters or amplifying lens. Substage condenser also fitted with rack and pinion focusing. Lamp adjustable for centring in the lamphouse by means of three screws. Two iris diaphragms fitted, one to control the amount of light on the specimen, the other situated immediately in front of the lamphouse, becoming, in effect, the source of light.

	£ s. d.
B 98-270. MICRO-PROJECTOR, Baker, as specified above, comprising stand, bed, substage condenser, microscope body, both fitted with rack and pinion adjustment, slide holder and lamphouse with 6 volt 5 amp. E.S. lamp. **Without** objective .. .. ..tx	27 10 0

Accessories for B 98-270

	£ s. d.
B 98-275 a. Objective, 2 in.	tx 2 4 0
„ „ **b.** Objective, $\frac{1}{2}$ in.	tx 2 17 3
„ „ **c.** Objective, $\frac{1}{6}$ in.	tx 5 4 6
„ „ **d.** Triple nosepiece	tx 1 19 8
„ „ **e.** Eyepiece, × 5	tx 0 17 8
„ „ **f.** Eyepiece, × 10	tx 0 17 8
„ „ **g.** Draw tube to fit microscope body and to take eyepieces **B 98-275 e, f**	tx 0 15 5
„ „ **h.** Prism attachment, right-angled	tx 1 18 8
„ „ **j.** Lamps, spare 6 volt, 5 amp., E.S. cap.	tx 0 8 4
„ „ **k.** Transformer, to operate lamp on A.C. mains	tx 2 9 6
„ „ **m.** Resistance, to operate lamp on D.C. mains	tx 2 15 0

Please state mains voltage when ordering.

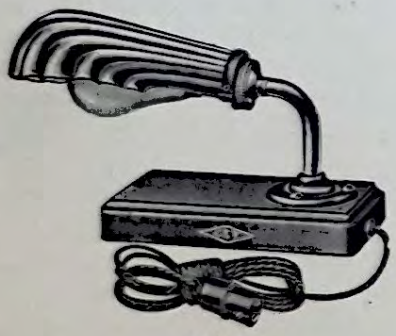


B 98-300.



B 98-305.

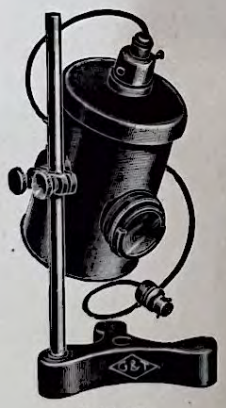
	£	s.	d.
B 98-300. DISSECTING MICROSCOPE, of simple design for use in schools. Heavy metal base 4 × 3⅛ in. fitted with opal glass and steel upright carrying an adjustable lens holder. Complete with single lens magnifier × 8, in standard mount	*t* 1	17	8
B 98-305. DISSECTING MICROSCOPE, with parallel action lens holders. Complete with lens 50 mm. diam., magnification about × 3, and extra holder 1 in. diam. to carry aplanatic lens	*t* 1	6	0
B 98-307. Dissecting Lens, doublet, magnification × 8, for **B 98-305**	0	7	6
B 98-309. Ditto, magnification × 10, for **B 98-305**	0	9	6



B 98-350.



B 98-355.



B 98-365.

	£	s.	d.
B 98-350. LAMP, Microscope, Electric, mounted on polished wood base 7 × 4 in. with metal arm and highly polished shell reflector to accommodate lamps up to 60 watt. The reflector can be turned so that the direct glare of the lamp does not fatigue the microscopist. Useful for illuminating specimens undergoing dissection. With 2 yards flex and combined lamp adapter and two-pin plug. **Without** lamp	1	15	0
B 98-355. LAMP, Microscope, Electric, stout metal casing, overall height 7½ in., diam. 4½ in., ventilated, and finished in crystalline enamel, with hooded aperture 1½ in. diam. Centre of aperture 2¾ in. from bench level, lampholder with bar switch, one yard flex and plug adapter. **Without** lamp (60 watt pearl required)	*t* 2	3	4
B 98-365. LAMP, Microscope, Electric, adjustable for height and inclination, mounted on heavy base. The lamphouse is fitted with a carrier for light filters, the bottom being removable for illuminating sections. With opal glass lamp (*please state voltage when ordering*), six feet flex, lampholder, adapter and daylight blue glass disc	2	15	0

Please use our Catalogue Numbers in your requisitions and orders. They are a complete specification of your requirements.

B 98-510. MICROSCOPE SLIDES, as listed below .. .. *each* £ 0 2 0

ANATOMICAL SLIDES

Human—
Lip of Infant, V.S.
Lip of Adult, V.S.
Bearded Chin, V.S.
Bearded Chin, surface section.
Scalp of Adult, surface section.
Scalp of Adult, V.S.
Bald Scalp, V.S.
Bald Scalp, surface section.
Pinna of Ear, V.S.
Brain, Cerebellum.
Brain, Cerebrum.
Brain, Medulla.
Spinal Cord, T.S.
Tongue of Infant, V.S.
Tongue of Infant, T.S.
Lung of Adult, section.
Lung of Still-born Child, section.
Heart Wall, section.
Aorta, section.
Artery, T.S.
Artery, L.S.
Vein, L.S.
Vein, T.S.
Diaphragm, T.S.
Diaphragm, L.S.
Stomach of Infant, pyloric orifice section.
Stomach of Adult, wall section.
Liver of Adult, section.
Kidney, T.S.
Kidney of Infant, T.S.
Kidney of Old Man, T.S.
Supra-renal Capsule, section.
Vermiform Appendix of Infant, T.S.
Vermiform Appendix of Infant, L.S.
Duodenum, T.S.
Colon, T.S.
Anal Orifice of Infant, T.S.
Testicle, T.S.
Ovary of Infant, T.S.
Ovary of Infant, L.S.
Ovary with Graafian follicle, section.
Ovary with Corpus luteum, section.
Ovary, advanced age, section.
Ovary, normal, section.
Fallopian Tube of Infant, T.S.
Fallopian Tube, normal, T.S.
Fallopian Tube, advanced age, T.S.
Fallopian Tube (fimbriated extremity), section.
Uterus, T.S.
Uterus (wall), V.S.
Uterus (neck), T.S.
Uterus, through opening of Fallopian Tube, T.S.
Placenta, section.
Amniotic Membrane, portion.
Vagina of Infant, T.S.
Vagina of Adult (wall), T.S.
Muscular Tissue, voluntary, T.S.
Muscular Tissue, voluntary, L.S.
Finger of Infant, L.S.
Finger of Infant, T.S.
Bone, T.S.
Blood Film, stained.
Blood, showing Hæmin Crystals.
Skin, V.S.
Subcutaneous Tissue, V.S.
Tonsil, T.S.
Mole from Face, V.S.

Lower Animals—
Lip of Cat, V.S.
Lip of Cat, surface section.
Lip of Cat, through sensory hairs and follicles, V.S.
Nose of Cat, V.S.
Ear of Cat, V.S.
Tongue of Cat, V.S.
Tongue of Cat, T.S.
Lung of Cat, section.
Skin of Cat, V.S.
Footpad of Cat, V.S.
Rectum of Cat, T.S.
Anus of Cat, T.S.
Duodenum of Cat, T.S.
Stomach of Cat (wall), V.S.
Stomach of Cat, pyloric orifice, T.S.
Tongue of Kitten, T.S.
Leg of Kitten, T.S.
Stomach of Dog (wall), V.S.
Stomach of Dog (pylorus), T.S.
Tail of Puppy, T.S.
Ear of Rat, T.S.
Heart of Rat, T.S.
Kidney of Rat, L.S.
Tongue of Rat, V.S.
Tongue of Rat, T.S.
Liver of Rat, section.
Ear of Mouse, section showing cellular cartilage.
Lung of Mouse, section.
Kidney of Mouse, V.S.
Skin of Mouse, V.S.
Head of Young Mouse, V.S.
Head of Young Mouse, T.S.
Thorax of Young Mouse, T.S.
Abdomen of Young Mouse, T.S.
Fœtal Mouse (entire), V.S.
Tongue of Rabbit, T.S.
Tongue of Rabbit, V.S.
Tongue of Rabbit, section through taste buds.
Cerebellum of Rabbit, V.S.
Ear of Ox, pinna section.
Ovary of Sow, V.S.
Testicle of Pig, V.S.
Frog (head), T.S. through eyes.
Frog (head), T.S. through nose.
Young Frog (entire), V.S.
Young Frog (entire), T.S.
Newt (head), T.S.
Newt (head), V.S.
Newt (body), T.S.
Leech, V.S.
Leech, posterior V.S.
Leech, T.S.
Garden Slug, T.S.
Earthworm, T.S.
Marine Worm, Nereis, T.S.
Amphioxus, T.S.

BOTANICAL PREPARATIONS

Stems—T.S. of
Alder.
Aristolochia sipho.
Balsam.
Bignonia.
Blackberry.
Bogbean, Menyanthus trifoliata.
Bottle Cork, quadrangular cells.
Brooklime.
Bryony, white, sieve plates.
Bryony, black, Tamus communis.
Butcher's Broom, Monocot shrub.
Chervil.
Chondodendron.
Clematis flammula.
Clematis vitalba.
Cucumber.
Cyperus.
Cypripedium, Orchid.
Dracœna, Cordyline rubra, young stem.
Dracœna, older stem, secondary thickening.
Eccremocarpus.
Elder, lenticels.
Elm.
Equisetum.
Equisetum, barren stem.
Eucalyptus, winged stem.
Fennel.
Fig.
Figwort, Scrofularia, winged stem.
Fool's Parsley.
Grapevine.
Hawthorn, L.S. through thorn.
Hazel.
Holly.
Ivy, adventitious root.
Lime, three years' growth.
Lycopodium, gamostele.
Maize.
Mare's-tail, Hippuris.
Mistletoe.
Mock Strawberry.
Nettle.
Oak.
Orange.
Passion Flower.
Pine, one year's growth.
Pine, annual growth.
Ranunculus acris, lateral branch.
Red Currant.
Rhubarb.
Rue.
Rush, stellate cells.
Selaginella.
Shee Oak, Casuarina equisetifolia.
Spruce, one year's growth.
Sunflower, Helianthus annuus.
Sunflower, Helianthus tuberosa.
Sweet Pea, winged stem.
Sycamore.
Tritoma.
Vegetable Marrow, sieve plates.
Velthemia.
Virginia Creeper.
Wallflower.
Water Plantain, Alisma plantago.
Wild Rose.
Wild Rose through prickle.
Witch Elm, development of cork.
Wisteria.
Woundwort, Stachis sylvatica.

Peduncles—T.S. of
White Water Lily, Nympha alba.
Yellow Water Lily, Nuphar luteum.

Stipes—T.S. of
Brake Fern, Pteris aquilina.
Brake Fern, L.S.
Brake Fern, oblique section.
Male Fern, Aspidium.
Lady Fern, Aspidium.
Royal Fern, Osmunda regalis.

Petioles—T.S. of
Aspidistra.
Helleborus.
Palm.
Plaintain.
Water Lily, idioblasts.

Roots—T.S. of
Aspidistra.
Autumn Crocus, Corm.
Dandelion, Taraxacum.
Dandelion, L.S.
Elm.
Fool's Parsley.
Helleborus niger.
Iris, axial cylinder.
Lemna, with root cap.
Maize.
Mock Strawberry.
Oak.
Potato Tuber.
Valerian.
Yellow Water Lily.
Yew, secondary thickening.

Rhizomes—T.S. of
Bogbean.
Brake Fern.
Male Fern.
Sweet Flag, Acorus calamus.
Turkey Rhubarb.

Leaves—T.S. of
Aloe.
Araucaria.
Cypripedium, water storage cells.
Fig.
Fittonia, lenses.
Hemp.
Holly.
Iris, sections stomata.
Lavender.
Maize.
Marram grass.
Pampas grass.
Pinus strobus.
Pinus sylvestris.
Potomageton, aquatic leaf type.
Rubber Plant, Ficus elastica.
Selaginella.
Tradescantia, section stomata.

[*continued overleaf*

B 98-510. MICROSCOPE SLIDES, as listed below *(continued)* .. .. *each* £ 0 s. 2 d. 0

BOTANICAL PREPARATIONS—*continued.*

Whole Leaves of—
Bog Moss, Sphagnum.
Sundew.
Bladderwort, Utricularia vulgaris.

Sections Showing Leaf-fall—
Horse Chestnut.
Sycamore.
Virginia Creeper.

Cuticle of—
Aloe, showing stomata.
Araucaria, showing stomata.
Holly, showing stomata.
Iris, showing stomata.
Oat, showing stomata.
Yucca, showing stomata.

Leaf Buds—T.S. of
Ash.
Poplar.
Sycamore.

Flower Buds—T.S. of
Dandelion.
Iris.
Lily.
Wallflower.

Ovary—T.S. of
Lily.
Poppy.

Anthers and Pollen Grains of—
Hollyhock.
Mallow.

Pollen Grains of—Pine.

Capsule of—
Shepherd's Purse.
Moss, Pottia truncatula.

Peristomes of—Moss.

Spores and Elaters of—Equisetum arvense.

Sections of Seeds—
Castor Oil Plant.
Coffee Berry.
Collomia.

Seeds of—
Argemone.
Antirrhinum.
Agrostemma.
Clematis.
Cornflower, parachute.
Dianthus.
Eccremocarpus, winged.
Eschscholtzia.
Foxglove.
Gaillardia, parachute.
Gypsophilium.
Larkspur.
Lophospermum, winged.
Lychnis dioica.
Nemesia strumosum.
Phacelia.
Pyrethrum.
Poppy.
Saponaria.
Silene schafter.
Viscaria.

Fruit of Fern—
Todea.
Osmunda Regalis.
Davilia canariense.
Polypodium.

Fruit and Stellate Hairs on Fern Leaf—
Niphobilus.

Stellate Hairs on Leaf—
Deutzia gracilis.
Deutzia scabra.
Leaf from Jamaica.

Stinging Hairs on Leaf—
Nettle.

Scales on Leaf—
Sea Buckthorn.

Rind of Orange, V.S.
Section of Deal, Test for Achromatism.
Spiral tissue of Rhubarb.
Lichen, T.S.
Cluster Cups, Coltsfoot leaf.
Cluster Cups, Willow herb leaf.
Cup Mould, Peziza vesiculosa, V.S.
Æcidium, Barberry leaf, V.S.
Yeast, budding.
Volvox globator.

Starches—Grains
African ginger.
American red wheat.
Barley.
Bean.
Lentil.
Maize.
Oat.
Pea.
Potato.
Rye.
Sarsaparilla.
Tous les mois.
Wheat.

POND LIFE, ALGAE, ETC.

(see also Zoology)

Asterionella.
Chara fragilis, showing reproductive organs.
Chlamydomonas.
Cladophora.
Desmids, mixed.
Diatoma vulgare on Cladophora.
Drapernaldia.
Frogspawn plant, Batrachospermum.
Nitella, showing reproductive organs.
Myxophyceæ, "Breaking of the Meres."
Œdogonium in fluid.
Pandorina.
Pediastrum, Staurastrum, etc.
Riccia fluitans.
Riccia natans.
Sphœrella.
Spirogyra.
Spirogyra in conjugation.
Spirogyra in lateral conjugation.
Ulothrix.
Vaucheria, showing sexual organs.
Zygnema.
Acineta.
Acomia vitrea.
Alcyonella.
Ceratium hirundinella.
Cordylophora.
Christatella.
Cyclops.
Cyclops, long-horned.
Cypris.
Rotifers, Aneura brevispinosa.
Rotifers, Brachionus.
Rotifers, Hydatina.
Rotifers, Notholca longispina.
Rotifers, Notops brachionus.
Rotifers, Proales Werneckii in galls on Vaucheria.
Epistylis.
Hydrachnia.
Lophopus.
Marine Plankton.
Medusa of Obelia.
Peridineae.
Plumatella.
Elephant Water Flea, Bosmina longirostris.
Water Flea, Chydorus sphœricus.
Water Flea, Daphnia Bairdii.
Water Flea, Daphnia pulex.
Water Flea, Daphnia reticulata.
Water Flea, Sida crystallina.

ENTOMOLOGY

Complete Insects—
Ant, Brown.
Ant, Garden.
Ant, Large wood.
Ant, Rare brown.
Ant, Red.
Ant Lion.
Bee.
Bed Bug.
Blow Fly.
Brachylytrous Insect, Stenus guttula.
Centipede.
Colorado Beetle.
Downhill Fly, Leptis.
Dipterous Fly, male.
Dipterous Fly, female.
Dragon Fly, male.
Dragon Fly, female.
Earwig, male, wings extended.
Earwig, female, wings extended.
Forest Fly.
Froghopper.
Glowworm.
Gnat, male.
Gnat, female.
House Fly, Homolomya.
House Fly, Musca domestica.
House Fly, Stomoxys.
Ladybird.
Looper Caterpillar.
Marsh Fly.
Millipede.
Mussel Scale.
Pencil Tail, Polyxenus.
Pond Skater.
Pseudo Scorpion, Chelifer.
Scarlet Forest Hopper.
Scorpion Fly, male.
Scorpion Fly, female.
Silkworm, young.
Silkworm, full-grown.
Snipe Fly, male.
Snipe Fly, female.
Soldier Beetle, male.
Soldier Beetle, female
Tortoise Plant Bug (Madagascar)
Water Boatman.
Water Measurer, Hydrometra.
Water Scorpion.
Water Scorpion, young.

Larvae and Pupae—
Caterpillar of Tortoise shell Butterfly.
Young Caterpillar, just hatched.
Larva of:—Blow Fly.
Chironomous Fly.
Colorado Beetle.
Currant Moth.
Ditch Skater.
Dragon Fly.
Elater Beetle (Wireworm)
Gnat, Common.
Gnat, Plumed.
Ladybird.
Pond Skater.
Simulium.
Water Beetle.
Water Boatman.
Cast Larval Skin of Gnat.
Pupa of:—Ant.
Ditch Skater.
Flea.
Froghopper.
Gnat, Common.
Gnat, Plumed.
Ladybird.
Pond Skater.
Water Boatman.
Cast Pupal Skin of Gnat.

Spiders—
Aquatic, Piratus piratica.
Aquatic, Argyroneta aquatica.
Carding.
Cellar.
Epeira diadema (Garden).
Epeira diadema side view.
Epeira diadema just hatched.
Epeira extensa—Meta.
Epeira (Tetragnatha extensa)
Epeira umbratica.
Epeira quadrata.
House.
Jumping Salticus.
Vertical section of Epeira.
Wolf, Lycosa.

Parasites—
Parasite of Bat.
Beetle.

B 98-510. MICROSCOPE SLIDES, as listed below *(continued)* .. .. *each* £ 0 s. 2 d. 0

ENTOMOLOGY—*continued.*

Parasites of :—Cow
Grouse, Ornithomya.
Horse, Hæmatopinus.
Humble Bee, Acaris.
Pigeon.
Pig, Hæmatopinus.
Sheep, Melophagus.
Tortoise, Ixodes.
Snake, Ixodes.
Bed Bug.
Body Louse, Pediculus vestimentis.
Crab Louse, Pediculus pubis.
Head Louse, Pediculus capitis.
Flea, Human, Pulex irritans.
Flea of :—Cat.
Dog.
Fowl.
Hedgehog.
Mole.
Rabbit.
Rat.

Parts of Insects—
Antenna of :—Bee.
Blowfly.
Cockchafer, male.
Cockchafer, female.
Cockroach.
Cricket.
Drone Fly
Gadfly.
Glowworm.
Gnat, male.
Gnat, female.
Gnat, Plumed.
Golden-eyed Gadfly.
Great Gadfly.
Hornet.
House Fly.
Silk Moth.
Snout Fly.
Wasp.
Water Beetle, Dytiscus.
Water Boatman.
Cornea of :—Bee.
Blowfly.
Butterfly.
Corixa, showing multiplied images.
Dragon Fly.
Drone Fly.
Dytiscus, showing multiplied images.
Flea.
Gadfly.
Gadfly, without pressure.
Great Gadfly.
House Fly.
Notonecta, showing multiplied images.
Ocelli of :—Bee.
Blowfly.
Hornet.
House Fly
Wasp.
Eye and Antennæ of Silkworm.
Eyes of Spider, Salticus.
Tongue of :—Bee.
Blowfly, front.
Blowfly, side.
Butterfly.
Cricket.
Drone Fly.
House Fly, front.
House Fly, side.
Snout Fly.
Spider.
Wasp.
Teeth of Blowfly.
Mouth Organs of :—
Larva of Crane Fly.
Cockroach.
Crane Fly.
Earwig.
Flea.
Gadfly.
Gnat, male.
Gnat, female.
Mouth organs of :—
Golden-eyed Gadfly.
Great Gadfly.
House Fly.
Scorpion Fly.
Water Beetle, Dytiscus.
Water Bug, Corixa.
Ixodes.
Hooked Mouth of Marsh Fly Larva.
Mouth and Jaws of Garden Spider.
Mouth and Jaws of Water Spider.
Jaws of :—Bee.
Hornet.
Silkworm.
Wasp.
Head and Jaws of Caterpillar.
Head of :—Blowfly.
Centipede.
Chironomous Fly.
Cockroach.
Crane Fly.
Earwig.
Gnat, male.
Gnat, female.
Gnat, Plumed.
House Fly.
Larva of Water Beetle.
Whirligig Beetle, showing double eye positions.
Foot of :—Biting House Fly, Stomoxys.
Blowfly.
Drone Fly.
Flesh Fly.
Gadfly.
Great Gadfly.
Hornet.
House Fly.
Marsh Fly.
S. African Leaping Spider.
Snout Fly.
Wasp.
Water Beetle.
Combs from Foot of Spider.
Proleg of Caterpillar, with Hooklets.
Leg of :—Cockchafer larva.
Cockroach.
Cricket, fore leg, showing Ear.
Cricket, hind leg.
Earwig, showing muscles.
Flea, showing muscles.
Froghopper.
Gadfly.
Great Gadfly.
Garden Spider.
Glowworm.
Gnat.
Jumping Spider.
Larder Beetle, Ptinus.
Sawfly.
Spider, showing sensory hairs.
Water Spider.
Wasp.
Water Beetle, Dytiscus, front leg with Suckers.
Water Beetle, Dytiscus, second leg with Suckers.
Water Beetle, Dytiscus, Oar leg.
Water Boatman, Oar leg.
Water Bug, Oar leg.
Whirligig Beetle, first.
Whirligig Beetle, second.
Whirligig Beetle, paddle.
Worker Bee, front leg with Antenna Comb.
Worker Bee, second leg with Spur.
Worker Bee, third leg with Pollen Basket
Sting of :—Bee, front, showing Barbs.
Bee, front, showing Muscles.
Bee, side.
Bee, side Lancets unsheathed.
Wasp, Lancets unsheathed.
Wasp, side.
Ovipositor of :—Blowfly.
Cockroach.
Crane Fly.
Cricket.
Drone Fly.
Sawfly.
Ovipositor and Lungs of Spider.
Lungs of Water Spider.
Spinnerets of :—Garden Spider.
House Spider.
Silkworm.
Water Spider.
Allulet of :—Blowfly.
Great Gadfly.
House Fly.
Haltere of :—Biting House Fly.
Blowfly.
Crane Fly.
Great Gadfly.
House Fly.
Snout Fly.
Elytron of :—Cricket, showing Chirping File.
Cricket, Embryonic.
Female Cricket.
American Cockroach.
German Cockroach.
Water Beetle, Asilius.
Water Beetle, Colymbetes.
Water Beetle Dytiscus.
Water Boatman, Notonecta.
Water Bug, Corixa.
Rudimentary Elytron of Cockroach.
Rudimentary Wing of Cockroach, female.
Wing of :—Alder Fly.
Bee, hooked.
Bee, unhooked.
Blowfly.
Clegg.
Cockroach.
Cricket.
Drone Fly.
Earwig.
Gnat.
Golden-eyed Gadfly.
Great Gadfly.
Hornet.
House Fly.
Lacewing Fly.
Ladybird.
Marsh Fly.
May Fly.
Psychoda.
Small Dragon Fly.
Wasp, hooked.
Wasp, unhooked.
Wasp, Queen.
Wasp, folded.
Water Beetle, Asilius.
Whirligig Beetle.
Emperor Moth, transparent or opaque.
Orange Tip.
Orange Tip, underwing, transparent or opaque.
Peacock Butterfly, transparent or opaque.
Tortoiseshell Butterfly, transparent or opaque.
Protective Hairs of Brazilian Caterpillar.
Spine of Vanessa Caterpillar.
Hairs from :—Larva of Dermestes Beetle.
Pencil Tail, Polyxenus.
Bee.
Brush Hair from Larva of Vapourer Moth.
Scales from :—Wing of Butterfly.
Wing of Clothes Moth.
Lepisma saccharina.
Skin of :—Caterpillar, showing pigment markings and spiracle.
Cockchafer larva, showing spindle hairs.
Garden Spider.
Glowworm.
Water Spider.
Spiracle of :—Blowfly, frontal.
Blowfly, lateral.
Blowfly, larva.
Cockchafer larva.
Cockroach.
Crane Fly larva.
Drone Fly.
Glowworm.
House Fly.
Marsh Fly larva.
Mydae Urbana.

[continued overleaf

B 98-510. MICROSCOPE SLIDES, as listed below *(continued)* .. .. *each* £0 2 0

ENTOMOLOGY—*continued.*

Spiracle of :—Puss Moth larva.
Water Beetle, Dytiscus.
Lesser Spiracle of Dytiscus.
Trachæ of :—Centipede.
Gadfly.
Blowfly.
Silkworm.
Water Beetle, Dytiscus larva.
Male Organs of :—Cockroach.
Crane Fly.
Flea.
Gnat.
Plumed Gnat.
Spider.
Abdominal Segments of :—
Blowfly.
House Fly.
Water Bug, showing stridulating organs.
Worker Bee, showing wax plates.
Abdominal Membrane of Blowfly.
Callipers of Earwig, male.
Callipers of Earwig, female.
Cercis of :—Cockroach.
Cricket.
Chirping File of Cricket.
Falces of Spider, showing poison sac.
Gizzard of :—Cockroach.
Cricket.
Flea.
Water Beetle.
Mandibles of Bee.
Mandibles of Wasp.
Pygidium of Flea.
Pylorus of Water Beetle, Dytiscus.
Rostrum of Water Boatman.
Rostrum of Water Bug.
Salivary Glands of Cockroach.
Stridulating Organ of Water Bug.
Sucker from Foot of Dytiscus.
Tail and Gills of Ephemera larva.
Thoracic Plate of Glowworm.
Wax Plates of Bee.

ZOOLOGY

Amphioxus, young, whole.
Amphioxus, T.S.
Hydra.
Hydra, budding.
Hydra, with swallowed animal (Daphnia).
Hydra, T.S.
Amœba.
Paramecium.
Vorticella.
Gammarus, Fresh Water Shrimp.
Sandhopper.
Perch, young, just hatched.
Perch, ova, with embryos.
Snail, Aquatic, ova.
Snail, Land, ovum.
Argulus foliaceus, Fish Parasite.
Marine Zoophytes :—Antennularia.
Coryne vaginata.
Halecium.
Obelia.
Plumularia pinnata.
Newt :—Gut.
gills.
tail, showing pigment cells.
Heart, T.S.
Heart, T.S.
Ivory, T.S.
Tadpole, tail.
Stickleback, tail.
Frog, head, T.S.
Frog, body, T.S.
Tubifex.
Oxyurus.
Ascaris, Intestinal Worm of Dog Fish.
Noctiluca miliaris.
Statoblasts of Cristatella.
Animal Hairs—
Hairs of :—Man.
Human Fœtus.
Arctic Fox.
Beaver.
Brown Bear.
Cat.
Chinchilla.
Dormouse.
Ermine.
Fox.
Kangaroo. ..
Lemur.
Lion.
Llama Goat.
Lynx.
Marmoset.
Mole.
Monkey.
Mouse.
Musquash.
Opossum.
Otter.
Ox.
Peccary (Section)
Persian Lamb.
Platypus.
Rabbit.
Rat.
Russian Sable.
Seal.
Sheep.
Silver Fox.
Skunk.
Squirrel.
Tiger.

MINERALS

Actinolite.
Agate.
Aluminium filings.
Amber (Baltic).
Antimony (Borneo).
Antimony (China).
Argentite.
Azurite.
Bismuth.
Blue John.
Brass filings.
Carborundum.
Chrome Iron ore.
Cinnabar.
Copper filings.
Copper pyrites.
Galena.
Garnet (Nepal).
Orpiment.
Gold ore.
Granite (Aberdeen)
Graphite (Ceylon)
Hornblende.
Iron (cast).
Lapis lazuli.
Magnetic Iron ore.
Malachite.
Meteoric dust.
Mundic Pyrites.
Nickel filings.
Nickel ore.
Olivine.
Opal.
Peacock Copper ore.
Realgar.
Red Iron ore.
Ruby Silver.
Rutile.
Schist Glaucophone.
Serpentine.
Silver glance.
Silver (native).
Silver ore.
Steel, mild.
Sylvanite.
Tin (block).
Tinstone.
Tourmaline.
Tungsten ore.
Volcanic dust, Cotopaxi.
Volcanic dust, Krakatao.
Volcanic dust, La-Soufriere.
Volcanic dust, Vesuvius.
Wolfram.
Zinc ore.

MISCELLANEOUS

Crystals of :—Cane Sugar.
Copper Sulphate.
Phenyl Glucosazone.
Triple Phosphates.
Uric Acid.
Plant Crystals, Sphœarphides.
Eggs of Bird Parasite.
Feather from Humming Bird.
Foraminifera from various localities.
Mouth Bones of Feather Starfish.
Oak Galls, Button Gall.
Oak Galls, Spangle Gall.
Palate of :—Limpet.
Trochus
Whelk.
Paper from Wasp's Nest.
Particles in suspension, showing "Brownian" movement.
Polycistina from Springfield, Barbadoes.
Polycistina moving in fluid.
Rolling Stones moving in fluid.
Scales of :—Dover Sole.
Lemon Sole.
Perch.
Skin of :—Dog Fish.
Dover Sole, showing scales in situ.
Spicules of :—Gorgonia flabellum.
Gorgonia plexaura.
Gorgonia, various.
Spines of Echinus, Clypeaster.
Sponge, T. S.
Sponge, V. S.
Textile Fibres :—Cotton.
Flax.
Hemp.
Jute.
Silk.
Wool.
Egyptian Mummy Cloth, over 2,000 years old.
Section of Gramaphone Record Track.
Feather from Budgerigar.
Gold Leaf (Transmitting Green Light).
Dendritia Spot on Paper.

EMBRYOLOGY.

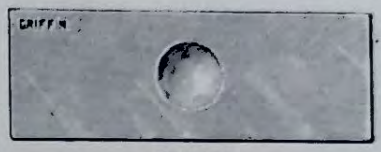
B 98-525. CHICK, Microscope Slides.

	£ s. d.		£ s. d.
No. 1. 12-18 hours, T.S. Embryo	0 5 6	No. 4. 48 hours, T.S. Body	0 2 6
No. 2. 36 hours, T.S. Embryo	0 5 6	No. 5. 72 hours, T.S. Embryo	0 4 6
No. 3. 48 hours, T.S. Embryo	0 4 6	No. 6. 72 hours, L.S. Embryo	0 4 6

B 98-527. Ditto, eight stages, continuation of above slides up to fully developed stage. In glass jar £2 7 6



B 98-700—710.



B 98-715.


B 98-720.

B 98-700. MICROSCOPE SLIDES, half-white, uniform, with ground and polished edges, packed in ½ gross boxes. For routine and students' use.

Dimensions	3 × 1	3 × 1½	
	7/-	9/-	*gross*

Special quotation for large quantities.

B 98-705. MICROSCOPE SLIDES, Chance's, slightly tinted, 3 × 1 in., non-corrosive, with ground and polished edges. **Specially suitable for use in hot climates.** Packed in ½ gross boxes .. .. *gross* — £ 0 10 6

B 98-710. MICROSCOPE SLIDES, colourless, extra thin, 3 × 1 in., uniform, with ground and polished edges, packed in ½ gross boxes .. .. *gross* — £ 0 11 6

B 98-715. MICROSCOPE SLIDES, colourless, 3 × 1 in., thickness about 1¼ mm., with round polished cavities 15 mm. diam. for hanging-drop cultures.

No. of cavities	1	2	3	
	3/3	6/-	8/-	*dozen*
	4d.	7d.	9d.	*each*

B 98-720. MICROSCOPE SLIDES, with fused-on glass ring 15 mm. diam., with finely ground edges .. .. *each* — £ 0 5 0


B 98-735


B 98-740.


B 98-750.


B 98-755.

B 98-735. MICROSCOPE COVER GLASSES, squares, finest quality, ⅛, ¼, ⅜ or 1 in. side, packed in ½ oz. boxes.

No.	0	1	2	3	
Thickness approx.	⅓₀	⅕₀	⅛₀	¼₀	*in.*
	p 14/6	10/-	8/-	5 6	*oz.*

B 98-740. Ditto, circles, ⅛, ¼, ⅜ or 1 in. diam., packed in ½ oz. boxes.

No.	0	1	2	3	
Thickness approx.	⅓₀	⅕₀	⅛₀	¼₀	*in.*
	p 19/-	13/6	10/-	7 8	*oz.*

B 98-745. Ditto, rectangular, packed in ½ oz. boxes.

No.	1	2	
Thickness approx.	⅕₀	⅛₀	*in.*
Dimensions, 1½ × ⅜ in.	*p* 7/6	6/-	*oz.*

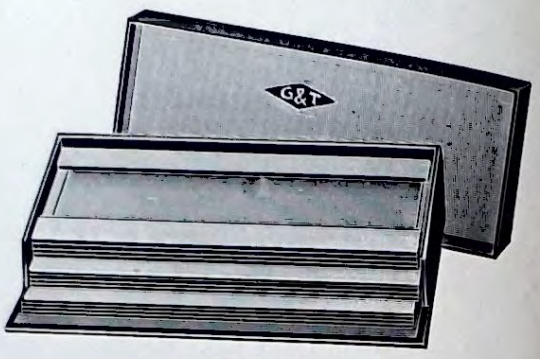
B 98-747. Ditto, 2 × ⅜ in. .. .. *p* 7/6 — 6/- *oz.*

B 98-750. GLASS RINGS, 15 mm. diam., 3 mm. high .. .. *dozen* — £ 0 5 0

B 98-755. GLASS CELLS, 24 mm. square, with circular hole 10 mm. diam. .. .. *dozen* — £ 0 14 0



B 98-770.



B 98-780.

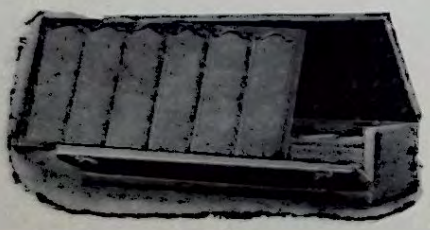
B 98-770. MICROSCOPE SLIDE BOXES, for 3 × 1 in. slides. Top and bottom of stout cardboard, rims of wood, leatherette covered. Lid hinged and fitted with two superior quality snap catches. Grooves cleanly cut and numbered, and a corresponding index on the inside of cover. An insertion along the bottom enables the slides to be tilted and easily removed.

To hold	50	100	*slides*
	5/6	**7/6**	*each*

B 98-775. MICROSCOPE SLIDE BOXES, Book form, for 3 × 1 in. slides. To hold 100 slides *each* £ s. d. **0 12 0**

B 98-780. MICROSCOPE SLIDE BOXES, Tray form, for 3 × 1 in. slides, of stout cardboard cloth covered and lined white inside. Fitted with drop-on lid, drop front and cardboard trays each holding 9 slides.

To hold	54	108	144	*slides*
	3/6	**5/6**	**7/-**	*each*



B 98-785.



B 98-790.

B 98-785. MICROSCOPE SLIDE BOXES, Tray form, for 3 × 1 in. slides. Constructed of varnished pinewood, with hinged cover and drop front. The flat trays each hold 6 slides.

To hold	36	72	144	*slides*
	p **12/6**	**35/-**	**50/-**	*each*

B 98-790. MICROSCOPE SLIDE TURNTABLE, brass, mounted on a heavy iron base, for making cells and ringing the edge of cover glasses. Table rotates on a ball bearing .. *tx* £ s. d. **1 18 6**

A great variety of Apparatus for all branches of Physics, Chemistry and Biology is made in our own factories and approved by rigid inspection in our own Test Rooms.



B 98-820—822.



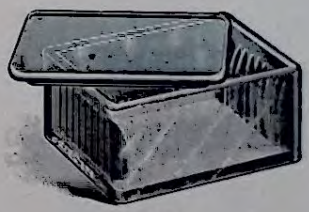
B 98-830—832.

	£	s.	d.
B 98-820. STAINING STAND, Wood, about 14 × 3 in., on rubber feet, with six 2 oz. dropping bottles, with ground-in pipette stoppers fitted with rubber teats	0	15	0
B 98-822. Stand only	0	8	0
B 98-830. STAINING STAND, Wood, about 14 × 3 in., on rubber feet, fitted with four 2 oz. bottles with ground-in pipettes and rubber teats, one 2 oz. cedar-wood oil bottle with ground-in pipette stopper and ground-on cover and one 1 oz. Canada balsam bottle with glass rod and loose cover	0	18	0
B 98-832. Stand only	0	9	0

Dropping Bottles, see p. 429.



B 98-850.



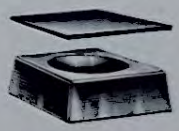
B 98-855.



B 98-865.



B 98-870.



B 98-875—877.

	£	s.	d.
B 98-850. STAINING JARS, Coplin, heavy glass with ground-on cover, for 10 slides 3 × 1 in. back to back .. .. *each pb* 4/3 ; *dozen*	2	5	0
B 98-855. STAINING TROUGH, Glass, horizontal pattern, with cover, to hold twenty 3 × 1 in. slides .. .. *tx*	0	5	6
B 98-860. Ditto, porcelain, to hold five 3 × 1 in. slides. **Without** cover .. .. .. *tx*	0	7	6

B 98-865. STONEWARE SAUCERS, white, useful for staining specimens.

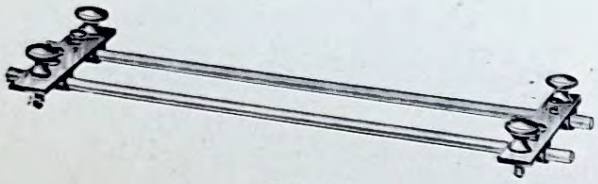
Diam.	50	64	70	*mm.*
	4/-	4/6	5/6	*dozen*

	£	s.	d.
B 98-870. STONEWARE DISHES, white, for staining specimens, 4 in. square, § in. deep, with raised supports facilitating removal of slides. Holds three 3 × 1 in. slides *each* 1/5 ; *dozen*	0	15	0
B 98-875. STAINING WELLS, 4 cm. square, clear moulded glass, with cavity about 30 mm. diam. **Without** covers .. .. *each* 1/8 ; *dozen*	0	18	0
B 98-877. Covers, for **B 98-875** .. .. *dozen*	0	1	9



B 98-885.

B 98-885. STAINING MATS, finest quality soft rubber with projections, for draining cover glasses after staining, 8 × 6¼ in. .. .. .. *Prices on application.*



B 98-890.



B 98-950—955.



B 98-970.

£ s. d.

B 98-890. STAINING RACK, stout brass, fitted with levelling screws and slots to take ¼ in. diam. glass rods which are held securely by small milled head screws. By using suitable lengths of glass rod the rack can be used over all sizes of laboratory sinks. **Without** glass rod *r* **1 5 0**

B 98-950. PETRI DISHES, Chance's Hysil, in pairs, bottom dish approx. 15 mm. deep.

Diam. of lower dish		2½	3	3½	4	4½	5⅞	*in.*
	tx	**37/-**	**43/-**	**44/-**	**60/-**	**72/-**	**90/-**	*dozen*
	tx	**3/6**	**4/-**	**4/-**	**5/6**	**7/-**	**8/-**	*each*

B 98-955. Ditto, Pyrex Glass.

Diam. of lower dish		2	2½	2¾	3¾	4½	5½	*in.*
	tx	**2/9**	**3/1**	**3/6**	**4/-**	**5/1**	**6/-**	*each*

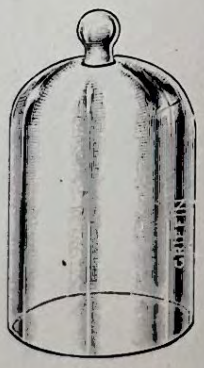
B 98-970. GLASS BOXES, with drop-over covers, white glass, 4 in. diam. × 2 in. deep *each* **5/6** ; *dozen* **3 0 0**



B 98-975.



B 98-977.



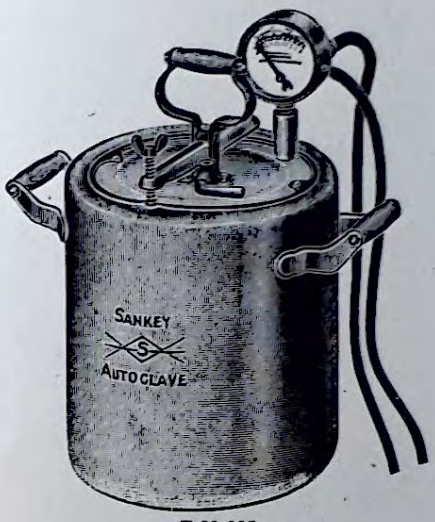
B 98-985.

JARS, Museum or Specimen, cylindrical, white flint glass, on foot, with ground-in stoppers.

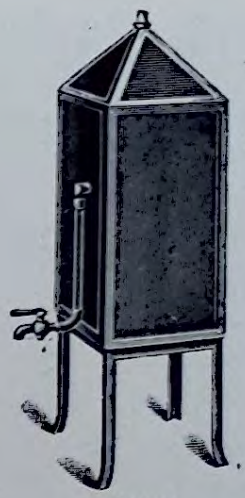
Height × diam. ..		8 × 3	5 × 5	8 × 5	10 × 5	15 × 5	*cm.*
B 98-975. Grip stopper	*tx*	**16/-**	**16/-**	**22/6**	**27/-**	**30/6**	*dozen*
B 98-977. Flat stopper	*tx*	—	**16/-**	**22/6**	**27/-**	**30/6**	*dozen*

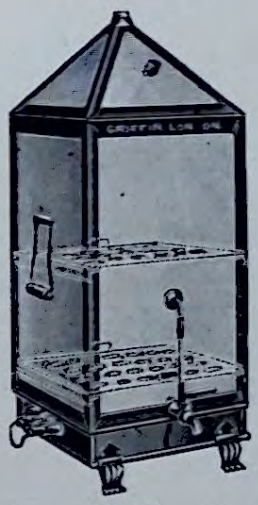
B 98-985. SHADES, Glass, without flange, for covering microscopes and other instruments.

Height × diam. ..	12 × 7	14 × 7	14 × 9	15 × 10	18 × 10	*in.*
	12/6	**15/-**	**17/6**	**18/6**	**25/-**	*each*



B 99-005.


B 99-010.


B 99-012.

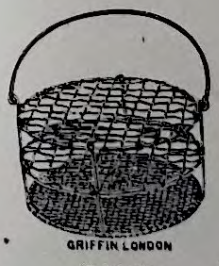
£ s. d.

B 99-005. STERILIZER, Steam, portable, for heating by gas or on electric hot plate, for sterilizing flasks, beakers, test tubes, etc. The lid is fitted with a fusible metal safety valve, pressure gauge reading to 40 lb./sq. in., and also in degrees Centigrade, and warning whistle adjustable to blow at desired pressure. With grid strainer. Dimensions 12 × 10¾ in., capacity 26 pints .. .. *t* 6 15 0

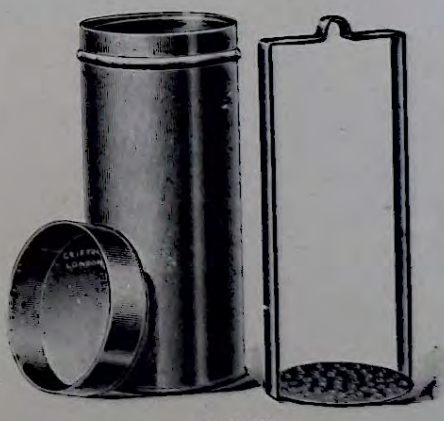
STERILIZERS, Steam, square pattern, stout copper, tinned inside and asbestos covered, with two perforated movable trays, draining tap and water gauge, tubulure for thermometer, mounted on iron legs. Electrically heated models are supplied with 3-heat rotary switch and 2 yds. 3-core tough rubber cable.

Size	A	B	C	
Inside dimensions ..	20 × 10 × 10	20 × 12 × 12	20 × 16 × 16	*in.*
B 99-010. Gas heated .. .. *p*	£12 10 0	£14 0 0	£18 10 0	*each*
B 99-012. Electrically heated .. *p*	£15 5 0	£18 10 0	£24 0 0	*each*

Please state voltage when ordering.



B 99-025.


B 99-030.


B 99-032.


B 99-035.

£ s. d.

B 99-025. STERILIZING BASKET, for test tubes, galvanised iron, diam 8 in., height 5 in., partitioned to hold about 50 tubes, with lifting handle .. .. *p* 0 9 6

B 99-030. STERILIZING BOXES, for Petri Dishes, copper, Hold 10 dishes up to 10 cm. diam. *each p* 1 2 0

B 99-032. Ditto, for Pipettes, copper, with lid fitting outside.

Length × diam.	14½ × 2	17½ × 2½	*in.*
	r 15/-	17/-	*each*

B 99-035. STERILIZING RACKS, for Petri Dishes, spring brass, nickel-plated. Will hold securely 5 dishes 100 × 15 mm. deep .. .. *each* 0 4 6

CHARTS



B 99-080—090.

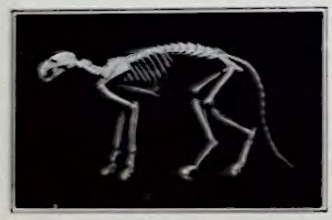
B 99-080. SOIL TESTING OUTFIT, B.D.H., designed for use in the field to enable the "reaction" of the soil to be determined with rapidity and ease, consisting of a dropping bottle containing soil indicator, a specially designed porcelain boat, and a small spatula. Complete in cardboard box — £ 0 4 6

B 99-082. Ditto, in leather-board box .. — £ 0 7 6

B 99-085. Soil Indicator, 100 ml., spare — *per bottle* £ 0 3 3

B 99-087. Porcelain Boats, spare .. — *each* £ 0 1 9

B 99-090. Spatulas, spare .. .. — *each* £ 0 0 6



Rabbit.
B 99-150.



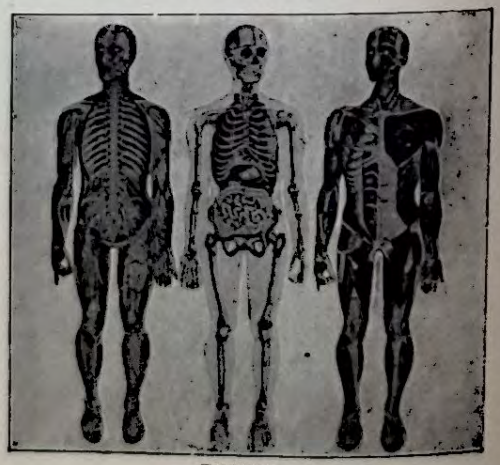
Frog.
B 99-155.

B 99-150. SKELETONS, mounted. Frog, fowl, rabbit, pigeon, bat, dogfish, etc. *Prices on application.*

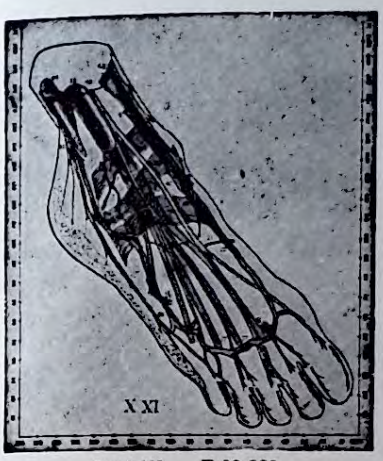
B 99-155. DISSECTIONS, Zoological, mounted on glass plates, in preserving liquid, hermetically sealed in glass jars .. .. *Prices on application.*

B 99-160. SPECIMENS, Zoological, mounted on glass plates, in preserving liquids, hermetically sealed in glass jars, or dry mounted in glass cases .. .. .. *Prices on application.*

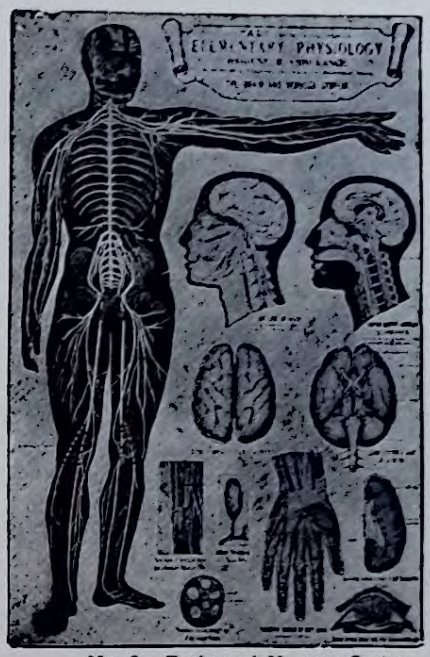
B 99-205. ATLAS, Anatomical, "Popular Manikin." Consists of a series of coloured plates and pages of explanatory notes. All the parts and organs are represented by appropriately coloured and shaped pieces of heavy paper arranged to fold into their proper places, so as to convey a correct idea of their relative sizes and positions. The text gives a condensed yet clear description of the subject of each plate. Size of model, 19 by 8 in. Stout board covers, cloth back .. *ea.* £ 0 9 6



B 99-205.



Part VI. B 99-220.



No. 3. Brain and Nervous System. B 99-242.



No. 6. Structure of the Eye. B 99-242.

B 99-220. ANATOMY, Synthetic. A series of carefully executed drawings 9 × 7¼ in., showing, by means of superimposed, coloured transparent plates, the soft tissues and structures *in situ* as expressed by dissection, impressions of depth and distance being extremely well conveyed. £ s. d.

The full series covers the whole human body. Each of the parts is complete in itself and contains a full descriptive text. There are 12 plates to each part, printed in 6 colours on transparent paper, a key index being provided .. .. *each part tx* 0 3 6

Part	I. **Upper Arm and Shoulder.**	Part	VIII. **Abdomen.**
,,	II. **Forearm.**	,,	IX. **Head and Neck.**
,,	III. **Hand.**	,,	IXA. **Pterygo-Maxillary Region (enlarged).**
,,	IV. **Thigh and Hip.**	,,	X. **Brain.**
,,	V. **Leg.**	,,	XI. **Perineum (male).**
,,	VI. **Foot.**	,,	XII. **Perineum (female).**
,,	VII. **Thorax.**	,,	XIII. **Eye and Orbit.**

B 99-225. Binding Case, loose leaf, to take the complete set, as well as enlargements and notes *tx* 0 3 6

CHARTS, Anatomy and Physiology. A series accurately drawn by a specialist, mainly from the actual specimens concerned, and beautifully printed in colours. All minute and unnecessary details not required for school and popular teaching are omitted, but everything for thoroughly understanding Human Physiology in its broad outlines, and in connection with Hygiene and Ambulance, is included. For *simplicity*, *clearness* and *accuracy*, these diagrams are superior to anything of the kind hitherto published. The names of the various organs or parts are boldly printed on, or adjacent to, the portion referred to.

The complete series consists of eight sheets, each 40 × 30 in., printed in colours.

No. 1. **Skeleton.** Entire Figure, with 10 enlarged details or parts.
No. 2. **Muscles.** Entire Figure, with 6 enlarged details or parts.
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No. 4. **Circulation of the Blood.** Entire Figure, with 12 enlarged details or parts.
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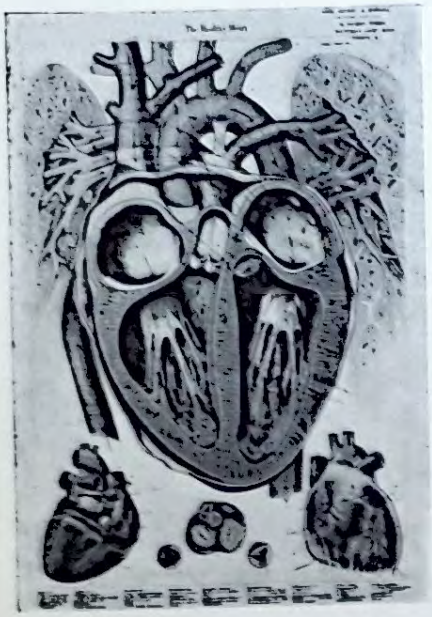
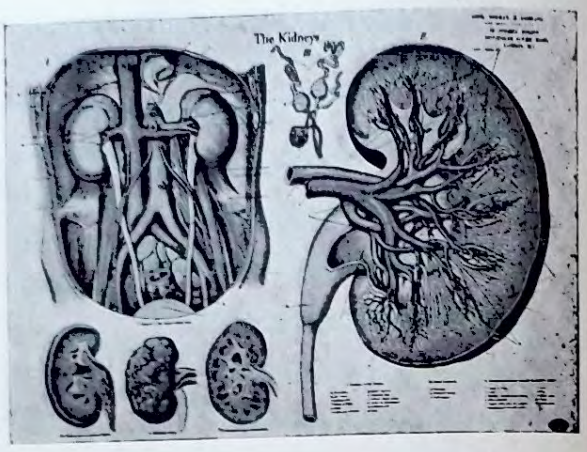
No. 7. **Structure of the Ear.** With 8 enlarged details or parts.
No. 8. **Skin and Excretory Organs.** With 9 enlarged details or parts.

B 99-240. Set of 8 Charts, mounted on calico with rollers, and varnished .. .. .. *tx* 3 12 0
B 99-242. Single Charts, mounted on calico with rollers, and varnished .. .. .. *tx* 0 9 0
B 99-245. Set of 8 Charts, unmounted, with lath at top .. .. *tx* 1 7 0
B 99-247. Single Charts, unmounted, with lath at top .. .. *tx* 0 3 6

Anatomical Models of the EYE, see A 56-805—815.
,, ,, ,, EAR, ,, A 63-810.
,, ,, ,, LARYNX, see A 63-815.



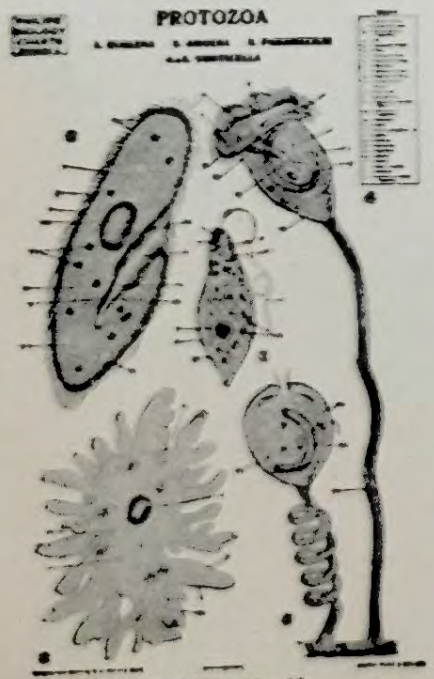
B 99-265 g.



B 99-265 m.

CHARTS, Anatomy and Physiology, Wall. A series of carefully executed and up-to-date coloured charts, characterised by clearness and fidelity to the original ; in some instances abnormal conditions are also included. Prepared by specialists in this field and suitable for intermediate study. Mounted on cloth with plain rollers.

		£	s.	d.
B 99-265 a.	**The Human Skeleton,** on black background. Front view, with the main arteries and pressure points. Size, 55 × 30 in.	1	15	0
" " b.	**Full Figure,** on black background. A large chart of the anterior aspect stressing the relationship of the skeleton, circulation and vital organs, *in situ*. Size, 55 × 30 in.	1	15	0
" " c.	**Full Figure.** A large chart on black background. A study of the nerves on the background of the posterior aspect of the skeleton. The muscles and the vital organs, *in situ*. Size, 55 × 30 in.	1	15	0
" " d.	**Full Figure,** on black background. The two charts, 2 and 3, grouped and combined on one complete plate, side by side.	3	5	0
" " e.	**Digestive System.** Life-size, with various sections to show wall structures of the stomach, duodenum, jejenum, ileum, colon and rectum. Size, 44 × 34 in.	1	10	0
" " f.	**Throat, Pharynx and Larynx.** Greatly enlarged. Size, 46 × 35 in.	1	10	0
" " g.	**Heart.** Greatly enlarged. Sectioned to show the details of all chambers, valves and the course of the blood in the pulmonary and systemic circulation. Size, 44 × 34 in.	1	10	0
" " h.	**Vision.** Abnormal eye showing near and longsighted eyes and corrective lenses with normal eyes for comparison. Size, 55 × 30 in.	1	10	0
" " k.	**Eye and Sight,** protective mechanism as function of the brain. Size, 55 × 30 in. ..	1	10	0
" " m.	**Kidney,** *in situ*. Greatly enlarged, showing also abnormalities. Size 43 × 30 in. ..	1	10	0



B 99-280. No. 11.

B 99-280. CHARTS, Biology, Wall. A series of coloured charts designed to illustrate various phases of elementary Biology. Mounted on cloth and varnished, with rollers. Size 37½ × 24 in. *each tx* £ 0 s. 9 d. 6

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No. 4. **Fowls.** Comb characters.

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Nos. 5 and 6. **Dog.** Skull.
No. 7. **Rabbit.** Skeleton and vertebrae.
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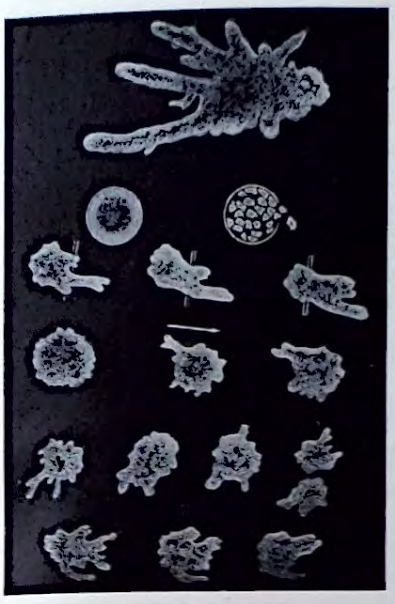
No. 9. **Rabbit.** Ribs, sternum and limb girdles.
No. 10. **Rabbit.** Limb bones.

GENERAL ZOOLOGY

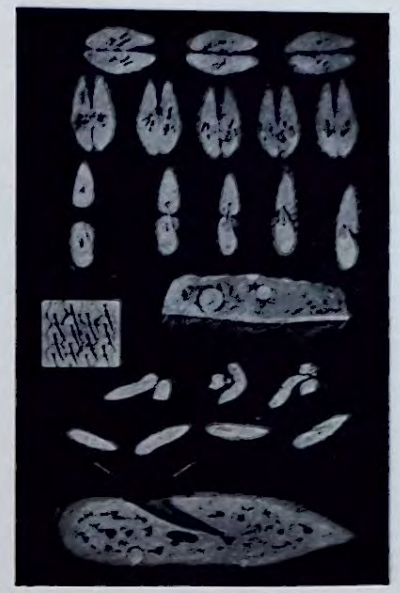
No. 11. **Protozoa.** Amoeba, Paramecium Vorticella and Euglena.
No. 12. **Earthworm.** General anatomy.
No. 13. **Earthworm.** T.S. and reproductive system.
No. 14. **Frog.** Blood vascular system.

BOTANY

No. 15. **Freshwater Algae.** Spirogyra, Chlamydomonas and Haematococcus.
No. 16. **Leaf.** T.S. (Sunflower), Epidermis (Iris), and Rolled leaf (Heath).



No. 1.—**Amoeba.**
General Anatomy and Life-History.



No 2.—**Paramoecium.**
General Anatomy and Life-History.



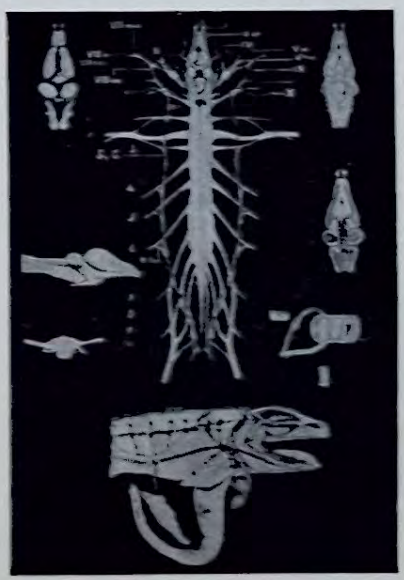
No. 5.—**Hydra Viridis.**
General Anatomy and Life-History.



No. 22.—**Rana Temporaria.**
General Dissection.



No. 24.—**Rana Temporaria.**
Skeleton.



No. 25.—**Rana Temporaria.**
Brain and Nervous System.

B 99-295.

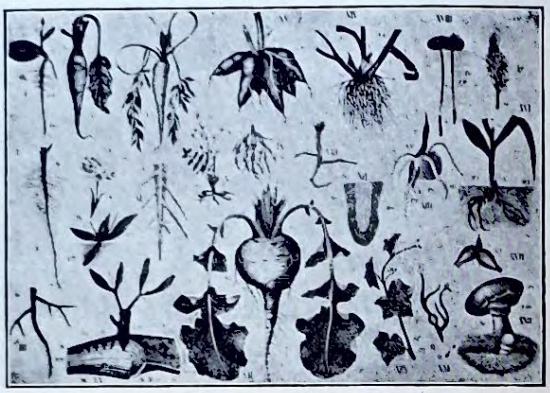
	£	s.	d.
B 99-295. ZOOLOGICAL DIAGRAMS, coloured, on linen-backed paper 42 × 29 in., with eyelets at the top for easy suspension .. .. *each tx*	0	10	6

These diagrams are taken from those prepared for the use of the Biological Dept. of Oundle School by its own staff. They are easily visible at a distance of 20 feet, and have been produced at the request of many science teachers who, having seen the originals in use, have expressed a desire to have similar diagrams made available for their own teaching purposes. They are notable for their clearness, artistic colouring and good printing. Colours used range from 3 to 6.

1. **Amoeba.** General anatomy and life-history.
2. **Paramoecium.** General anatomy and life-history.
5. **Hydra Viridis.** General anatomy and histology.
8. **Lumbricus.** External features.
9. **Lumbricus.** General dissection and nervous system.
10. **Lumbricus.** Histology of T.S. with enlarged details.
11. **Astacus.** External features, both dorsal and ventral, together with longitudinal section of whole body.
13. **Periplaneta.** External features.
15. **Periplaneta.** Dissection. General and reproductive organs.
16. **Musca domestica.** External features and life-history.
19. **Scyllium.** Externals, dissection of female, and details of urogenital systems.
20. **Scyllium.** Brain and nervous system.
21. **Scyllium.** Skeleton.
22. **Rana.** General dissection and reproductive organs.
23. **Rana.** Arterial and venous systems.
24. **Rana.** Skeleton.
25. **Rana.** Brain and nervous system.
27. **Lepus.** General dissection, including nerves and great blood-vessels of the neck.
28. **Lepus.** Vascular system of mammal.



B 99-320—325. No. 11.



B 99-340—342. No. 1.

B 99-320. CHARTS, Botany, 40 × 29 in., coloured to give faithful renderings of the external form and internal structure of common plants. Each chart contains smaller diagrams illustrating fruits, flowers and other noteworthy features. Mounted on cloth, flat .. .. *each* (*a*) *tx* **0 12 2**

B 99-322. Ditto, varnished, on rollers .. .. *each* (*a*) *tx* **0 14 10**

B 99-325. Ditto, paper sheets .. .. *each* (*a*) *tx* **0 7 10**

No. 1. **Rose-bay Willow-herb.**
No. 2. **Sweet Pea.**
No. 3. **Wood Anemone.**
No. 4. **Goat Willow.**
No. 5. **Strawberry.**
No. 6. **Cowslip.**
No. 7. **Coltsfoot.**
No. 8. **Sundew and Bladderwort.**
No. 9. **Algae** (Sheet 1)—Spirogyra (conjugation), Zygnema, Vaucheria and Pleurococcus.
No. 10. **Algae** (Sheet 2)—Fucus vesiculosus, Laminaria saccharina, Diatoms, Micrasterias.
No. 11. **Fern.**
No. 12. **Moss.**

The above are available for sale only in Great Britain and Northern Ireland.

B 99-330. CHARTS, Botany, 50 × 42 in., on cloth and rollers, varnished .. *each* (*a*) *tx* **1 10 6**

B 99-332. Ditto, on cloth, folded in sections .. .. *each* (*a*) *tx* **1 10 6**

B 99-335. Handbooks, for use with the above charts .. .. *each tx* **0 0 6**

No. 1. **Organs of Tissues, Plants, Root, Stem.**
No. 2. **Leaves and their modifications.**
No. 3. **Inflorescence, Whorls of Flowers.**
No. 4. **Pistil, Ovule, Fruit, Seed, Organs of Flowerless Plants.**

B 99-340. CHARTS, Botany for Beginners, 34 × 28 in. On cloth and rollers, varnished *each* (*a*) *tx* **0 14 10**

B 99-342. Ditto, on cloth, cut in sections to fold .. .. *each* (*a*) *tx* **0 14 10**

No. 1. **Roots.**
No. 2. **Stems.**
No. 3. **Leaves.**
No. 4. **Leaves.**
No. 5. **Flowers.**
No. 6. **Fruits and Seeds**

B 99-350. CHART, Elementary Anatomical Botany, 34 × 28 in. On cloth and rollers, varnished.
Root .. .. *each* (*a*) *tx* **0 11 5**

B 99-352. Ditto, on cloth, cut in sections to fold .. .. *each* (*a*) *tx* **0 11 5**

Chemicals and Reagents

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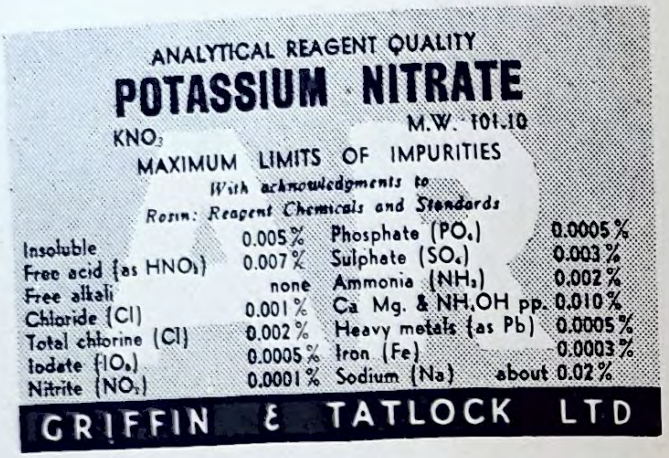
If the reagent you require is not found in this Catalogue please write to us for quotations.

ANALYTICAL REAGENTS



A.R. Chemicals—A Typical Label.

Analytical Reagent (A.R.) is a description of quality applied to chemicals manufactured to approved specifications and suitable for use in exact analysis.

Each A.R. chemical supplied by us carries on its label a specification of the Maximum Limits of the Impurities to be found in it. These specifications are based on the stringent and authoritative specifications by Rosin in **"Reagent Chemicals and Standards"** (Chapman & Hall). This comprehensive work is an extension and revision of the work originated by the American Chemical Society through its Committee on Analytical Reagents.

Our A.R. chemicals are prepared with meticulous care. Immediately after analysis they are packed in the sealed containers in which they are delivered to the user.

	100 *gm.*	250 *gm.*	500 *gm.*		
Acetic acid, glacial, A.R.	-/11	1/11	3/6	2½ kg.	15/9
,, anhydride, A.R.	1/3	2/8	5/-	2½ kg.	22/6
Acetone, A.R.	-/10	1/8	3/-	1¾ kg.	9/6
Acetyl chloride, A.R.	3/4	7/6	14/6		
Aluminium ammonium sulphate, A.R.	—	1/5	2/6	2½ kg.	11/3
,, oxide, A.R.	-/10	1/10	3/4	2½ kg.	15/-
,, potassium sulphate, A.R.	—	1/5	2/6	2½ kg.	11/3
,, sulphate, A.R.	-/11	1/11	3/6	2½ kg.	15/9
Aminoacetic acid, A.R. 10 *gm.*, 1/10 ; 25 *gm.*, 4/3	13/-	—	—		
Ammonium acetate, A.R.	1/8	3/8	7/-	2½ kg.	31/6
,, carbonate, A.R.	-/9	1/7	2/11		
,, chloride, A.R.	—	2/-	3/8	2½ kg.	16/6
P1 ,, fluoride, A.R. 25 *gm.*, -/10	2/8	6/1	11/9		
P2 ,, hydroxide soln., 0·880, A.R.	—	-/9	1/3	2 kg.	4/6
,, molybdate, A.R. 25 *gm.*, 1/-	3/3	7/5	14/3		
,, nitrate, A.R.	-/11	2/2	4/-	2½ kg.	18/-
,, nitrosophenylhydroxylamine (Cupferron) A.R. 5 *gm.*, 3/6 ; 25 *gm.*, 10/-	—	—	—		
,, oxalate, A.R.	1/6	3/2	6/-	2½ kg.	27/-
,, persulphate, A.R.	1/2	2/7	4/9	2½ kg.	21/5
,, phosphate, dibasic, A.R.	1/9	3/11	7/6	2½ kg.	33/9
,, sulphate, A.R.	—	1/6	2/9	2½ kg.	12/6
,, sulphide solution, A.R.	—	2/3	4/2	2½ kg.	18/9
,, thiocyanate, A.R.	2/-	4/7	8/9	2½ kg.	39/5
,, vanadate, A.R. 25 *gm.*, 2/8	8/3	19/10	39/-		
Amyl acetate, A.R.	1/3	2/8	5/-	2 kg.	18/-
,, alcohol iso, A.R.	1/11	4/5	8/6	2 kg.	31/3
Aniline, A.R.	1/3	2/8	5/-	2½ kg.	23/-

		100 gm.	250 gm.	500 gm.	A.R.	
S1	Antimony potassium tartrate, A.R. ... 25 gm., 1/4	3/11	9/2	17/10		
S1	,, trichloride, A.R. ... ... 25 gm., 1/-	3/-	6/10	13/3		
S1	Arsenic trioxide, A.R.	1/4	2/11	5/6		
S1	Barium acetate, A.R.	1/8	3/9	7/2		
S1	,, carbonate, A.R.	2/8	6/-	11/6		
S1	,, chloride, A.R.	-/9	1/8	3/-	2½ kg.	13/6
S1	,, hydroxide, A.R.	1/-	2/1	3/9	2½ kg.	17/-
S1	,, nitrate, A.R.	1/3	2/8	5/-	2½ kg.	23/-
S1	,, peroxide, A.R.	1/2	2/3	4/-		
	Benzene, A.R.	—	1/3	2/3	2 kg.	8/4
	Benzidine, A.R.... ... ... 25 gm., 2/2	6/9	16/2	31/4		
	Benzoic acid, A.R. ... ... 25 gm., 1/11	6/3	14/8	25/8		
	Benzoyl chloride, A.R. ... ... 25 gm., 1/1	3/4	7/8	14/10		
	Boric acid, A.R.	1/1	2/4	4/3	2½ kg.	19/2
	Bromine, A.R. ... ... 25 gm., -/10	2/6	5/8	11/-		
	,, sealed tubes, A.R. 1 c.c., -/6 ; 2 c.c., -/8 2·2 c.c., -/8 ; 2·5 c.c., -/9	—	—	—		
	Cadmium chloride, A.R. ... ... 25 gm., 1/7	5/-	11/8	22/9		
	,, iodide, A.R. ... ... 25 gm., 2/11	8/11	21/6	42/3		
	,, sulphate, A.R. ... ... 25 gm., 1/7	5/-	11/7	22/7		
	Calcium carbonate precip., A.R.	2/8	6/-	11/6	2½ kg.	51/9
	,, chloride, anhyd., A.R.	1/4	2/11	5/6	2½ kg.	24/9
	,, ,, hexahydrate, A.R.	-/9	1/6	2/9	2½ kg.	12/6
	Carbon bisulphide, A.R.	—	2/1	3/10	3 kg.	21/2
	,, tetrachloride, A.R.	1/1	2/3	4/2	4 kg.	30/7
P1	Chloroform, A.R.	1/6	3/4	6/4	3½ kg.	40/8
	Chromium potassium sulphate, A.R.	1/-	2/1	3/10	2½ kg.	17/3
	,, trioxide, A.R.	2/9	6/3	12/-	2½ kg.	54/-
	Citric acid, A.R.	1/2	2/5	4/6	2½ kg.	20/3
	Cobalt chloride (cobaltous), A.R. ... 25 gm., 1/8	5/4	12/5	24/2		
	,, nitrate (cobaltous), A.R. ... 25 gm., 1/6	4/8	11/-	21/6		
	,, sulphate, A.R. ... ... 25 gm., 1/6	4/8	11/-	21/6		
	Copper foil, electrolytic, 0·003 inch, A.R.	1/3	2/7	4/9		
	Cupric acetate, normal, A.R.	1/6	3/2	6/-	2½ kg.	27/-
	,, ammonium chloride, A.R.	1/4	2/11	5/6	2½ kg.	24/9
	,, chloride, A.R.	1/6	3/2	6/-	2½ kg.	27/-
	,, nitrate, A.R.	1/6	3/2	6/-	2½ kg.	27/-
	,, oxide, powder, A.R.	2/4	5/5	10/6	2½ kg.	47/3
	,, sulphate, A.R.	1/-	1/11	3/6	2½ kg.	15/9
	Cuprous chloride, A.R.	2/5	5/8	11/-	2½ kg.	49/6
	Devarda's metal, A.R....	2/2	4/10	9/5		
	Dextrose, anhyd., A.R.	1/-	2/1	3/10	2½ kg.	17/3
	Dimethyl yellow, A.R. 10 gm., 1/10 ; 25 gm., 4/3	13/-	—	—		
	p-Dimethylaminobenzaldehyde, A.R. 10 gm., 2/5 ; 25 gm., 5/5	19/-	—	—		
	Dimethylaniline, A.R. ... ... 25 gm., 1/4	4/-	9/4	18/2		
	Dimethylglyoxime, A.R. 10 gm., 2/7 ; 25 gm., 4/11	17/3	—	—		
	Diphenylamine, A.R. ... ... 25 gm., 1/7	5/1	11/10	23/-		
	Eschka's mixture, A.R. ... ... 25 gm., 1/1	3/6	8/-	15/6		
	Ether, A.R.	1/3	2/8	5/-	1½ kg.	13/9
	Ferric ammonium sulphate, A.R.	-/11	1/11	3/6	2½ kg.	14/7
	,, chloride, hydrated, A.R.	-/11	1/10	3/3	2½ kg.	14/8
	Ferrous ammonium sulphate, A.R.	-/9	1/5	2/6	2½ kg.	11/3
	,, sulphate, A.R....	-/8	1/3	2/3	2½ kg.	10/5
P2	Formaldehyde solution, A.R.	—	1/3	2/3	2½ kg.	10/5
	Formic acid, 90%, A.R.	1/3	2/8	5/-	2½ kg.	23/-
	Fusion mixture, A.R.	1/2	2/5	4/6	2½ kg.	20/3
	Glycerol, A.R.	—	1/6	2/8	3 kg.	14/8
	Hydrazine sulphate, A.R. ... ... 25 gm., 2/8	8/3	19/10	39/-		

We invite your enquiries for substances not listed

A.R.

			100 gm.	250 gm.	500 gm.		
	Hydriodic acid, S.G. 1·7, A.R.	25 gm., 2/2	6/9	16/–	31/4		
	,, ,, (for methoxyl determination), S.G. 1·94, A.R.	25 gm., 2/8	8/5	20/2	39/7		
	Hydrobromic acid (46/48%), A.R.		1/9	4/–	7/9		
P2	Hydrochloric acid, S.G. 1·18, A.R.		—	—	–/10	2¾ kg.	4/3
P2	,, ,, arsenic free, A.R.		—	—	–/10	2¾ kg.	4/3
P2	Hydrofluoric acid, A.R.		1/8	3/8	7/–	*ceresine bottles extra*	
	Hydrogen peroxide, 100 vols., A.R.		—	8/6	16/6		
	,, ,, 20 vols., A.R.		1/–	2/2	4/–		
	,, ,, 10 vols., A.R.		–/8	1/3	2/3		
	Hydroxylamine hydrochloride, A.R.	10 gm., 1/6; 25 gm., 3/4	10/4	25/–	49/6		
	8-Hydroxyquinoline, A.R.	10 gm., 2/3; 25 gm., 4/3	13/–	31/8	62/8		
	Iodic acid, A.R.	25 gm., 2/5	7/5	17/8	34/7		
	Iodine, A.R.	25 gm., 1/10	5/9	13/6	26/4		
	Iron. *See Ferric, ferrous.*		—	—	—		
	Lactic acid, A.R.		1/8	3/8	7/–	2¾ kg.	31/6
	Lactose, A.R.		1/6	3/2	6/–	2½ kg.	27/–
	Lead, A.R.		–/9	1/7	2/11	2½ kg.	13/–
P1	Lead acetate, A.R.		–/10	1/10	3/4	2½ kg.	15/6
P1	,, ,, basic, A.R.		1/3	2/7	4/9	2½ kg.	21/11
	,, chromate, A.R.		2/–	4/7	8/10	2½ kg.	39/9
	,, dioxide, A.R.		1/9	3/11	7/6	2½ kg.	33/9
	,, monoxide, A.R.		–/8	1/3	2/3	2½ kg.	10/5
	,, nitrate, A.R.		1/1	2/3	4/2	2½ kg.	18/9
	Magnesium ammonium chloride, A.R.		1/3	2/8	5/–	2½ kg.	22/6
	,, chloride, A.R.		1/–	2/–	3/7	2½ kg.	16/3
	,, oxide, A.R.	25 gm., 1/4	4/4	10/2	19/9		
	,, sulphate, A.R.		—	1/–	1/9	2½ kg.	7/11
	Manganese chloride (manganous), A.R.		1/3	2/7	4/9	2½ kg.	21/5
	,, sulphate, A.R.		2/1	4/8	9/–	2½ kg.	40/6
S1	Mercuric chloride, A.R.	25 gm., 1/9	5/5	12/6	24/6		
P1	,, oxide, red, A.R.	25 gm., 1/11	6/–	14/1	27/6		
	Mercurous chloride, A.R.	25 gm., 1/9	5/6	13/–	25/6		
S1	,, nitrate, A.R.	25 gm., 2/6	7/11	18/10	37/–		
	Mercury, A.R.	25 gm., 1/4	4/3	10/6	19/6		
	Methyl orange, A.R.	25 gm., 2/1	6/8	15/9	—		
	,, red, A.R.	25 gm., 7/–	24/6	—	—		
	Molybdenum trioxide, A.R.	25 gm., 1/2	3/7	8/4	16/3		
	Molybdic acid, 85%, A.R.	25 gm., 1/1	3/5	7/10	15/2		
	Monochloroacetic acid, A.R.	25 gm., –/7	1/11	4/4	8/3		
	α-Naphthol, A.R.	25 gm., 2/1	6/6	15/6	30/3		
	β-Naphthol, A.R.	25 gm., 1/–	3/2	7/3	14/–		
	Nickel chloride, A.R.	25 gm., 1/–	3/2	7/3	14/–		
	,, sulphate, A.R.	25 gm., –/11	2/11	6/7	12/8		
P2	Nitric acid, S.G. 1·42, A.R.		—	1/1	1/10	3¼ kg.	10/10
P2	Nitrobenzene, A.R.		1/4	2/10	5/3		
P1	Oxalic acid, A.R.		1/3	2/8	5/–	2½ kg.	22/6
	Perchloric acid, 70%, A.R.	25 gm., 2/1	6/6	15/6	30/3		
	,, ,, 20%, A.R.	25 gm., –/9	2/3	5/2	9/11		
	Petroleum ether, A.R. (40–60° C.)		—	1/10	3/4	1½ kg.	9/2
P1	Phenol, A.R.		1/2	2/8	5/–	3 kg.	23/6
	Phenolphthalein, A.R.	25 gm., 1/–	3/–	6/10	13/3		
	Phenylhydrazinehydrochloride, A.R.	10 gm., 1/8; 25 gm., 4/6	15/9	37/6	—		
	Phloroglucinol, A.R.	25 gm., 16/8	—	—	—		
	Phosphomolybdic acid, A.R.	25 gm., 2/11	9/3	22/4	44/–		
	Phosphoric acid, S.G. 1·75, A.R.		1/–	2/1	3/10	4 kg.	28/3
	Phosphotungstic acid, A.R.	25 gm., 3/9	11/6	27/10	55/–		
P1	Picric acid, A.R.	25 gm., 1/3	3/11	9/2	17/8		
	Potassium acetate, A.R.		2/1	4/6	8/–		
	,, bicarbonate, A.R.		–/9	1/6	2/9	2¼ kg.	12/6
	,, bichromate, A.R.		1/4	2/11	5/6	2½ kg.	24/9

		100 gm.	250 gm.	500 gm.	A.R.	
	Potassium bisulphate, A.R.	1/1	2/4	4/3	2½ kg.	19/2
	,, bromate, A.R. 25 gm., -/10	2/6	5/8	11/-		
	,, bromide, A.R.	1/9	3/11	7/6	2½ kg.	33/9
	,, carbonate anhyd., A.R.	1/-	2/2	4/-	2½ kg.	19/4
	,, chlorate, A.R.	1/3	2/11	5/6	2½ kg.	24/9
	,, chloride, A.R.	1/-	2/1	3/10	2½ kg.	17/3
	,, chromate, A.R.	2/-	4/7	8/9	2½ kg.	39/5
	,, citrate, A.R.	1/9	3/11	7/6	2½ kg.	33/9
S1	,, cyanide, A.R. 25 gm., 1/1	3/6	8/-	15/6		
	,, ferricyanide, A.R. 25 gm., 1/3	3/11	9/2	17/8		
	,, ferrocyanide, A.R.	2/6	5/8	11/-		
	,, hydrogen phthalate, A.R. 25 gm., 1/7	5/1	11/10	23/-		
	,, ,, tartrate, A.R.	1/9	4/-	7/9		
P2	,, hydroxide, sticks, A.R.	—	4/5	8/6		
	,, iodate, A.R. 25 gm., 1/9	5/6	13/-	25/4		
	,, iodide, A.R. 25 gm., 1/7	5/1	11/10	23/-		
	,, metabisulphite, A.R.	—	2/5	4/6	2½ kg.	20/3
	,, nitrate, A.R.	—	2/2	4/-	2½ kg.	18/-
P2	,, oxalate, A.R.	2/2	4/11	9/6	2½ kg.	42/9
	,, perchlorate, A.R.	1/8	3/10	7/4	2½ kg.	33/-
	,, permanganate, A.R.	1/7	3/6	6/8	2½ kg.	30/-
	,, persulphate, A.R. 25 gm., 1/3	3/9	8/9	17/-		
	,, phosphate, monobasic, A.R.	1/8	3/9	7/2		
	,, sodium tartrate, A.R.	1/1	2/3	4/2	2½ kg.	18/9
	,, sulphate, A.R.	1/-	2/1	3/10	2½ kg.	17/3
	,, tetroxalate, A.R.	1/11	4/4	8/3	2½ kg.	37/2
	,, thiocyanate, A.R. 25 gm., 1/-	3/1	7/-	13/6		
	Pyridine, A.R. 25 gm., 2/-	6/4	15/-	29/2		
	Quinhydrone, A.R. 25 gm., 4/-	12/4	30/-	—		
	Resorcinol, A.R. 25 gm., 1/10	5/8	13/3	25/10		
	Salicylic acid, A.R.	1/5	3/-	5/9		
	Silver nitrate, A.R. 25 gm., 5/10	20/6	49/-	96/6		
	Sodium acetate, anhyd., A.R.	1/5	3/-	5/9	2½ kg.	26/-
	,, ,, hydrated, A.R.	1/-	2/1	3/10	2½ kg.	17/3
	,, ammonium phosphate, A.R.	1/1	2/3	4/2	2½ kg.	18/9
	,, bicarbonate, A.R.	—	-/9	1/4	2½ kg.	6/5
	,, bismuthate, A.R. 25 gm., 2/3	7/1	16/10	33/-		
	,, bisulphate, fused, A.R.	1/7	3/6	6/8	2½ kg.	30/-
	,, borate, A.R.	—	1/5	2/6	2½ kg.	11/3
	,, carbonate, anhyd., A.R.	—	1/8	3/-	2½ kg.	13/6
	,, ,, decahydrate, A.R.	—	1/-	1/8	2½ kg.	7/6
	,, chloride, A.R.	—	1/2	2/-	2½ kg.	9/-
	,, ,, fused, A.R.	1/8	3/8	7/-		
	,, citrate, A.R.	1/9	3/11	7/6	2½ kg.	33/9
S1	,, cobaltinitrite, A.R. 25 gm., 1/11	6/-	14/2	27/6		
P2	,, cyanide, A.R. 25 gm., 2/-	5/-	10/9	20/-		
	,, hydroxide, sticks, A.R.	—	3/3	6/3		
	,, nitrate, A.R.	—	2/5	4/6	2½ kg.	20/3
	,, nitrite, A.R.	1/1	2/4	4/4	2½ kg.	19/2
P2	,, nitroprusside, A.R. 25 gm., 2/3	7/1	16/10	33/-		
	,, oxalate, A.R.	2/6	5/8	11/-		
	,, peroxide, A.R.	1/9	3/11	7/5		
	,, phosphate, dibasic, anhyd., A.R.	1/4	2/10	5/3	2½ kg.	23/8
	,, ,, ,, hydrated, A.R.	-/10	1/8	3/-	2½ kg.	13/6
	,, ,, monobasic, A.R.	1/3	2/8	5/-	2½ kg.	22/6
	,, sulphate, anhyd., A.R.	-/9	1/6	2/9	2½ kg.	12/6
	,, ,, hydrated, A.R.	—	-/11	1/6	2½ kg.	6/9
	,, sulphide, A.R.	1/2	2/5	4/6	2½ kg.	20/3
	,, sulphite, hydrated, A.R.	—	1/2	2/-	2½ kg.	9/-
	,, thiosulphate, A.R.	—	1/3	2/3	2½ kg.	10/5
	,, tungstate, A.R. 25 gm., 1/9	5/5	12/8	24/9		
	Stannous chloride, A.R.	2/1	4/8	9/-	2½ kg.	40/6
	Succinic acid, A.R. 25 gm., 1/11	6/-	14/2	27/6		

A.R.

	100 *gm.*	250 *gm.*	500 *gm.*		
Sucrose, A.R.	1/1	2/1	3/9		
Sulphanilic acid, A.R. ... ... 25 *gm.*, -/11	2/9	6/3	12/-		
Sulphosalicylic acid, A.R. ... ... 25 *gm.*, 1/6	4/10	11/3	22/-		
Sulphuric acid, A.R.	—	—	1/1	4½ kg.	9/-
Tartaric acid, A.R.	1/8	3/8	7/-	2½ kg.	31/6
Tin, A.R.	2/3	5/3	10/2		
Toluene, A.R.	—	1/5	2/6	2 kg.	11/3
Trichloroacetic acid, A.R. ... ... 25 *gm.*, 2/6	7/9	18/6	36/3		
Uranium acetate, A.R. ... ... 25 *gm.*, 2/10	8/10	21/3	41/9		
,, nitrate, A.R. ... ... 25 *gm.*, 2/10	8/10	21/3	41/9		
Urea, A.R.	2/-	4/6	8/4		
Vanillin, A.R. ... ... 25 *gm.*, 4/-	12/4	—	—		
Xylene, A.R.	—	2/9	5/2	2 kg.	18/10
Zinc, A.R.	—	2/-	3/8	2½ kg.	17/8
,, carbonate, A.R.	—	2/9	5/-		
,, oxide, A.R.	—	1/5	2/6		
,, sulphate, A.R.	—	1/3	2/3	2½ kg.	10/5

TETRAHYDROXYQUINONE

A new indicator for determination of sulphates by titration

THQ is a dispersion of the disodium salt of tetrahydroxyquinone in a solid organic medium. The product is anhydrous and stability tests show that its sensitivity remains unimpaired over a considerable period.

The method is rapid and a complete determination may be made in two minutes. Only 0·2 gm. THQ is required per test. An accuracy within 1 to 2 per cent. of gravimetric may be obtained, quickly and simply in a single direct titration. The end point is sharp and readily discernible.

THQ has been applied to the estimation of sulphur and sulphate in rubber, soil, salt brines, oil, coal, etc., and the indicator can be used in the evaluation of sulphate in practically any system where sulphates are now determined gravimetrically.

PROCEDURE FOR THE DETERMINATION OF SO_4 BY THQ

METHOD FOR NATURAL AND BOILER WATERS AND SOLUTIONS SIMILARLY CONSTITUTED

Pipette a clear 25 c.c. sample into an Erlenmeyer flask of 125 or 250 c.c. capacity. Neutralise carefully to the acid side of phenolphthalein by 0·02N HCl or NaOH. The temperature of the sample must be below 35° C. and preferably between 20° and 25° C. Add 25 c.c. of ethyl alcohol or isopropyl alcohol or denatured alcohol. Introduce the THQ indicator in amounts specified in the table in leaflet (on application), using as a measure, the scoop dipper supplied. The solution is coloured yellow by the THQ. Titrate with standard $BaCl_2$ solution until the yellow colour changes to a rose-red.

If phosphates are known to be present, add 2-3 drops of 0·04 per cent. Bromcresol Green indicator and neutralise to the yellow range of this indicator. By the use of this procedure, 60 p.p.m. PO_4 can be tolerated. To increase PO_4 tolerance to 150 p.p.m. use 10 c.c. sample diluted to 25 c.c. Multiply SO_4 results by 2·5.

Fuller details on request.

† **THQ (Tetrahydroxyquinone)** in bottles with scoop dipper to measure out sufficient indicator for one titration.

Bottle	25	50	100 *gm.*
	† 20/-	35/-	67/6

CHEMICALS AND REAGENTS

			oz.	lb.	
	Acetaldehyde		–/9	8/6	
	Acetamide		2/1	24/6	
	Acetic Anhydride		–/4	3/2	w. qt. (5½ lb.) at 3/– lb.
	Acetone, pure redistilled		–/2	1/7	w. qt. (4 lb.) at 1/5 lb.
	Acetylene Tetrachloride, coml. solvent (*see Westron*)		—	—	
	Acid Acetic, 33%		—	–/10	w. qt. (5½ lb.) at 8d. lb.
	,, ,, glacial, 99/100 %		–/2	1/6	w. qt. (5½ lb.) at 1/4 lb ; 6 w. qts. at 1/2 lb.
	,, Aminoacetic (Glycocoll, Glycine)		3/4	40/–	
S1	,, Arsenic, pure		–/7	6/6	
S1	,, Arsenious (Arsenious Oxide), coml.		—	1/4	7 lb. at 1/3 lb.
S1	,, ,, pure powder		–/3	2/–	7 lb. at 1/10 lb.
	,, Benzoic, from toluene		–/6	5/6	7 lb. at 5/– lb.
	,, Boric (Boracic), powder or cryst.		—	1/1	7 lb. at 1/– lb.
P1	,, Carbazotic (*see Acid, Picric*)		—	—	
P1	,, Carbolic (Phenol), loose crystals		-/5	4/–	7 lb. at 3/6 lb.
P1	,, ,, crude liquid		--	—	gallon, 6/6
	,, Chromic, pure cryst.		–/10	9 6	
	,, ,, for batteries		–/4	3/9	7 lb. at 3/6 lb.
	,, Citric, pure cryst. or powder				*Less than 4 lb.*, 2/1 lb. 4–7 *lb.*, 2/– lb. 7–14 *lb.*, 1/11 lb.
P1	,, Cresylic (*see Cresol*)		—	—	
	,, Formic, sp. gr. 1·2		–/3	2/6	
	,, ,, sp. gr. 1·06		–/2	1/6	
	,, Hydriodic, dilute 10 %		–/8	7/6	
	,, ,, sp. gr. 1·5		1/9	21/–	
	,, Hydrobromic, pure, sp. gr. 1·375		–/6	6/–	
	,, ,, dilute 10 %		–/3	2/3	
P2	,, Hydrochloric, pure, sp. gr. 1·16		—	–/8	w. qt. (6 lb.) at 7d. lb. ; 12 w. qts. at 6d. lb.
P2	,, ,, coml., sp. gr. 1·16		—	–/6	w. qt. (6 lb.) at 5d. lb. 12 w. qts. at 4d. lb.
P2	,, Hydrofluoric, redistilled, 40 %		–/6	5/6	
P2	,, ,, coml., 50/60 %		–/2	1/8	7 lb. at 1/6 lb.

Gutta-percha bottles are not returnable but can be refilled ; prices include stoppers.

1 oz.	2 oz.	4 oz.	8 oz.	16 oz.	
2/9	3/3	5/6	6/6	9/–	*each.*

,,	Molybdic, pure	1/4	15/6	7 lb. at 15/– lb.	
P2	,, Nitric, pure, sp. gr. 1·42	—	–/10	w. qt. (8 lb.) at 9d. lb. 12 w. qts. at 8d. lb.	
P2	,, ,, coml., sp. gr. 1·42	—	–/8	w. qt. (8 lb.) at 7d. lb. ; 12 w. qts. at 6d. lb.	
P2	,, ,, fuming, sp. gr. 1·5	—	1/9	w. qt. (8 lb.) at 1/8 lb.	
,,	Oleic, pure	-/9	8/6		
,,	,, pale	–/3	2/2	w. qt. (4½ lb.) at 2/– lb.	
,,	Osmic, 1 % solution	13/–	—		
,,	,, cryst. in sealed tubes	0·1 gram. 8/10 0·5 ,, 20/5 1·0 ,, 49/6			
P1	,, Oxalic, anhydrous	–/5	4/6		
P1	,, ,, pure cryst.	–/6	5/6	7 lb. at 5/3 lb.	
P1	,, ,, coml.	–/2	1/10	7 lb. at 1/8 lb.	
,,	Palmitic, technical	–/3	2/3		
,,	Perchloric, 20%, sp. gr. 1·12	–/5	4/8		
,,	Phosphoric, *ortho*, sp. gr. 1·5	–/3	2/6	w. qt. (9 lb.) at 2/3 lb.	
,,	,, ,, ,, 1·75	–/3	2/9	w. qt. (10 lb.) at 2/7 lb.	
,,	,, *meta*, sticks	–/9	8/6		
,,	Phosphorous, solution, sp. gr. 1·12	–/6	5/–		
,,	,, cryst.	1/2	14/–		

		oz.	lb.	
	Acid Phthalic, pure	–/10	9/6	
P1	,, **Picric**, cryst. (damped with equal weight of water)	–/6	5/6	
	,, **Pyrogallic**, pure, resublimed	3/4	40/–	
	,, ,, ,, heavy crystals	2/11	35/–	
	,, **Salicylic**, synthetic	–/5	4/6	
	,, **Silicic**, precip. (*see Silica, precip.*)	—	—	
	,, **Stearic**, coml. (Stearine)	–/2	1/10	7 lb. at 1/7 lb.
	,, **Succinic**, pure cryst.	2/4	28/–	
	,, **Sulphanilic**, pure, white cryst.	–/9	8/6	
P2	,, **Sulphuric**, pure, sp. gr. 1·84	—	–/8	w. qt. (10 lb.) at 6d. lb. ; 12 w. qts. at 5d. lb.
P2	,, ,, coml.	—	–/5	w. qt. (10 lb.) at 3d. lb.
P2	,, ,, fuming, 20 % SO_3	–/2	1/6	w. qt. (10 lb.) at 1/3 lb.
P2	,, ,, for accumulators, sp. gr. 1·200 or 1·250	—	–/5	w. qt. (6 lb.) at 4d. lb.
P2	,, ,, for milk testing, ,, 1·820–1·825	—	–/6	w. qt. (10 lb.) at 4d. lb.
	,, **Sulphurous**, solution	—	–/6	w. qt. (5½ lb.) at 4d. lb.
	,, **Tannic**, coml.	–/7	6/3	
	,, **Tartaric**, cryst. or powder	–/5	4/8	7 lb. at 3/9 lb.
	,, **Vanadic** (Vanadium Pentoxide), anhydrous	2/10	33/6	
	Agar-Agar, powder, bacteriological 60–80 mesh	3/–	35/9	
	,, fibre	2/9	32/6	
	Albumen, Blood	–/10	10/–	
	Alcohol, Amyl, pure, 128°–132° C. (for milk testing)	–/4	3/2	w. qt. (4½ lb.) at 3/– lb.
	,, ,, coml. (Fusel Oil)	–/3	2/9	w. qt. (4½ lb.) at 2/7 lb.
	,, Ethyl, absolute (duty paid)	3/4	—	pint, 45/– ; w. qt. (4 pints) at 44/6 pint.
	,, ,, 96 % (duty paid)	3/2	—	pint, 42/6 ; w. qt. (4 pints) at 42/– pint.
	,, ,, 90 % (Rectified Spirit) (duty paid)	3/–	—	pint, 40/– ; w. qt. (4 pints) at 39/6 pint.
	,, ,, Methylated Spirit, mineralised	—	—	pint, 1/3 ; gallon, 8/6.
	,, Isopropyl, technical	–/3	3/–	w. qt. (4 lb.) at 2/9 lb.
	,, Methyl, acetone free (duty paid)	3/10	—	pint, 45/– ; w. qt. (4 pints) at 44/6 pint.
	,, ,, (Wood Spirit) purified 98%	–/2	1/7	w. qt. (4 lb.) at 1/4 lb.
	Alloy, Devarda's, powder	–/9	8/6	
	,, ,, lump	–/8	8/–	
	,, Lipowitz, m.pt., about 60° C.	1/2	14/–	
	,, Rose's, m.pt., about 100° C.	–/11	11/–	
	,, Wood's, m.pt., about 71° C.	1/–	11/6	
	Alum, coml. powder	—	–/6	7 lb. at 5d. lb.
	,, Ammonia (Ammonium aluminium sulphate), pure	—	–/11	7 lb. at 10d. lb.
	,, ,, coml.	—	–/7	14 lb. at 6d. lb.
	,, Chrome, pure (Chromium potassium sulphate),	–/2	2/1	7 lb. at 1/10 lb.
	,, ,, coml.	–/2	1/2	14 lb. at 1/– lb.
	,, Iron, pure (Ferric ammonium sulphate),	–/2	1/3	7 lb. at 2/6 lb.
	,, ,, coml.	–/3	2/9	14 lb. at 1/1 lb.
	,, Manganese (Manganese ammonium sulphate)	–/7	7/–	
	,, Potash, pure (Potassium aluminium sulphate),	–/2	1/3	7 lb. at 1/1 lb.
	,, ,, coml.	—	–/6	14 lb. at 5d. lb.
	,, Soda, pure cryst. (Sodium aluminium sulphate),	–/3	2/8	
	Aluminium Metal foil, 0·1 mm.	–/10	9/6	*Price variable.*
	,, ,, ,, 0·5 mm.	–/7	7/–	*Price variable.*
	,, ,, powder, fine (100 mesh to dust)	–/6	5/6	*Price variable.*
	,, ,, ,, coarse (8–30 mesh)	–/4	4/–	*Price variable.*
	,, ,, sheet, 1 mm.	–/5	5/–	*Price variable.*
	,, ,, turnings	–/4	4/–	*Price variable.*
	,, ,, wire, 1 mm.	–/6	5/–	*Price variable.*
	,, ,, ,, 2 mm.	–/5	4/8	*Price variable.*
	,, ,, ,, 5 mm.	–/5	4/6	*Price variable.*
	,, ,, in thin leaves			*book of 25 leaves*, 2/6
	,, Chloride, anhydrous	–/7	7/–	

		oz.	lb.	
	Aluminium Hydroxide, coml.	–/2	1/4	7 lb. at 1/2 lb.
	,, Oxide, pure anhydrous	–/4	4/–	
	,, ,, coml.	–/2	1/4	7 lb. at 1/2 lb.
	,, Phosphate	–/7	6/6	
	,, Sulphate, pure cryst.	–/4	3/3	7 lb. at 3/– lb.
	,, ,, coml.	—	–/8	14 lb. at 7d. lb.
	Amidol	1/9	20/6	
P2	**Ammonia**, solution, sp. gr. ·880	—	–/10	w. qt. (4½ lb.) at 7d. lb. ; 12 w. qts. at 8d. lb.
	Ammonium Acetate, pure cryst.	–/5	4/6	
	,, Bichromate, pure cryst.	–/5	4/9	7 lb. at 4/6 lb.
	,, Bisulphate	–/3	3/–	
	,, Bromide, cryst.	–/6	5/3	
	,, Carbonate, lump, coml.	—	1/0	7 lb. at 11d. lb.
	,, ,, powder, coml.	—	1/–	7 lb. at 11d. lb.
	,, Chloride cryst., for batteries	—	–/9	7 lb. at 8d. lb.
	,, ,, (Sal Ammoniac)	—	–/10	7 lb. at 9d. lb.
	,, ,, (Voltoids)	—	–/11	7 lb. at 10d. lb.
	,, Chromate, pure	–/8	7/6	
	,, Iodide, cryst.	2/1	25/–	*Price variable.*
	,, Molybdate, chem. pure	–/11	10/6	
	,, Nitrate, coml.	—	–/8	7 lb. at 7d. lb.
	,, Oxalate, pure, recryst.	–/6	5/2	7 lb. at 5/– lb.
	,, Perchlorate	–/6	5/3	
	,, Persulphate, pure	–/4	3/6	7 lb. at 3/3 lb.
	,, Phosphate, dibasic, pure	–/5	4/6	7 lb. at 4/3 lb.
	,, ,, coml.	–/2	1/9	7 lb. at 1/7 lb.
	,, Sodium Phosphate (Microcosmic Salt) ..	–/3	2/9	7 lb. at 2/6 lb.
	,, Sulphate, coml.	—	–/6	14 lb. at 5d.
	,, Sulphide, (Hydrosulphide) concentrated solution	—	1/–	w. qt. (5½ lb.) at 11d. lb.
	,, Sulphite, coml.	–/5	4/10	
	,, Thiocyanate (Sulphocyanide), pure cryst.	–/6	6/–	7 lb. at 5/9 lb.
	,, Vanadate	1/4	16/–	
	Amyl Acetate, technical (Pear Oil)	–/3	2/6	w. qt. (5 lb.) at 2/4 lb.
	Aniline, coml.	–/3	2/2	w. qt. (5 lb.) at 2/– lb.
	,, Hydrochloride, technical	–/3	2/6	
	,, Sulphate	–/7	7/–	
	Anthracene, pure	3/2	38/–	
	,, coml.	–/8	7/6	
	Anthraquinone, technical	–/9	8/6	
	Antimony Metal, powder	–/5	4/3	7 lb. at 3/9 lb.
S1	,, Potassium Tartrate (Tartar emetic) ..	–/9	8/6	
S1	,, Sulphide (tri-), black	–/3	2/9	7 lb. at 2/7 lb.
S1	,, ,, (penta-), orange	–/3	3/–	
	Arsenic Metal, lump	1/5	16/6	
S1	,, Sulphide (Orpiment)	–/4	4/–	
S1	,, ,, (Realgar)	—	—	*Price on application.*
	Asbestos, coml., fibre	–/8	7/6	
	,, platinized, 5 %	30/–	—	*Price variable.*
	,, Gooch crucible, ordinary quality, unwashed	1/1	12/6	
	,, ,, ,, Powminco	2/1	25/–	
	Barium Metal	—	—	*Price on application.*
S1	,, Carbonate, precip. coml.	—	–/9	7 lb. at 8d. lb.
S1	,, Chloride, pure cryst.	–/3	2/9	7 lb. at 2/6 lb.
S1	,, ,, coml.	—	1/1	7 lb. at 1/– lb.
S1	,, Nitrate, pure	–/3	3/–	7 lb. at 2/9 lb.
S1	,, ,, coml.	–/2	1/6	7 lb. at 1/5 lb.
S1	,, Oxide, anhydrous	–/7	7/–	
S1	,, Peroxide (85-90 %)	–/5	4/6	
	,, Platino-Cyanide for X-Ray screens	—	—	*Price on application.*
S1	,, Sulphate, pure (for X-Ray diagnosis) ..	–/3	2/6	7 lb. at 2/4 lb.
	,, Sulphide, pure	–/3	3/–	
	Benzaldehyde (from toluene), pure	–/11	11/–	

	oz.	lb.	
Benzene (Benzol), pure, for molecular weight determination	1/–	12/–	
,, ,, ,, free from thiophene ..	–/2	2/–	w. qt. (4 lb.) at 1/10 lb.
,, ,, ,, B.P. 80–82° (crystallizable)	—	1/–	w. qt. (4 lb.) at 11d. lb.; 1 gallon, 6/6.
,, ,, 90 %	—	–/8	w. qt. (4 lb.) at 7d. lb.
Benzoyl Chloride, technical	–/5	5/–	
Beryllium Carbonate .. .. .. 25 *gms.*, 5/3	—	—	
,, Nitrate .. .. .. 25 *gms.*, 3/9	—	—	
,, Oxide .. .. 25 *gms.*, 13/6	—	—	
,, Sulphate .. .. .. 25 *gms.*, 1/11	—	—	
Bismuth Metal, coml., lump	1/9	21/–	
,, Carbonate	1/6	17/6	
,, Chloride, (tri-.)	2/3	27/–	
,, Nitrate, cryst.	1/–	11/6	
,, Oxide (B.P.C.)	2/4	28/–	
,, Subnitrate	1/8	20/–	
Bleaching Powder	—	—	8 *oz. tin*, 10d. ; 1 *lb. tin*, 1/4.
Bone Ash, Assayers' (Calcium Phosphate)	—	–/8	14 lb. at 7d. lb.; 1 cwt., 55/–.
Borax, recryst.	—	–/11	7 lb. at 11d. lb.
,, refined, powder or cryst.	—	–/9	14 lb. at 8d. lb.
Bromine	–/9	8/6	original bottle (6½ lb.) at 8/– lb.
,, tubes, 2·2 c.c. .. .. *dozen* (*a*) 10/–	—	—	
Cadmium Metal, stick	1/8	20/-	
,, Borotungstate, sp. gr. 3·28 .. 25 *gms.*, 8/–	—	—	
,, Iodide	2/6	30/–	
,, Sulphate, pure	1/3	14/9	
Calcium Metal, turnings	4/10	57/6	
,, Carbide	—	1/2	*in* 1 *lb. free tins*
,, Carbonate, precipitated, light	—	–/7	7 lb. at 6d. lb.
,, ,, (Marble Chips)	—	–/4	7 lb. at 3½d. lb. ; 28 lb. at 3d. lb.
,, ,, (Iceland Spar) ordinary	–/8	7/6	
,, Chloride pure, anhydrous, granular	—	1/4	7 lb. at 1/2 lb.
,, ,, coml. ,, ,, ...	—	–/9	7 lb. at 8d. lb.
,, ,, cryst.	—	1/3	7 lb. at 1/2 lb.
,, ,, coml., lump	—	–/5	14 lb. at 4d. lb.
P1 ,, Fluoride, pure	–/4	4/–	
,, Hydroxide	—	–/6	7 lb. at 5d. lb.
,, Hypochlorite (*see Bleaching Powder*)	—	—	
,, Nitrate, pure	–/4	3/9	
,, Oxide, sulphur free	–/8	8/–	
,, ,, from marble, lump or powder ..	–/4	3/6	7 lb. at 3/4 lb.
,, ,, coml. (Quicklime)	—	–/6	7 lb. at 5d. lb.
,, Phosphate, precipitated	–/3	2/6	
,, ,, dibasic, pure	–/4	4/–	
,, ,, acid, pure	–/6	5/6	
,, Sulphate, pure precipitated	–/3	3/–	7 lb. at 2/10 lb.
,, ,, (Plaster of Paris)	—	–/5	7 lb. at 4d. lb.
,, Sulphide, pure	–/6	5/6	
,, ,, phosphorescent	1/10	22/–	
,, Tungstate, 96/98% Ca WO_4	1/10	21/6	
Camphor, blocks	1/11	22/6	
Canada Balsam (*see Mounting Media*)	—	—	
Candles, standard sperm	—	—	*each*, 1/8 ; *dozen*, 18/–.
Carbon Bisulphide, coml.	–/2	1/9	w. qt. (7 lb.) at 1/7 lb.
,, Tetrachloride, 99·95%	–/2	1/3	w. qt. (9 lb.) at 1/1 lb.
Carborundum, powder	—	—	*various grades*, 2/6–5/– *lb. tin.*
Casein, coml.	–/5	5/–	7 lb. at 4/9 lb.
,, soluble (edible)	–/5	5/–	
Celloidin, pure (*see Mounting Media*)	—	—	
Celluloid cuttings	–/5	4/6	
Cellulose Acetate	–/6	6/–	
Cerium Metal, technical	4/–	—	

		oz.	lb.	
	Cerium Oxide, technical	–/10	9/6	
	,, Sulphate, technical	–/8	8/–	
	Chalk, French, powder	—	–/8	7 lb. at 7d. lb.
	Charcoal, animal, coml., granular	—	1/2	7 lb. at 1/1 lb.
	,, ,, coml., powder	—	–/7	7 lb. at 6d. lb.
	,, wood, sticks, selected	—	–/8	7 lb. at 7d. lb.
	,, ,, powder	—	–/9	7 lb. at 8d. lb.
	Chatterton's Compound	—	5/6	4 oz. stick, 2/–.
	China Clay (*see Kaolin*)	—	—	
	Chloramine T	–/9	9/–	
	Chlorine Water	—	—	w. qt. (5½ lb.) at 11d. lb.
	,, Cubes, for generating (*see Cubes*)	—	—	
P1	Chloroform, pure, from acetone	–/5	4/2	w. qt. (8 lb.) at 3/10 lb.
	Chlorophyll, oil soluble	3/6	—	
	Chromium Metal 98 %	—	—	*Price on application.*
	,, Hydroxide	–/8	8/–	
	,, Nitrate	–/7	7/–	
	,, Oxide, green	–/5	5/–	
	,, Sulphate	–/7	6/9	
	Cobalt Metal, pellets	1/5	16/6	
	,, Chloride, cryst.	–/8	8/–	
	,, Nitrate, cryst.	–/8	8/–	
	,, Oxide, black, coml.	1/5	16/6	
	,, Sulphate	–/6	6/–	
	Collodion, methylated	–/5	4/6	w. qt. (4 lb.) at 4/2 lb.
	Copper Metal, filings	–/3	3/–	
	,, ,, foil electrolytic, 0·1 mm.	–/5	4/3	
	,, ,, granulated	–/3	3/–	
	,, ,, turnings	–/4	3/6	
	,, Acetate, neutral cryst.	–/6	6/–	
	,, Ammonium Chloride, pure	–/5	5/–	
	,, ,, Sulphate	–/5	5/–	
	,, Bromide (cupric)	1/11	23/–	
	,, ,, (cuprous)	1/11	23/–	
	,, Carbonate, pure	–/5	4/10	
	,, Chloride (cupric), pure cryst.	–/4	3/9	
	,, ,, ,, coml.	–/3	2/8	
	,, ,, (cuprous)	–/8	8/–	
	,, Chromate	–/10	10/–	
	,, Ferrocyanide, pure	–/11	10/6	
	,, Iodide	2/7	31/–	
	,, Nitrate, coml.	–/4	3/8	
	,, Oxide (cupric), pure, precip.	–/6	5/6	
	,, ,, ,, from wire	–/8	7/8	
	,, ,, ,, coml. (black)	–/3	2/2	7 lb. at 1/11 lb.
	,, ,, (cuprous), coml.	–/3	2/6	
	,, Sulphate, pure anhydrous	–/5	5/–	
	,, ,, recryst.	–/3	2/3	7 lb. at 2/1 lb.
	,, ,, coml., small cryst.	—	1/2	7 lb. at 1/– lb. ; cwt., 75/–.
	Cotton Wool (*see Wool*)	—	—	
	Cream of Tartar (*see Potassium Bitartrate*)	—	—	
P1	Cresol, pure	–/3	2/9	gallon, 18/6.
P1	,, coml.	–/2	1/7	gallon, 9/6.
P1	,, *ortho*, 98/100 %	–/7	7/–	
P1	,, *meta*, 98/100 %	–/10	9/6	
P1	,, *para*, 98/100 %	–/9	8/6	
	Cubes for generating Chlorine	–/3	2/9	
	,, ,, Oxygen	–/3	2/9	*To be used with dilute Hydrochloric Acid.*
	,, ,, Sulphur Dioxide	–/3	3/–	
	,, ,, Sulphuretted Hydrogen	–/4	3/9	
	Dextrine, white or yellow	—	–/11	14 lb. at 10d. lb.
	Dextrose, coml.	—	–/11	14 lb. at 10d. lb.
	Diamantine, (substitute)	1/6	17/6	

		oz.	lb.	
	Diastase (Malt)	2/1	25/–	
	Diethyl-aniline, coml.	–/7	7/–	
	Dimethyl-aniline, technical	–/11	10/6	
	Dimethyl-glyoxime (reagent for nickel)	3/7	42/6	
	Emery Powder, finest	—	1/–	7 lb. at **11d.** lb.
	,, ,, coarser grades	—	1/–	7 lb. at **11d.** lb.
	Ether, pure, sp. gr. ·720 (from duty free rectified spirit)	–/3	2/9	w. qt. (4 lb.) at **2/6** lb.
	,, Methylated, sp. gr. not above ·725	–/3	2/6	w. qt. (4 lb.) at **2/3** lb.
	,, ,, sp. gr. ·720 anhydrous (dried over Na)	–/6	5/3	w. qt. (4 lb.) at **4/9** lb.
	,, Petroleum, boiling range 40°–60° C.	—	2/7	w. qt. (3½ lb.) at **2/4** lb.
	,, ,, boiling range 60°–80° C.	—	2/7	w. qt. (3½ lb.) at **2/4** lb.
	Ethyl Acetate (Acetic Ether)	–/4	3/9	w. qt. (5 lb.) at **3/4** lb.
	,, Acetoacetate	–/9	8/4	
	,, Chloride .. .. 60 cc. sealed tubes, *each*, **5/3**	—	—	
	,, Iodide	2/11	35/–	
	,, Sulphate (Diethyl Sulphate)	1/1	12/6	
	Ethylene Glycol, tech.	–/5	4/6	w. qt. (6 lb.) at **4/3** lb.
	Faraday's Wax (*see Wax, Faraday's*)	—	—	
P2	**Fehling's Solution** (in two solutions)	–/6	6/–	
P2	**Formaldehyde** 40 %	—	–/10	w. qt. (5½ lb.) at **9d.** lb.
	Fuller's Earth, powder	—	–/7	7 lb. at **6d.** lb.
	Fusion Mixture	–/3	2/–	
	Gelatine, flake	–/9	9/–	
	,, powder coml	–/4	3/3	
P2	**Glass Writing Ink** (Rampart's)	5/–	—	*Glass bottle free.*
	,, Powder	—	–/6	14 lb. at **5d.** lb.
	,, Wool, lead free	–/10	9/3	
	Glucose (*see Dextrose*)	—	—	
	Glue, Hollis' 1 *oz. bottle*, **10d.**	—	—	
	,, Marine	–/2	1/6	
	Glycerol (Glycerine), sp. gr. 1·26, pure	–/2	1/6	w. qt. (7 lb.) at **1/4** lb.
	Glycin, photographic	3/3	—	
	Glycocoll, pure (*see Acid, Aminoacetic*)	—	—	
	Gold Chloride 1 *gram*, **6/10**	—	—	*Gold Metal and Salts at current Market Prices.*
	,, ,, solution 2 %	6/–	—	
	Grape Sugar (*see Dextrose*)	—	—	
	Guaiacol, pure crystal	2/2	25/6	
	Guanidine Nitrate	4/6	—	
	Gum Arabic, picked, ordinary	–/3	2/3	7 lb. at **2/–** lb.
	,, Benzoin	–/10	9/6	
	,, Sandarac	1/–	12/–	
	,, Shellac, best orange flake	–/6	5/6	
	,, ,, white	–/6	5/3	
	,, Tragacanth, flake	1/1	12/6	
	,, ,, powder	1/8	19/6	
	Gun Cotton (low temperature)	–/11	10/6	
	Gutta-percha, shredded	1/9	21/–	
	Hexane, from Petroleum	–/4	4/–	
	Hydrogen Peroxide, 10 volume	—	–/10	w. qt. (5 lb.) at **8d.** lb.
	,, ,, 20 volume	—	1/–	w. qt. (5 lb.) at **10d.** lb.
	,, ,, 90/100 volume	–/4	3/4	
	Hydroquinone, chem. pure	1/1	12/6	
	India Rubber (*see Rubber*)	—	—	
	Iodine, resublimed	1/8	19/6	
	,, Bromide, mono	3/9	—	
	,, Chloride, mono	5/–	—	
	,, ,, tri	3/9	45/–	
	Iodoform, pure cryst.	1/9	21/–	
	,, powder	2/7	31/–	
	Iridium Metal	—	—	*Price on application.*
	,, Chloride	—	—	*Price on application.*
	Iron Metal filings, fine	—	–/10	14 lb. at **8d.** lb.
	,, ,, ,, coarse	—	–/8	14 lb. at **6d.** lb.

		oz.	lb.	
	Iron Metal wire, pure, on 1 oz. reels	—	—	*each*, 8d. ; *dozen*, 7/-.
	,, ,, ,, for burning in Oxygen, 30 S.W.G.	-/3	3/-	
	,, Ammonium Chloride (ferric)	-/4	3/3	
	,, ,, Citrate (ferric), brown scales ..	-/6	5/9	
	,, ,, ,, ,, green scales ..	-/6	6/-	
P1	,, ,, Oxalate (ferric)	-/7	6/6	
	,, ,, Sulphate (ferric) (*see Alum, Iron*) ..	—	—	
	,, ,, ,, (ferrous), pure	-/2	1/6	
	,, Chloride (ferric), pure	-/2	1/3	7 lb. at 1/1 lb.
	,, ,, ,, coml.	—	-/7	14 lb. at 6d. lb.
	,, ,, (ferrous), pure	-/5	5/-	
	,, Oxide (ferric), pure	-/3	3/-	
	,, ,, ,, coml. red	—	-/10	14 lb. at 9d. lb.
	,, ,, magnetic, precipitated	—	—	*Price on application.*
	,, ,, ,, coml.	-/3	1/5	
	,, Sulphate (ferric), pure	-/3	2/2	
	,, ,, (ferrous), pure cryst.	—	-/7	7 lb. at 6d. lb.
	,, ,, ,, ,, gran.	—	-/8	7 lb. at 7d. lb.
	,, Sulphide, lump, fused	—	-/6	14 lb. at 5d. lb.
	,, ,, plates, fused	—	-/6	14 lb. at 5d. lb.
	,, ,, sticks	—	-/8	14 lb. at 7d. lb.
	Kaolin, coml.	—	-/5	7 lb. at 3d. lb.
	Kieselguhr, acid washed	-/2	1/9	14 lb. at 1/7 lb.
	Lactose, (Milk Sugar)	-/3	2/9	
	Lamp Black	-/2	1/6	
	Lead Metal, assayer's foil, chem. pure	-/2	1/8	7 lb. at 1/6 lb.
	,, ,, ,, grain	-/2	1/8	7 lb. at 1/6 lb.
	,, ,, ,, granulated	-/2	1/8	7 lb. at 1/6 lb.
	,, ,, sheet, 1 mm. thick	-/2	1/8	7 lb. at 1/6 lb.
	,, ,, powder, pure	-/2	2/-	
	,, ,, shot	-/3	2/9	7 lb. at 2/6 lb.
	,, ,, sticks, pure	-/3	3/-	
	,, ,, wire	—	3/-	
P1	,, Acetate, recryst.	-/3	2/2	7 lb. at 1/11 lb.
	,, Carbonate, pure precipitated	-/5	4/3	
	,, ,, coml.	-/2	1/6	7 lb. at 1/5 lb.
	,, Chloride, pure	-/4	4/-	
	,, Chromate, pure precipitated	-/6	5/3	
	,, ,, fused, powder, pure	-/6	5/9	
	,, Nitrate, recryst.	-/5	4/3	7 lb. at 4/1 lb.
	,, ,, coml.	-/2	1/6	7 lb. at 1/4 lb.
	,, Oxide (litharge), assayer's, silver free, flake or powder	—	1/5	7 lb. at 1/4 lb.
	,, ,, (minimum, red lead)	—	1/6	7 lb. at 1/5 lb.
	,, Peroxide, pure	-/7	6/9	
	,, ,, coml.	-/2	1/6	7 lb. at 1/4 lb.
	,, Sulphate, pure precipitated	-/3	2/6	
	Ligroin, sp. gr. ·71/·72	-/2	1/10	w. qt. (4 lb.) at 1/8 lb.
	Lime Water	—	-/6	w. qt. (5½ lb.) at 5d.
	Litharge (*see Lead Oxide*)	—	—	
	Lithium Metal, 93/95 %	35/-	—	
	,, Carbonate	1/3	14/2	
	,, Chloride, cryst.	1/7	19/6	
	,, Citrate cryst.	1/3	14/6	
	,, Nitrate	2/1	25/-	
	Litmus, granular, finest	2/6	30/0	
	,, solution 1	-/9	8/6	
P2	**Lycopodium**, powder	2/1	25/-	
	Lysol	—	2/6	gallon, 10/6.
	Magnesium Metal, powder, finest	-/9	8/6	
	,, ,, ribbon, in ¼, ½, 1 oz. coils	1/6	18/-	
	,, ,, wire, in 1 oz. coils	2/4	27/3	
	,, Bromide	1/-	11/6	

		oz.	lb	
	Magnesium Carbonate, heavy	–/3	2/3	7 lb. at 2/– lb.
	,, ,, light	–/2	1/10	7 lb. at 1/8 lb.
	,, ,, in 4-oz. blocks	—	2/6	*each*, 8d.
	,, Chloride, pure cryst.	–/3	2/6	7 lb. at 2/4 lb.
	,, ,, fused	–/5	4/6	7 lb. at 4/3 lb.
	,, Nitrate	–/4	3/9	
	,, Oxide, calcined, light	–/6	5/6	
	,, ,, ,, heavy	–/7	6/9	
	,, ,, ,, free from sulphur	1/6	17/4	
	,, Peroxide 15% MgO_2	1/–	11/4	
	,, Phosphate, dibasic, pure	–/6	6/–	
	,, Sulphate, recryst.	—	1/2	7 lb. at 1/– lb.
	,, ,, anhydrous	–/2	1/3	14 lb. at 1/1 lb.
	,, ,, cryst. (Epsom Salts)	—	–/7	14 lb. at 6d. lb.
	Manganese Metal, coml.	–/5	4/6	
	,, Chloride, coml.	–/2	2/–	7 lb. at 1/10 lb.
	,, Nitrate, pure	–/7	6/6	
	,, Oxalate	–/8	8/–	
	,, Oxide, MnO_2, pure precipitated	–/7	6/10	
	,, ,, ,, coml. powder	—	–/9	14 lb. at 8d. lb.
	,, ,, ,, ,, granular	—	–/8	14 lb. at 7d. lb.
	,, ,, Mn_3O_4, pure	–/10	9/4	
	,, Sulphate, pure cryst.	–/5	5/–	7 lb. at 4/10 lb.
	,, ,, powder	–/2	1/4	7 lb. at 1/2 lb.
	Marble Chips (*see Calcium Carbonate*)	—	—	
	Mercury Metal	1/4	14/–	
	,, ,, redistilled	1/7	16/–	
SI	,, Acetate (ic)	3/–	34/8	
SI	,, ,, (ous)	3/2	37/10	
PI	,, Ammonium Chloride, powder	1/7	18/2	
SI	,, Chloride (ic) (Corrosive Sublimate) powder	1/4	15/7	
	,, ,, (ous) (Calomel)	1/7	18/4	
SI	,, Nitrate (ic)	2/1	25/–	
SI	,, ,, (ous)	2/3	26/9	
PI	,, Oxide (ic) yellow	1/8	19/7	
PI	,, ,, ,, red	1/8	19/10	
PI	,, ,, (ous), black	2/9	32/8	
	,, Sulphate (ic)	2/6	29/5	
	,, Sulphate (ous)	2/11	34/11	
	Methyl Ethyl Ketone, purified	–/11	10/6	
	,, ,, ,, technical	–/4	3/2	w. qt. (4½ lb.) at 2/11 lb.
	,, Orange, purest, sensitive	2/6	30/–	
	Methylated Spirit (*see Alcohol*)	—	—	
	Methylene Chloride	–/5	4/3	
	,, Iodide	8/–	—	
	Metol	2/4	27/6	
	Mica, in sheets 6 in. square	*each*, 5/–	—	
	Microcosmic Salt (Sodium Ammonium Phosphate)	–/3	2/9	7 lb. at 2/6 lb.
	Molybdenum Metal, powder 99·5 %	—	—	*Price on application.*
	Naphtha, purified and dried, for Potassium and Sodium	—	1/4	
	Naphtha, Coal, solvent	—	1/6	gallon, 9/–.
	,, Wood (*see Alcohol, Methyl*)	—	—	
	Naphthalene, for molecular weight determination	1/11	22/6	
	,, pure	–/3	2/6	
	,, flake, technical	—	1/3	7 lb. at 1/1 lb.
	,, marbles, technical	—	1/7	7 lb. at 1/6 lb.
	Nickel Metal, pellets	–/5	4/6	
	,, ,, powder	–/10	10/–	
	,, ,, sheet, 0·2, or 0·5 mm.	–/8	8/–	
	,, ,, wire, 0·5 or 1 mm.	1/7	18/6	
	,, Ammonium Sulphate, pure	–/3	3/–	7 lb. at 2/9 lb.
	,, ,, ,, coml.	–/2	1/4	7 lb. at 1/2 lb.

	oz.	lb.	
Nickel Chloride, pure cryst.	–/5	4/6	
,, Nitrate, cryst.	–/5	4/6	
,, Oxide, black, Ni_2O_3	–/5	5/–	
,, ,, green, NiO	–/5	4/6	
,, Sulphate, cryst., technical	–/2	1/8	7 lb. at 1/6 lb.
P2 **Nitrobenzene** (Oil of Mirbane)	–/2	1/8	w. qt. (6 lb.) at 1/6 lb.
Oil, Almond, sweet	1/6	17/6	
,, Cassia	–/9	8/9	
,, Castor, finest	–/2	1/6	
,, Cedarwood, ordinary	–/8	8/–	w. qt. (6 lb.) at 7/9 lb.
,, Cloves, finest	2/–	24/–	w. qt. (6 lb.) at 23/– lb.
,, Coconut	–/2	1/4	7 lb. at 1/2 lb.
,, Colza	–/2	2/–	w. qt. (5 lb.) at 1/10 lb.
,, Cottonseed	–/3	2/–	w. qt. (5 lb.) at 1/9 lb.
,, Eucalyptus	1/2	14/–	
,, Lavender, spike	2/11	35/–	
,, Linseed, raw or boiled	—	1/5	w. qt. (5 lb.) at 1/3 lb.
,, Mineral, for Oil Baths, b.p. above 250° C.	—	—	*pint*, 1/6 ; *gallon*, 8/6
,, Sperm	—	6/–	
,, Turkey Red	—	1/11	w. qt. (5 lb.) at 1/9 lb.
,, Wintergreen, natural	2/4	27/6	
Oxygen Mixture ($KClO_3 + MnO_2$)	–/4	3/6	
,, ,, for Thompson's Calorimeter	–/4	3/6	
Palladium, foil or wire	—	—	} *Palladium and Salts at current*
,, Chloride, dry	—	—	} *Market Prices.*
Paraffin, Liquid B.P., sp. gr. ·885/90	—	—	*Price on application.*
,, **soft white** (Petroleum Jelly)	–/2	1/10	7 lb. at 1/7 lb.
,, **soft yellow** (Petroleum Jelly)	–/2	1/4	7 lb. at 1/2 lb.
,, **wax**, refined white, in 1 lb. blocks—			
melting point 44/46° C. (110/115° F.)	—	1/3	
,, ,, 48/49° C. (118/120° F.)	—	1/3	
,, ,, 50/52° C. (122/125° F.)	—	1/4	
,, ,, 54/57° C. (130/135° F.)	—	1/4	
,, ,, 60/63° C. (140/145° F.)	—	1/4	
,, ,, 65/71° C. (150/160° F.)	—	2/9	
Pentane, Standard, for photometry	–/8	7/6	w. qt. (3 lb.) at 7/3 lb.
Pepsin, scales, or powder	2/8	32/–	
Peptone, dry	1/4	15/6	
Perchlorethylene (Tetrachlorethylene)	—	1/7	w. qt. (9 lb.) at 1/5 lb.
Perhydrol (*see Hydrogen Peroxide*)	—	—	
Petroleum Ether (*see Ether, Petroleum*)	—	—	
Phenol (*see Acid, Carbolic*)	—	—	
Phenolphthalein, purest white	–/11	10/3	
Phenylenediamine, *meta*, technical	1/3	15/–	
,, Hydrochloride, *meta*	3/–	—	
,, *para*, technical	1/3	15/–	
,, Hydrochloride, *para*, technical	1/3	15/–	
P1 **Phosphorus**, stick	–/9	8/6	
,, amorphous	–/8	8/–	
,, Chloride, oxy	–/8	7/6	
,, ,, penta	–/10	10/–	
,, ,, tri	–/10	9/6	
,, Oxide, penta (Phosphoric Anhydride)	–/8	8/–	
Pitch, Burgundy	–/2	1/6	
Plaster of Paris (*see Calcium Sulphate*)	—	—	
Plasticine	—	2/–	*in 1 lb. cartons.*
Platinum Tetrachloride, cryst. *gram.* 7/6	—	—	
,, ,, solution 10 %	23/–	—	} *Platinum Metal and Salts at current*
,, ,, ,, 5 %	12/6	—	} *Market Prices.*
S1 **Potassium** Metal	9/–	—	
,, Antimonate, pyro, pure	1/3	14/6	

POT			oz.	lb.	
	Potassium	Bicarbonate, pure	–/3	2/3	7 lb. at 2/1 lb.
	,,	Bichromate, pure cryst.	–/4	3/9	7 lb. at 3/7 lb.
	,,	,, coml.	–/2	1/6	7 lb. at 1/3 lb.
P1	,,	Bifluoride (*see Potassium Fluoride, acid*)	—	—	
P2	,,	Binoxalate (*see Potassium Oxalate, acid*)	—	—	
	,,	Bisulphate, pure cryst.	–/4	3/2	7 lb. at 3/– lb.
	,,	,, fused	–/4	3/6	7 lb. at 3/4 lb.
	,,	Bitartrate (Cream of Tartar)	–/5	4/3	
	,,	Bromide, pure cryst.	–/6	5/3	7 lb. at 4/10 lb.
	,,	Carbonate, pure anhydrous	–/2	1/9	7 lb. at 1/7 lb.
	,,	,, pure cryst.	–/3	2/6	7 lb. at 2/4 lb.
	,,	,, coml.	—	1/6	7 lb. at 1/5 lb.
	,,	Chlorate, pure recryst.	–/6	5/6	7 lb. at 5/4 lb.
	,,	,, coml.	–/3	2/4	
	,,	Chloride, pure	–/3	2/2	7 lb. at 2/– lb.
	,,	,, coml.	—	–/9	7 lb. at 8d. lb.
	,,	Chromate, pure, neutral	–/6	6/–	7 lb. at 5/9 lb.
S1	,,	Cyanide, 90/95 %, single salt	–/8	8/–	7 lb. at 7/10 lb.
S1	,,	,, fused, 98/100 %, double salt	–/3	3/2	14 lb. at 3/– lb.
	,,	Ferricyanide, recryst.	1/–	12/–	
	,,	,, coml. (Red Prussiate of Potash)	–/9	9/–	7 lb. at 8/10 lb.
	,,	Ferrocyanide, recryst.	–/6	5/3	
	,,	,, coml. (Yellow Prussiate of Potash)	–/2	4/3	7 lb. at 4/– lb.
P2	,,	Fluoride, white	–/9	8/6	
P1	,,	,, acid	–/10	9/6	
	,,	Hydrogen Phthalate (*see Potassium Phthalate, acid*)	—	—	
P2	,,	Hydroxide (Caustic Potash), pure sticks	—	6/–	
P2	,,	,, ,, ,, pure pellets	—	5/3	
P2	,,	Hydroxide, coml., gran.	—	2/8	14 lb. at 2/1 lb.
P2	,,	,, ,, lump	—	2/9	14 lb. at 2/6 lb.
	,,	Hyposulphite (*see Potassium Thiosulphate*)	—	—	
	,,	Iodate	2/–	24/–	
	,,	Iodide, pure	1/3	14/6	7 lb. at 13/9 lb.
	,,	Metabisulphite, pure, cryst.	–/4	3/3	7 lb. at 3/– lb.
	,,	Nitrate, recryst.	–/3	2/1	7 lb. at 2/– lb.
	,,	,, coml.	—	1/4	14 lb. at 1/2 lb.
	,,	Nitrite, pure cryst.	2/4	27/6	
	,,	,, sticks	2/7	31/–	
P2	,,	Oxalate, neutral, recryst.	–/8	7/9	
P2	,,	,, acid, pure	–/6	6/–	
P2	,,	,, tetra	–/6	6/–	
	,,	Perchlorate, recryst	–/8	7/6	
	,,	Permanganate, cryst.	–/4	3/9	7 lb. at 1/4 lb.
	,,	Persulphate	–/8	7/4	
	,,	Phosphate, monobasic, pure	–/8	8/–	
	,,	,, dibasic, pure	–/7	6/6	
	,,	,, ,, coml.	–/4	4/–	
	,,	,, tribasic	–/9	8/–	
	,,	Phthalate, acid	1/6	18/6	
	,,	Platinochloride	—	—	*Price on application.*
	,,	Platinocyanide	—	—	*Price on application.*
	,,	Silicate, pure, dry	–/11	10/3	
	,,	,, solution, coml.	—	1/3	w. qt. (7 lb.) at 1/– lb.
	,,	Sodium Carbonate (*see Fusion Mixture*)	—	—	
	,,	Sodium Tartrate (Rochelle Salt), cryst.	–/4	4/–	7 lb. at 3/10 lb.
	,,	Sulphate, pure cryst.	–/3	2/3	7 lb. at 2/1 lb.
	,,	,, powder	—	2/–	7 lb. at 1/10 lb.
	,,	Tartrate, acid (*see Potassium Bitartrate*)	—	—	
	,,	,, neutral	–/9	8/6	

	oz.	lb.	
Potassium Tetroxalate (*see Potassium Oxalate, tetra*)	—	—	
,, Thiocyanate (Sulphocyanide), pure ..	-/8	8/-	
,, Thiosulphate (Hyposulphite)	1/5	16/6	
Pumice, lump	—	-/10	7 lb. at 8d. lb.
,, powder	—	-/6	7 lb. at 4d. lb.
Pyrogallol (*see Acid, Pyrogallic*)	—	—	
Pyroxylin (*see Gun Cotton*)	—	—	
Quinine, pure	7/-	—	
,, Hydrochloride	5/-	—	
,, Sulphate, pure	7/-	—	
Resin, lump, pale	—	1/4	7 lb. at 1/3 lb.
,, powder, finest	—	1/6	7 lb. at 1/4 lb.
Rochelle Salt (*see Potass. Sod. Tartrate*)	—	—	
Rouge, jewellers', finest	-/7	6/9	
Rubber Solution	—	5/3	1 *lb. tins free.*
Sal Ammoniac (*see Ammon. Chloride*)	—	—	
Sand, Silver	—	-/3	28 lb. at 2d. lb.
,, ,, washed with acid	—	1/6	7 lb. at 1/3 lb.
,, Standard for cement testing	—	-/6	cwt., 26/-.
Saponin, white	2/3	23/6	
,, crude	1/4	15/6	
Selenium, sticks	2/9	—	
,, Chloride, oxy-	3/9	—	
Shellac (*see Gum Shellac*)	—	—	
,, Varnish (*see Varnish, Shellac*)	—	—	
Silica, pure precipitated	-/6	6/-	
,, coml., white	—	1/-	14 lb. at 10d. lb.
,, Gel, "Sorbsil" brand, for air drying	-/5	4/11	
Silicon, cryst.	19/6	—	
,, lump	-/6	6/-	
,, Tetrachloride, technical	-/9	8/6	
Silver Metal foil, pure, for assaying	15/6	—	
,, ,, leaf .. .. *book*, 3/4	—	—	
,, ,, wire, pure, for assaying, 26 S.W.G. ..	10/-	—	
,, Chloride	8/9	—	
S1 ,, Cyanide	7/-	—	
,, Nitrate, pure cryst.	6/6	—	
,, ,, solution 1 %	-/4	4/-	
,, ,, ,, 10 %	1/-	12/-	
,, Oxide	8/6	—	
,, Sulphate	4/9	—	
Soda Ash (*see Sodium Carbonate, assaying*)	—	—	
,, **Lime**, coarse, medium or fine	-/2	1/3	7 lb. at 1/1 lb.
Sodium Metal, dry	—	5/-	8 oz., 3/6.
,, ,, in naphtha	-/6	6/-	
,, Acetate, pure fused	-/5	5/-	
,, ,, pure cryst.	-/2	1/6	7 lb. at 1/4 lb.
,, Amalgam, 5 %	2/1	25/-	
,, Ammonium Phosphate (Microcosmic Salt) ..	-/3	2/9	7 lb. at 2/6 lb.
,, Biborate (*see Borax*)	—	—	
,, Bicarbonate, powder	—	-/4	28 lb. at 3d. lb.
,, Bichromate, pure	-/3	3/-	7 lb. at 2/10 lb.
P1 ,, ,, coml.	-/2	1/1	7 lb. at 11d. lb.
,, Bifluoride (*see Sodium Fluoride, acid*)	—	—	
,, Bisulphate, pure fused	-/5	4/6	7 lb. at 4/3 lb.
,, ,, pure cryst.	-/3	2/6	7 lb. at 2/4 lb.
,, Bisulphite, (*see Sodium Metabisulphite*)	—	—	
,, Borate, neutral	-/3	2/8	7 lb. at 2/4 lb.
,, Bromide, dry	-/6	5/2	7 lb. at 4/8 lb.
,, Carbonate, pure pea cryst.	—	-/5	14 lb. at 4d. lb.
,, ,, cryst. coml.	—	-/1½	cwt., 8/3
,, ,, dried, for assaying (Soda Ash) ..	—	-/5	14 lb. at 4d. lb. ; cwt., 18/6.
,, ,, pure anhydrous	—	1/-	7 lb. at 10d. lb.

		oz.	lb.	
	Sodium Chlorate, pure cryst.	–/3	3/–	7 lb. at **2/10** lb.
	,, ,, comL	—	1/3	7 lb. at **1/2** lb.
	,, Chloride, pure fused	–/6	5/3	
	,, ,, recryst.	—	–/6	14 lb. at **5d.** lb.
	,, Chromate	–/4	3/2	
	,, Citrate	–/5	5/3	
	,, Cobaltinitrite, powder	2/2	25/6	
	,, Dichromate (*see Sodium Bichromate*)	—	—	
	,, Dithionate (*see Sodium Hyposulphate*)	—	—	
P2	,, Fluoride, chem. pure	–/6	5/9	
P2	,, ,, white	–/3	2/1	7 lb. at **1/11** lb.
P1	,, ,, acid	–/5	4/2	
	,, Hydrosulphite ($Na_2S_2O_4$)	–/3	2/5	7 lb. at **2/2** lb.
P2	,, Hydroxide (Caustic Soda), from sodium ..	—	8/6	
P2	,, ,, sticks, pure	–/5	4/10	7 lb. at **4/8** lb.
P2	,, ,, pellets	—	5/6	7 lb. at **5/3** lb.
P2	,, ,, coml., lump	—	–/10	14 lb. at **9d.** lb.
P2	,, ,, ,, powder, ...	—	–/9	14 lb. at **8d.** lb.
	,, Hypochlorite, solution (10% available Cl.)	—	–/9	w. qt. (5 lb.) at **7d.** lb.
	,, Hyposulphite (*see Sodium Thiosulphate*)	—	—	
	,, Iodate	2/4	28/–	
	,, Iodide	1/5	16/6	
	,, Metabisulphite, powder	—	–/9	7 lb. at **8d.** lb.
	,, Nitrate, pure	-/2	1/6	7 lb. at **1/4** lb.
	,, ,, coml.	—	–/9	14 lb. at **8d.** lb.
	,, Nitrite, coml.	—	1/–	14 lb. at **11d.** lb.
	,, ,, sticks	–/8	7/6	
	,, Nitroprusside, cryst.	2/–	24/–	
	,, Oleate	–/7	7/–	
	,, Perborate	–/4	3/3	7 lb. at **3/1** lb.
	,, Perchlorate, pure	–/5	4/2	
	,, Peroxide	—	4/–	8 oz. tins at **2/3** *each*.
	,, Persulphate	–/9	9/–	
	,, Phosphate, dibasic, pure cryst.	–/2	1/3	7 lb. at **1/1** lb.
	,, ,, *meta*	–/3	2/10	
	,, ,, monobasic	–/3	3/–	
	,, ,, tribasic, pure	–/3	2/6	7 lb. at **2/4** lb.
	,, Potassium Tartrate (Rochelle Salt), cryst. ..	–/4	4/–	7 lb. at **3/10** lb.
	,, Salicylate, pure	–/5	4/9	
	,, Silicate, coml., powder	—	–/9	14 lb. at **8d.** lb.
	,, ,, solution (Water Glass) 140° T ..	—	1/–	2 lb., **1/8** ; 4 lb., **2/6**, *tins free*.
	,, Sulphate, pure anhydrous	–/2	1/2	7 lb. at **1/–** lb.
	,, ,, cryst. (Glauber Salts)	—	–/4	14 lb. at **3d.** lb.
	,, Sulphide, pure cryst.	–/3	2/8	7 lb. at **2/4** lb.
	,, ,, coml.	—	–/8	14 lb. at **7d.** lb.
	,, Sulphite, exsiccated	—	1/–	7 lb. at **10d.** lb.
	,, ,, recryst.	—	–/8	14 lb. at **7d.** lb.
	,, Thiosulphate, anhydrous	—	1/–	7 lb. at **10d.** lb.
	,, ,, ,, pure cryst.	—	1/–	7 lb. at **10d.** lb.
	,, ,, "Hypo"	—	–/6	14 lb. at **5d.** ; cwt., **32/6**
	,, Tungstate, pure	–/10	10/–	*Price variable*
Sorbail (*see Silica Gel*)		—	—	
Spirit, Methylated (*see Alcohol*)		—	—	

	oz.	lb.	
Starch Maize	—	–/6	
,, Potato	—	–/7	
,, Soluble (Lintner's)	–/4	3/3	7 lb. at 3/– lb.
,, Wheat	—	–/10	
Strontium Bromide, cryst.	–/9	8/6	
,, Carbonate, pure precip.	–/7	6/6	
,, Chloride, pure cryst.	–/5	4/9	
,, Hydroxide, pure cryst.	–/8	7/6	
,, Nitrate, pure cryst.	–/6	5/3	
,, ,, coml., powder	–/3	2/6	7 lb. at 2/4 lb.
,, Oxide, pure	1/–	11/6	
,, Sulphate, pure precipitated	–/8	7/8	
,, ,, precipitated	–/7	7/–	
Sulphur, pure cryst.	1/2	14/–	
,, precipitated	–/3	2/2	
,, roll	—	–/7	14 lb. at 6d. lb.
,, sublimed, flowers	—	–/9	14 lb. at 8d. lb.
,, Chloride (S_2Cl_2)	–/3	2/9	
,, Dichloride (SCl_2)	–/7	6/6	
,, Dioxide, cubes for generating (*see Cubes*)	—	—	
,, ,, in syphons	—	3/6	Syphons (about 3½ lb. SO_2), 21/– each extra ; 17/6 allowed on return.
Sulphur Iodide	2/–	23/6	
Sulphuric Anhydride .. .. .. *specimen*, 4/6	—	—	
Sulphuryl Chloride, redistilled	1/3	15/–	
,, ,, coml.	–/8	8/–	
Talc (*see Chalk, French*)	—	—	
Tallow	–/2	1/10	
Tapers, thin, medium or thick	—	2/3	*in 1 lb. packets.*
Tellurium Metal, sticks	4/10	—	
,, Tetrachloride, in sealed tubes 10 *grams*, 22/6	—	—	
Terebene, pure	–/7	6/6	w. qt. (5 lb.) at 6/3 lb.
Tetrachlorethane (*see Westron*)	—	—	
Tetrachlorethylene (*see Perchlorethylene*)	—	—	
Tetralin (Tetrahydronaphthalene) technical	—	2/3	w. qt. (5 lb.) at 2/1 lb.
Thallium Metal	9/–	—	
Sl ,, Acetate	8/6	—	
Sl ,, Carbonate	7/9	—	
Sl ,, Chloride	10/6	—	
Sl ,, Nitrate	6/9	—	
Sl ,, Sulphate	7/2	—	
Thermit	–/4	3/2	
Thorium Nitrate	3/9	45/–	
Tincture Benzoin (Friars' Balsam)	–/9	8/4	
,, Iodine, mitis	–/7	5/9	
Tin Metal, granulated	–/7	6/4	
,, ,, foil, pure, 99·5%	–/10	7/3	
,, ,, foil, 50% composition	–/4	3/2	
,, ,, fine powder	–/7	6/3	
,, ,, sticks, pure	–/10	9/6	
,, Chloride (stannic), hydrate cryst.	–/10	10/–	
,, ,, (stannous), coml.	–/7	6/9	

	oz.	lb.	
Tin Oxide (stannic), putty powder	–/6	6/3	
,, ,, (stannous)	1/1	12/6	
,, Sulphate (stannic)	1/–	12/–	
,, ,, (stannous)	–/11	10/6	
,, Sulphide (stannous)	1/7	18/6	
Titanium Metal, pure powder	11/–	—	
,, Chloride (ic), 15% solution	–/5	4/9	
,, Oxide, technical	–/4	3/6	7 lb. at 3/4 lb.
Toluene (**Toluol**), pure	–/2	1/10	w. qt. (4½ lb.) at 1/8 lb.
,, ,, coml.	—	1/7	w. qt. (4½ lb.) at 1/5 lb.
Toluidine, *ortho*, coml.	–/3	2/6	
,, *para*, coml.	–/5	4/5	
Trichlorethylene (*see Westrosol*)	—	—	
Tripoli (for Photography), finest	–/3	2/1	7 lb. at 1/11 lb.
Tungsten Metal, powder 99·5%	1/7	18/6	
Turmeric, powder	–/2	2/–	
Turpentine, genuine .. *pint*, 2/– ; *gallon*, 14/–	—	—	
,, dehydrated .. *pint*, 1/11 ; *gallon*, 13/6	—	—	
,, Venice	–/2	2/–	
Uranium Acetate	2/11	35/–	
,, Chloride	2/6	—	
,, Nitrate	2/11	35/–	
,, Oxide, black	2/11	35/–	
,, ,, orange	2/9	32/6	
Vanadium Metal 92–94%	4/6	—	
,, Chloride (VCl_2) Solution, 50%	2/10	—	
Varnish, Celluloid	–/3	3/–	
,, Copal	–/5	4/3	
,, Label (Bakelite)	–/8	8/–	
,, Shellac	–/3	2/3	
Vaseline, yellow	—	*tx* 2/4	¼ lb., 11d. ; ½ lb., 1/7.
,, white	—	*tx* 3/6	¼ lb., 1/2 ; ½ lb., 2/1.
Water, Distilled .. .. *gallon*, 2/6	—	—	carboy, 10 gallons, 15/–.
Wax, Bees', white	–/6	5/9	7 lb. at 5/7 lb.
,, ,, genuine, refined	–/7	6/3	7 lb. at 6/– lb.
,, Bottling (all colours)	—	1/8	
,, Faraday's	–/7	7/–	
Westron (Tetrachlorethane)	–/2	1/4	w. qt. (9 lb.) at 1/1 lb.
Westrosol (Trichlorethylene)	–/2	1/3	w. qt. (9 lb.) at 1/– lb.
Wool, Asbestos (*see Asbestos*)	—	—	
,, Cotton, best absorbent	—	2/6	*in* 1 *lb. rolls.*
,, ,, best non-absorbent, white, for bacteriological purposes	—	3/6	*in* 1 *lb. rolls.*
,, ,, best non-absorbent, coloured, for bacteriological purposes	—	4/3	*in* 1 *lb. rolls.*
,, ,, coml., packing	—	1/4	*in* 1 *lb. rolls.*
,, Glass (*see Glass*)	—	—	
Xylene (**Xylol**), pure	–/2	1/6	w. qt. (4½ lb.) at 1/3 lb.
,, ,, coml.	—	1/4	w. qt. (4½ lb.) at 1/1 lb.
Zinc Metal, granulated, coml.	—	1/6	7 lb. at 1/4 lb.
,, ,, sticks, coml.	–/2	2/–	7 lb. at 1/10 lb.
,, ,, dust 98–99%	–/2	1/6	7 lb. at 1/4 lb.
,, ,, foil, pure, roll 6 in. × 0·012 in.	–/4	3/3	

	oz.	lb.	
Zinc powder, pure	–/2	1/10	7 lb. at 1/7 lb.
,, Ammonium Chloride (33% $ZnCl_2$)	–/3	2/3	7 lb. at 2/- lb.
,, ,, Sulphate	-/4	3/8	
,, Carbonate, pure precipitated	-/4	3/-	
,, Chloride, pure fused	–/3	2/4	
,, ,, coml. powder	–/2	1/4	7 lb. at 1/2 lb.
,, Iodide	2/6	30/-	
,, Nitrate, pure cryst.	–/4	4/-	
,, Oxide, coml.	–/2	1/6	7 lb. at 1/4 lb.
,, Sulphate, pure dry	–/2	1/8	7 lb. at 1/4 lb.
,, ,, pure cryst.	—	–/11	7 lb. at 9d. lb.
,, ,, coml. cryst.	—	–/8	7 lb. at 7d. lb.
,, Sulphide, phosphorescent	12/-	—	
Zirconium Nitrate	7/6	—	

A.R. Chemicals

(See pages 562-566.)

Adopted by critical users in the leading laboratories.

Prepared to a definite specification under most stringent conditions to ensure their purity.

Packed in sealed containers ensuring freedom from contamination.

Labelled with a definite statement of maximum limits of impurities.

Delivered from Works Laboratory to user's laboratory in sealed packages, so that A.R. standard of purity is positively ensured.

INDICATORS

		pH Range.	Solid.	Solution Ready for Use. 25 ml.		100 ml.	
				s.	d.	s.	d.	s.	d.
	Alizarin	11·0–13·0	5 *grams*	1	0	1	6	2	6
	Alizarin Blue S.	9·0–13·0	5 ,,	1	0	1	6	2	6
	,, Red S.	4·0–12·0	5 ,,	1	0	1	6	2	6
	,, Yellow G.	10·1–12·1	5 ,,	1	6	1	6	2	6
	Azolitmin	5·0– 8·0	1 ,,	7	6	1	9	3	3
	Brilliant Yellow	6·4– 9·4	5 ,,	2	6	1	6	2	6
	Brom Cresol Green	3·6– 5·2	1 ,,	7	6	1	9	3	3
	,, Cresol Purple	5·2– 6·8	1 ,,	2	6	1	6	2	6
	,, Phenol Blue	2·8– 4·6	1 ,,	2	0	1	6	2	6
	,, Thymol Blue	6·0– 7·6	1 ,,	2	6	1	6	2	6
	Congo Red	3·0– 5·0	5 ,,	0	9	1	6	2	6
	o-Cresol-phthalein	8·2– 9·8	1 ,,	2	0	1	6	2	6
	Cresol Red	7·2– 8·8	1 ,,	1	6	1	6	2	6
	Dimethyl-amino-azo-benzene	2·9– 4·0	5 ,,	1	0	1	6	2	6
SI	Dinitrophenol, α	2·8– 4·5	5 ,,	1	0	1	6	2	6
SI	,, β	2·2– 4·4	1 ,,	3	9	1	6	2	6
SI	,, γ	4·0– 5·5	1 ,,	9	0	1	9	3	3
	Haematoxylin	6·0–11·0	5 ,,	2	0	1	6	2	6
	Iodo-eosin		5 ,,	2	6	1	6	2	6
	Lacmoid	4·0– 6·0	1 ,,	2	6	1	6	2	6
	Methyl Orange	2·9– 4·0	10 ,,	1	0	1	6	2	6
	,, Red	4·2– 6·3	5 ,,	1	8	1	6	2	6
	p-Naphthol-phthalein	7·3– 8·7	1 ,,	3	6	1	9	3	3
	Neutral Red	6·8– 8·0	5 ,,	2	6	1	6	2	6
SI	α-Nitrophenol	5·0– 7·0	5 ,,	1	0	1	6	2	6
	Phenacetolin	1·0–13·0	5 ,,	2	0	1	6	3	0
	Phenol Red	6·8– 8·4	1 ,,	1	6	1	6	2	6
	Phenolphthalein	8·3–10·0	10 ,,	1	0	1	6	2	6
	Phenol-tetra-chlor-phthalein	0·3– 8·0	1 ,,	2	0	1	6	2	6
	Phenol-thymol-phthalein	8·3–11·0	1 ,,	1	6	1	6	2	6
	,, Violet	8·0–10·0	1 ,,	2	0	1	6	2	6
	Rosolic Acid	6·9– 8·0	1 ,,	1	6	1	6	2	6
	Thymol Blue	8·0– 9·6	1 ,,	2	0	1	6	2	6
	,, Phthalein	9·3–10·5	1 ,,	2	0	1	6	2	6
	Tropæolin 0	11·1–12·7	5 ,,	1	6	1	6	2	6
	,, 00	1·4– 2·6	5 ,,	1	6	1	6	2	6
	,, 000	7·0– 8·9	5 ,,	1	6	1	6	2	6

Prices include cost of bottles. For other indicators see Dry Stains, page 583.

UNIVERSAL INDICATOR, showing the complete range of spectrum colours from red to violet in correct order. Very serviceable for quickly determining the approximate *p*H of a liquid. Colour indicating the approximate *p*H is shown when 0·1 ml. of the indicator is added to 10 ml. of the liquid under test.

Bottle containing	25	100 *ml.*
	1/9	3/3

The following table gives the range and colour change of the Universal Indicator :—

*p*H up to 3·0	Red	*p*H 6·0	Orange Yellow	*p*H 8·5	Bluish Green	*p*H 10·5	Reddish Violet
,, 4·0	Deeper Red	,, 6·5	Yellow	,, 9·0	Greenish Blue	,, 11·0	Deeper Reddish Violet
,, 5·0	Orange Red	,, 7·0–7·5	Greenish Yellow	,, 9·5	Blue		
,, 5·5	Orange	,, 8·0	Green	,, 10·0	Violet		

MICROSCOPICAL STAINS—DRY

	1 gram.	5 grams.	10 grams	25 grams.
Acetin Blue	—	–/9	1/2	2/3
Acid Green	—	–/9	1/5	2/6
,, Violet	—	1/2	2/–	3/11
Acridine Yellow	—	1/5	2/6	5/–
Alizarin	—	–/10	1/8	3/4
Alizarin Blue S (Ehrlich)	—	1/2	2/–	3/11
Alkali Blue	—	1/5	2/6	5/–
Alkanin	—	1/5	2/6	5/–
Alum Carmine	—	1/5	2/6	5/–
Ammonia Carmine	—	2/–	3/11	7/9
Aniline Blue, soluble in alcohol	—	1/5	2/6	5/–
,, ,, ,, water	—	1/2	2/–	3/11
Auramine	—	1/2	2/–	3/11
Aurantia	—	2/9	5/3	11/–
Azo Blue	—	1/2	2/–	3/11
Azocarmine Gx	—	1/2	2/–	3/11
Azoeosin	—	1/5	2/6	5/–
Azofuchsin	—	1/5	2/6	5/–
Azorubin	—	1/2	2/–	3/11
Azur I. (Giemsa)	1/8	6/1	11/–	24/3
,, II. (Giemsa)	1/4	3/11	7/6	16/6
,, II. Eosin (Giemsa)	1/8	5/6	10/6	22/–
,, A, B or C (MacNeal)	2/9	11/–	—	—
Benzo Purpurin (Birch-Hirschfeld)	—	1/2	1/8	3/11
Berlin Blue, insoluble	—	–/10	1/5	3/1
,, ,, soluble	—	1/2	2/–	3/11
Biebrich Scarlet	—	1/2	2/–	3/11
Biondi Ehrlich Heidenhain Stain	—	2/3	3/11	7/2
Bismarck Brown	—	1/2	2/–	3/7
Bleu de Lyon	—	1/2	2/–	3/11
,, de Nuit	—	1/5	2/6	5/–
Borax Carmine Sicc	—	1/5	2/6	6/1
Bordeaux R	—	1/2	2/–	3/11
Brazilin	1/8	7/6	14/7	33/–
Brilliant Cresyl Blue	3/4	13/3	24/3	—
,, Green	—	1/2	2/–	3/11
Carbol Fuchsin, dry	—	1/5	2/6	5/–
,, Gentian Violet, dry	—	1/2	2/–	3/11
,, Methyl Green-Pyronin, dry	—	2/9	5/–	11/–
Carmalum	—	1/5	2/6	5/–
Carmine	—	2/–	3/7	7/9
,, Muci	—	2/9	5/6	11/7
Carminic Acid	2/3	9/11	17/8	38/6
Chromotrop	—	2/9	5/3	10/6
Chrysamine	—	1/5	2/6	5/–
Chrysaniline	—	1/5	2/6	5/–
Chrysoidin	—	1/2	2/–	3/11
Chrysophenine	—	1/5	2/6	5/–
Congo Red	—	1/2	2/–	3/4
Corallin, soluble in spirit	—	3/4	6/1	12/2
,, ,, water	—	3/4	6/1	12/2
Cotton Blue	—	1/2	2/–	3/11
Cresyl Fast Violet	—	1/2	2/–	3/11
Crystal Ponceau	—	1/5	2/6	5/–
,, Violet	—	1/2	2/–	3/11
Cyanosin, soluble in water	—	1/5	2/6	5/–
Dahlia	—	1/2	2/–	3/11
Dianil Blue 2R	—	1/8	3/1	6/1
Ehrlich's Triacid Stain, dry	—	2/3	3/11	7/2
,, Acidophilous Mixture, dry	—	2/3	3/11	7/2

	1 gram.	5 grams.	10 grams.	25 grams.
Eosin, soluble in water, yellowish	—	1/5	2/6	5/–
,, ,, ,, bluish	—	1/5	2/6	5/–
,, ,, alcohol	—	2/–	3/7	7/2
,, for blood	—	1/8	3/1	6/1
,, **Scarlet**	—	1/8	3/1	6/1
,, **Azur** (*see Giemsa*)				
Eosin Methylene Blue, Jenner (*see Jenner's Stain*)				
,, ,, Leishman (*see Leishman's Stain*)				
,, ,, May-Grunwald	—	2/9	5/3	10/6
,, ,, Wright (*see Wright's Stain*)				
Eosin Methylene Violet	—	3/11	7/2	16/–
Erythrosin	—	1/5	2/6	5/–
Ethyl Violet	—	1/5	2/6	5/–
,, **Violet-Orange G** (Bailey)	—	1/8	3/1	6/1
Fettponceau	—	1/2	2/–	3/11
Fluorescein	—	1/5	2/6	4/5
Fuchsin Basic, Special for Bacteria	—	1/2	2/3	4/2
,, **Acid**	—	1/2	1/8	3/11
Gentian Blue	—	1/5	2/6	5/–
,, **Violet**	—	1/2	2/3	4/2
Giemsa Stain, dry	2/–	6/1	11/–	24/3
Gossypimine	—	1/2	2/–	3/11
Hæmalum	—	1/2	2/–	3/11
Hæmatein	1/5	5/6	10/6	23/2
Hæmatein-Ammonia	1/5	5/6	10/6	23/2
Hæmatoxylin	—	2/3	4/2	8/3
,, Delafield, dry	—	1/8	3/1	6/1
Helianthin	—	1/2	2/–	3/11
Hexamethylviolet	—	1/2	2/–	3/11
Hofmann's Blue	—	1/5	2/6	5/–
,, **Violet**	—	1/2	2/–	3/11
Indigo Carmine	—	1/5	2/6	5/–
Indulin, water soluble	—	–/10	1/2	2/3
,, alcohol soluble	—	1/2	2/–	3/11
Iodine Green	—	2/3	4/2	8/3
Iodo Eosin	—	1/5	2/6	5/–
Isamine Blue (Pyrrol Blue)	—	1/5	2/6	5/–
Janus Blue	—	1/2	2/–	3/11
,, **Green B**	1/5	5/6	10/6	—
Jenner's Stain	—	2/3	4/2	8/3
Leishman's Stain	1/2	3/4	6/4	14/11
Leuco Malachite Green	—	2/–	3/7	8/3
Light Green	—	1/5	2/6	5/–
Lithium Carmine	—	1/5	2/6	5/–
Magdala Red	—	2/3	3/11	8/10
Magenta	—	1/2	2/–	3/11
Malachite Green	—	1/2	2/–	3/11
Martius Yellow	—	1/5	2/6	5/–
Meldola's Blue	—	1/2	2/–	3/11
Metanil Yellow	—	1/2	2/–	3/11
Methyl Blue	—	1/2	2/–	3/11
,, **Eosin**	—	2/3	4/2	8/3
,, **Green**	—	3/4	6/4	13/9
,, **Green-Pyronin**, (Pappenheim)	—	2/9	5/6	11/–
,, **Violet 2 B**	—	1/2	2/–	3/11
,, ,, **5 B**	—	1/2	2/–	3/11
,, ,, **6 B**	—	1/2	2/–	3/11
Methylene Blue, Pure for Bacteria	—	1/2	2/–	3/11
,, ,, Polychrome	—	1/5	2/6	5/6
,, ,, Alkaline, Loeffler, dry	—	1/2	2/3	4/5
,, ,, Borax, (Manson)	—	1/2	2/–	3/11
,, **Green**	—	1/2	2/3	4/5
,, **Violet** (Dimethylsafranin)	—	1/2	2/–	3/11

STAINS—DRY

		1 gram.	5 grams.	10 grams.	25 grams.
	Muci Carmine (Mayer)	—	2/9	5/6	11/7
	Mucihaematein	—	2/9	5/6	11/7
	Naphthalene Blue	—	1/2	2/–	3/11
	,, Red	—	1/2	2/–	3/11
	,, Yellow	—	1/2	2/–	3/11
	Naphthol Green	—	1/2	2/–	3/11
	,, Yellow	—	1/5	2/6	5/–
	Neutral Red (Ehrlich)	—	2/3	4/5	8/10
	,, Red-Light Green (*see Twort's Stain*)				
	New Methylene Blue	—	1/5	2/6	5/–
	Nicholson's Blue	—	1/5	2/6	5/–
	Night Blue	—	3/4	6/1	13/9
	Nigrosin, water soluble	—	1/2	2/–	3/4
	,, alcohol soluble	—	1/2	2/–	3/4
	Nile Blue		*Prices on application.*		
	Orange G.	—	1/2	2/–	3/11
	,, II. Beta Naphthol	—	1/2	2/–	3/11
	Orcein	1/2	5/6	8/10	20/11
	Panchrom Mixture, Pappenheim, dry	2/3	10/6	19/3	38/6
	Pararosanilin	—	2/9	5/3	10/6
	Patent Blue	—	1/5	2/6	5/–
	Phenosafranin	—	1/5	2/6	5/–
	Phloroglucin	1/2	3/7	6/4	13/9
	Phloxine Red	—	1/5	2/6	5/–
P1	Picro-Aniline Blue	—	1/3	2/–	3/11
P1	Picrocarmine	—	2/9	5/–	9/11
P1	Picrofuchsin, Van Gieson, dry	—	1/2	2/–	3/11
P2	Picro-indigo-carmine, dry	—	1/2	2/–	3/11
	Ponceau 2 R	—	1/2	2/–	3/11
	,, S	—	1/2	2/–	3/11
	Prussian Blue	—	–/10	1/5	2/6
	Purpurin	—	2/9	5/–	9/11
	Pyronin	—	1/8	3/1	6/4
	Pyroll Blue (*see Isamine Blue*)				
	Resorcin-Fuchsin (Weigert's Elastin Stain)	—	2/3	4/2	8/3
	Rhodamine B	—	1/8	3/1	6/1
	Romanowsky Stain (*see Leishman's Stain*)				
	Rosaniline Hydrochloride	—	1/2	2/3	4/5
	,, Violet	—	1/2	2/–	3/11
	Rose Bengale	—	3/4	6/1	13/9
	Rosolic Acid (*see Indicators, page* 582)				
	Rubin S	—	1/2	2/–	3/11
	Ruthenium Red	22/–	—	—	—
	Saffron	—	9/11	17/8	38/–
	Safranin O, water soluble	—	1/5	2/6	5/–
	Scarlet R, for staining fat (Michælis)	—	1/2	2/–	3/11
	Spiller's Purple	—	2/–	3/7	7/2
	Sudan II.	—	1/2	2/–	3/11
	,, III.	—	1/5	2/6	5/–
	Tartrazine	—	1/2	2/–	3/11
	Thionin (Ehrlich)	2/–	7/9	14/11	33/–
	Toluidine Blue	—	2/3	4/2	8/3
	Tropœolin, 0	—	1/5	2/6	5/3
	,, 00	—	1/5	2/6	5/3
	,, 000	—	1/5	2/6	5/3
	Trypan Blue	—	1/5	2/6	5/–
	Twort's Stain	—	2/–	3/11	7/2
	Uranin	—	1/5	2/6	5/–
	Vesuvin Brown	—	1/2	2/–	3/11
	Victoria Blue B.	—	1/2	2/–	3/11
	Water Blue	—	1/2	2/–	3/11
	Wright's Blood Stain	—	4/2	8/–	16/–
	Xylidine Red	—	1/2	2/–	4/2

Muci Carmine (Mayer) .. .. — 2/9 5/6 11/7
Mucihaematein .. .. — 2/9 5/6 11/7
Naphthalene Blue .. .. — 1/2 2/– 3/11
,, Red .. .. — 1/2 2/– 3/11
,, Yellow .. .. — 1/2 2/– 3/11
Naphthol Green .. .. — 1/2 2/– 3/11
,, Yellow .. .. — 1/5 2/6 5/–
Neutral Red (Ehrlich) .. .. — 2/3 4/5 8/10
,, Red-Light Green (*see Twort's Stain*)
New Methylene Blue .. .. — 1/5 2/6 5/–
Nicholson's Blue .. .. — 1/5 2/6 5/–
Night Blue .. .. — 3/4 6/1 13/9
Nigrosin, water soluble .. .. — 1/2 2/– 3/4
,, alcohol soluble .. .. — 1/2 2/– 3/4
Nile Blue .. .. *Prices on application.*
Orange G. .. .. — 1/2 2/– 3/11
,, II. Beta Naphthol .. .. — 1/2 2/– 3/11
Orcein 1/2 5/6 8/10 20/11
Panchrom Mixture, Pappenheim, dry 2/3 10/6 19/3 38/6
Pararosanilin .. .. — 2/9 5/3 10/6
Patent Blue .. .. — 1/5 2/6 5/–
Phenosafranin .. .. — 1/5 2/6 5/–
Phloroglucin 1/2 3/7 6/4 13/9
Phloxine Red .. .. — 1/5 2/6 5/–
P1 Picro-Aniline Blue .. .. — 1/3 2/– 3/11
P1 Picrocarmine .. .. — 2/9 5/– 9/11
P1 Picrofuchsin, Van Gieson, dry .. .. — 1/2 2/– 3/11
P2 Picro-indigo-carmine, dry .. .. — 1/2 2/– 3/11
Ponceau 2 R .. .. — 1/2 2/– 3/11
,, S .. .. — 1/2 2/– 3/11
Prussian Blue .. .. — –/10 1/5 2/6
Purpurin .. .. — 2/9 5/– 9/11
Pyronin .. .. — 1/8 3/1 6/4
Pyroll Blue (*see Isamine Blue*)
Resorcin-Fuchsin (Weigert's Elastin Stain) .. .. — 2/3 4/2 8/3
Rhodamine B .. .. — 1/8 3/1 6/1
Romanowsky Stain (*see Leishman's Stain*) .. ..

MICROSCOPICAL STAINS IN SOLUTION

Prices include bottles

		25 ml.	50 ml.	100 ml.	500 ml.
	Albert's Stain No. 1	1/5	2/6	3/1	13/9
	,, ,, 2	-/9	1/2	1/8	3/11
	Alkanin tincture	2/3	4/2	7/9	29/9
	Aniline Blue, aqueous	1/2	2/-	2/9	10/6
	Aniline Blue-Orange (Mallory)	1/2	2/-	2/6	11/-
	Aniline Chloride Solution	—	—	2/6	9/11
	,, **Gentian Violet** (Stable)	1/5	2/6	3/1	13/9
	Bie's Stain	1/2	—	3/1	13/9
	Biondi-Ehrlich-Heidenhain's triple stain	1/2	2/3	3/4	13/9
	Borrel's Blue (*see M. Blue, Borrel*)				
P1	**Carbol Fuchsin** (Ziehl-Nielsen)	1/2	2/-	2/6	11/-
P1	,, **Gentian Violet**	1/2	2/-	2/6	11/-
P1	,, **Methylene Blue**	1/2	2/-	2/6	11/-
P1	,, **Methyl Green-Pyronin** (Pappenheim-Unna)	2/-	3/7	6/1	24/3
P1	,, **Thionin**	1/2	2/3	3/4	13/9
	Carmalum (Mayer)	1/2	2/-	2/6	11/-
	Carmine Acetic	1/2	2/-	2/6	10/6
	,, Alum (Grenacher) aqueous	1/2	2/-	2/6	10/6
	,, ,, (Mayer)	1/2	2/-	2/6	11/-
	,, Ammonia Picrocarmine	1/2	2/-	2/6	11/-
	,, Ammonia	1/2	2/-	2/6	10/6
	,, Best's Stock Solution	1/8	3/1	4/5	20/11
	,, Borax (Grenacher) aqueous	1/2	2/-	2/6	11/-
	,, ,, ,, alcoholic	1/8	3/1	4/5	18/3
	,, Hydrochloric, alcoholic (Mayer)	2/3	3/1	7/9	—
	,, Lithia	1/5	2/-	2/6	11/-
	Cochineal (Spuler)	1/8	2/6	6/11	22/-
	Corallin (Strassburger)	1/2	2/-	2/6	11/-
	Ehrlich's Acidophilous Mixture	2/-	2/9	6/8	26/5
	,, **Triacid Stain**	1/2	2/3	3/4	13/9
	,, **Triple Stain**	1/2	2/3	3/4	13/9
	Elastin Stain (Weigert)	2/-	3/7	5/3	22/-
	Eosin Methylene Blue (*see Leishman' Stain*)				
	,, ,, ,, **Jenner** (*see Jenner's Stain*)				
	,, ,, ,, (May-Grünwald)	3/4	6/4	10/6	38/6
	,, ,, **Violet**	3/4	6/1	11/-	—
	,, **Solution**, alcoholic	1/2	2/9	3/7	13/9
	,, ,, aqueous	1/2	2/-	2/6	11/-
	Flagella Stain (Zike's)	2/3	3/11	5/10	—
	Fontana's Stain, set of 3 bottles	—	—	7/9	31/3
	Fuchsin, alcoholic, saturated	2/3	4/2	6/11	27/6
	Gabbet's Double Stain (*see Carbol Fuchsin and Methylene Blue*)				
	Gentian Violet, alcoholic, concentrated	2/3	4/2	6/11	27/6
	Giemsa Stain	2/6	4/9	7/9	30/10
	Glychæmalum	1/2	2/-	2/6	11/-
	Gram's Iodine	—	1/5	2/3	4/5
	Hæmalum	1/2	2/-	2/6	11/-
	,, **Acid**	1/2	2/-	2/6	11/-
	Hæmatoxylin (Benda) No. 1	1/2	2/-	2/6	7/9
	,, ,, No. 2	1/2	2/-	2/6	11/-
	,, (Delafield)	1/2	2/-	2/6	11/-
	,, (Ehrlich), acid	1/8	3/1	5/-	20/5
	,, (Heidenhain) No. 1	1/2	2/-	2/6	5/-
	,, ,, No. 2	1/2	2/-	2/6	11/-
	,, (Kleinenberg)	2/3	4/2	8/-	29/9
	,, (Weigert) A	1/8	3/1	4/2	16/-
	,, ,, B	—	1/2	2/-	3/11
	Hæmatoxylin Phosphotungstic (Mallory)	1/5	2/6	3/1	12/8

STAINS IN SOLUTIONS

Prices include bottles

	25 ml.	50 ml.	100 ml.	500 ml.
Herzberg's Iodine Stain	1/2	2/–	3/4	13/9
Indian Ink, special for Micro work	—	—	3/3	—
Jenner's Stain for blood	3/4	6/1	10/6	38/6
Kardos Mixture (*see Methyl Green—Orange G*)				
Kernschwarz	1/8	—	5/10	24/9
Leishman's Stain	3/4	6/4	10/6	38/6
,, Wright's modification	3/4	6/4	10/6	38/6
Light Green in clove oil	3/4	5/10	9/8	44/–
Loeffler's Flagella, mordant	1/2	1/8	2/3	8/10
,, ,, stain	1/2	1/8	2/3	8/10
Lugol's Solution (Strong)	—	—	1/8	3/11
Methyl Blue-Eosin (Mann)	1/2	2/–	2/6	10/6
,, Green	1/2	2/–	2/6	10/6
,, Green-Orange G (Kardos)	3/4	6/1	10/6	38/6
,, Green Pyronin (Pappenheim)	2/–	3/4	5/–	19/10
,, ,, ,, (Pappenheim-Unna)	2/–	3/4	5/–	19/10
,, Violet 6B (Jensen)	1/2	2/–	2/6	10/6
Methylene Blue Acetic (Neisser A)	1/2	2/–	2/6	9/11
,, ,, Alcoholic, concentrated	2/3	4/2	6/11	27/6
,, ,, Alkaline (Lœffler)	1/2	2/3	3/1	11/–
,, ,, Aqueous	1/2	2/–	2/6	10/6
,, ,, Borrel	1/8	3/1	5/10	23/2
,, ,, Borax	1/5	2/6	3/7	13/9
,, ,, Nissl	1/8	3/1	5/10	23/2
,, ,, Polychrome (Unna)	1/5	2/6	3/1	12/8
,, ,, Sulphuric (Gabbet)	1/2	2/–	2/6	10/6
Mucicarmine	2/3	4/2	7/9	29/9
Mucihæmatein	2/3	4/2	7/9	29/9
Neisser's Stain (*see Methylene Blue and Vesuvin Brown*)				
Neutral Red-Light Green (*see Twort's Stain*)				
,, Red (Jensen)	1/2	2/–	2/6	10/6
Nigrosin	1/2	2/–	2/6	10/6
Nissl Blue	1/8	3/1	5/10	23/2
Orahge Tannin (Unna)	1/5	2/3	3/1	12/8
Orcein (Unna)	2/6	4/5	9/5	38/5
Panchrom (Pappenheim)	2/3	4/2	8/–	29/9
Phloroglucin Solution	1/8	3/1	4/2	16/6
P1 Picric Acid, aqueous	—	—	–/11	3/4
P1 ,, ,, (70 per cent. alcohol)	—	—	1/5	5/10
P1 Picro-carmine Ammonia (*see Carmine*)				
P1 Picronigrosin	1/2	2/–	2/6	11/–
P1 Picroindigocarmine	1/2	2/–	2/6	10/6
Romanowsky's Stain (*see Leishman's Stain*)				
Safranin, aqueous	1/2	2/–	2/6	10/6
Scarlet R. alcoholic (Botanical)	2/–	2/9	3/7	16/6
Sudan III. alcoholic (Botanical)	2/–	2/9	3/7	16/6
Thionin Carbol	1/2	2/–	3/4	12/2
Toluidine Blue, acetic (Pugh)	1/5	2/6	3/1	13/3
Twort's Stain	2/3	3/11	7/2	24/3
Van Ermengen's Stain A	5/6	9/11	17/8	—
,, ,, ,, B	1/8	2/3	2/9	—
,, ,, ,, C	1/8	2/3	2/9	—
,, Gieson's Stain	1/2	2/–	2/6	—
Vesuvin Brown (Neisser B)	1/2	2/–	2/6	8/10
Wright's Stain for blood (*see Leishman*)				

MINERALS—NATIVE AND ORES

		lb.
	Actinolite	3/9
	Aeschynite	3/–
	Agate	2/3
	Alabaster	3/9
	Albertite	3/9
	Albite	3/–
	Allanite	7/6
	Almandine garnet	6/–
	Alumstone	3/–
	Amazonstone, small	4/6
	Amber chips	15/–
	Amblygonite	3/9
	Andalusite	7/–
	Anglesite	24/–
	Anhydrite	3/–
	Antimony (native)	19/–
S1	,, sulphide	3/–
	Apatite	2/3
	Arragonite	3/9
S1	Arsenical pyrites. *See Mispickel.*	—
	Asbestos	6/–
	Asphaltum	3/9
	Atacamite	9/–
	Axinite	9/–
	Baddeleyite	9/–
	Barytes, carbonate	1/6
	,, sulphate	1/6
	Barytocalcite	6/–
	Bauxite	3/9
	Bentonite	8/6
	Beryl	3/9
	Blackband ironstone	3/–
	Blende	2/3
	Blue ground (Kimberley)	6/–
	Bog iron ore	2/3
	Bornite	4/6
	Braunite	12/–
	Brucite	15/–
	Calamine	3/–
	Calcite	1/2
	Calcspar	–/9
	Carnallite	7/6
	Carnotite	19/–
	Celestine (strontium sulphate)	1/6
	Cerite	15/–
	Cerussite	9/–
	Cervantite	6/–
	Chlorite	3/–
	Chrome iron ore	1/6
	Cinnabar	27/–
	Clay ironstone	1/2
	Cleveland iron ore	1/6
	Cobalt arsenic (Smaltite)	11/6
	Cobaltite (Cobalt glance)	38/–
	Colemanite	4/6
	Columbite (Niobite)	57/6
	Copper (native)	5/6
	,, nickel	11/6
	,, pyrites	1/6

		lb.
	Copper (red oxide)	3/9
	,, (vitreous)	3/–
	Coprolites	2/3
	Corundum	3/–
	Corelline	8/6
	Crocoite	27/–
	Cryolite (pure white)	11/6
	Dolomite, pure	2/3
	,, massive	–/9
	Emery	1/6
	Erubescite	4/6
	Essonite	4/6
	Euxenite	27/–
	Fahlerz (Tetrahedrite)	7/6
	Felspar (Orthoclase)	–/9
	Fergusonite, pulv.	19/–
	Flint	–/8
	Fluorspar, best quality	1/3
	,, ordinary	–/9
	Franklinite	4/6
	Gadolinite	27/–
	Galena	2/3
	Garnet	6/–
	Garnierite	11/6
	Gold ore	3/9
	Göthite (choice fibrous)	6/–
	Graphite	5/3
	Gypsum	1/–
	,, special crystals	2/3
	Hematite, red	3/–
	Hornblende	3/9
	Iceland spar, ordinary	10/–
	,, ,, selected	15/–
	Ilmenite	15/–
	Iron pyrites	1/2
	Jet	6/9
	Kainite, natural, pure	6/–
	Keilhauite	18/–
	Kieserite, pure	6/–
	Labradorite	2/3
	Lapis lazuli, small	6/9
	Lead Carbonate	4/6
	Lepidolite (plates)	11/6
	,, (massive)	3/–
	Limestone	1/–
	Limonite	2/3
	Magnesite	3/6
	Magnetite, common	2/3
	,, strongly attractive	13/–
	Malachite, best quality	14/6
	,, ordinary	4/6
	Manganite	6/–
	Mica	7/6
S1	Mispickel (Arsenical pyrites)	3/–
	Molybdenite (no matrix)	27/–
	Monazite	14/6
	,, sand	4/6
	Nephrite	19/–
	Oligoclase	4/6

	lb.
Olivine	2/3
Opal (common)	3/9
S1 Orpiment	9/-
Orthite	7/6
Peat	1/6
Petalite	3/-
Phosphorite	3/-
Pitchblende (Cornwall)	*Price on app.*
,, (Canada and Bohemia)	*Price on app.*
Psilomelane	3/9
Pyrolusite	2/3
Pyrrhotite	4/6
Quartz (massive)	-/9
Realgar	8/6
Red Ochre	2/3
Rhodochrosite	9/-
Rhodonite	6/-
Rock Crystal	3/-
Rock Salt	1/-
,, ,, (white transparent)	4/6
Rose Quartz	7/6
Rutile (massive)	3/9
Samarskite	27/-
Scheelite	22/6
Selenite	2/3
Serpentine, common	-/9
Sillimanite	4/6
Silver Ore	3/9
Smaltite	11/6
Sodalite	14/6
Spathic iron ore	2/3
Sphene	9/-
Spodumene	3/9
Steatite	3/-
Strontian carbonate (natural)	3/-
Sulphur ore (native)	3/-
Sylvine	6/-
Talc	2/3
Tin oxide	3/-
,, pyrites	9/-
Titaniferous iron. *See Ilmenite.*	
Topaz	9/-
Torbanite	3/-
Uintahite (Gilsonite)	4/6
Ullmannite (X. line pure)	38/-
Vanadium ore	23/-
Wernerite	7/-
Wiikite, black	45/-
,, brown	45/-
Willemite	38/-
Wolfram	4/6
Zinc blende	2/3
,, (red oxide), ordinary	8/6
Zircon	23/-

MINERAL COLLECTIONS

	Specimens only	*In cabinet*
Set of 50 British Minerals, 1¾" × 1¼"	35/-	57/6
,, ,, ,, ,, ,, 2" × 2"	67/6	115/-
Complete Set of 142 Minerals, 1¾" × 1¼"	150/-	210/0
,, ,, ,, ,, ,, 2" × 2"	260/-	415/-
Set of 9 beautiful British minerals (specially selected), 2" × 2"	19/-	—
,, ,, 9 ,, ,, ,, ,, ,, 3" × 2"	37/6	—
,, ,, 9 ,, ,, ,, ,, ,, 4" × 3"	97/6	—
Explorers' cabinet of ores, minerals and precious stones, packed in well-made mahogany cabinet	—	555/-
Set of 25 natural mineral crystals	40/-	—
,, ,, 50 ,, ,, ,,	95/-	—
,, ,, 25 precious and semi-precious stones (rough uncut)	—	105/-
,, ,, 50 ,, ,, ,, ,, ,, ,,	—	195/-
,, ,, 25 ,, ,, ,, ,, (cut and faceted)	—	230/-
,, ,, 50 ,, ,, ,, ,, ,, ,, ,,	—	440/-

SETS OF ROCK SPECIMENS ILLUSTRATING DR. HARKER'S "PETROLOGY FOR STUDENTS"

Set of 50 common rocks, 1¾" × 1¼"	27/-	50/-
,, ,, 100 ,, ,, ,,	50/-	92/6
,, ,, 200 ,, ,, ,,	90/-	145/-

MOUNTING MEDIA, OILS

Prices include bottles

		25 grams.	100 grams.	500 grams.
	Asphalt Varnish	1/2	3/1	12/2
	Brunswick Black	–/10	2/–	7/2
	Canada Balsam, filtered	2/3	7/9	33/–
	,, ,, dried	3/1	11/–	46/3
	,, ,, ,, neutral	3/4	12/2	49/6
	,, ,, ,, and dissolved in xylene	2/6	7/9	33/–
	,, ,, ,, ,, ,, ,, ,, neutral	3/1	11/–	46/3
	,, ,, ,, ,, ,, ,, benzene	2/6	7/9	33/–
	Carbol Xylol	—	1/8	4/5
	Celloidin	5/–	—	—
	,, **Solution**, thick	2/3	7/9	33/–
	,, ,, thin	1/8	4/5	19/3
	Cement for cover glasses (Krönig)	1/8	4/1	—
	Colophonium Benzol	1/5	4/1	16/6
	Creosote, beechwood	—	3/4	13/3
	Dammar Mastic	1/2	2/9	11/–
	,, **Xylol**	1/2	2/9	11/–
S1	**Farrant's Medium**	–/11	2/3	8/10
	Flemming's Solution (Strong)	4/6	15/9	—
	,, ,, (Weak)	1/1	3/6	—
	Fluorchrome Mordant (Weigert)	—	3/11	15/5
	,, **Powder**	1/2	3/11	15/5
P2	**Formalin** (Formaldehyde 40%)	—	2/–	5/6
	Gelatine, bacteriological	—	2/9	12/2
	,, **Solvent Mixture**	1/5	5/–	19/10
	Glycerin Albumen	–/11	2/3	8/10
	,, **Ether Mixture**	2/3	7/9	—
	,, **Jelly** *collapsible tubes, ea.* 1/2	—	—	—
	,, ,, neutral	1/2	2/9	11/–
	Gold Size	–/10	1/8	6/8
	Gum-syrup for freezing microtome	—	2/3	8/10
	Injection Masses, Gelatine—			
	Transparent Green, Yellow, Brown, Blue Carmine	—	3/1	12/2
	Opaque Red, Blue, Yellow, White, Black	—	3/1	12/2
P1	**Lactophenol**	1/2	3/4	13/9
	Microscopic Cement (*Please state colour required*)	1/8	3/4	—
	Neutral Mounting Medium	2/9	9/5	39/8
	Oil, Bergamot	7/9	27/6	—
	,, **Cajuput**	5/6	20/11	88/–
	,, **Cedarwood**, for clearing	1/2	3/4	13/3
	,, ,, for immersion lenses	2/–	5/6	22/–
	,, **Cloves**	2/9	8/10	33/–
	,, **Origanum**	2/9	9/5	41/3
	Origanum Balsam	3/4	12/2	55/–
	Osmic Acid 1 *gram*, 49/6			
	,, ,, 0·5 *gram*, 20/5			
	,, ,, 0·1 *gram*, 8/10			
	,, ,, 2% solution	23/8	82/6	—
	,, ,, 1% solution	12/2	44/–	—
	Schulze Solution	–/9	2/2	5/–
	Styrax Mounting Solution	2/3	7/9	33/–
	Trypsin, dry	8/3	31/11	—
	Water Mounting Medium	2/–	5/–	19/11
	Zinc Cement	1/8	3/4	—

ORGANIC REAGENTS

For the detection of minute quantities of various radicles by Spot tests

		Reagent for	1 gm.	5 gm.
	Acridine hydrochloride	Co, Fe, Zn	1/10	7/6
	Alizarin	Al, Zr	-/6	1/-
	,, S	Fluorides, Al	-/6	1/-
	Aurine-tricarboxylic acid (Aluminon)	Al	1/4	5/6
	Benzidine	W, Pb, Tl, Au, Cr, Ce, Co, Mn	-/6	1/-
	α-Benzoin-oxime (Cupron)	Cu, Mo	-/8	2/3
S1	Brucine	Nitrates	-/6	1/-
	Cacotheline (nitro-bruciquinone hydrate)	Sn	-/9	2/10
	6-Chloro-5-nitrotoluene-3-sulphonic acid (sodium salt)	K	3/3	13/-
	Chromotropic acid (sodium salt)	Ti	-/8	1/10
	Cupferron	Fe, Ti, Zr	-/6	1/6
	Diazine green (Janus green)	Sn	1/3	5/-
	Dihydroxy-tartaric acid	Na	1/8	6/6
	Dimedone	Aldehydes	-/9	2/6
	Dimethyl-glyoxime	Ni, Bi, Co	-/6	1/3
	Dinitro-diphenyl-carbazide	Cd	2/3	9/-
	2 : 4-Dinitro-phenylhydrazine	Aldehydes and ketones	-/6	1/-
	Diphenylamine	Nitrates	-/6	1/-
	Diphenylbenzidine	Nitrates	4/-	16/-
	Diphenylcarbazide	Cd, Cr	1/-	4/3
	Diphenylcarbazone	Hg	2/-	8/3
	Diphenylthiocarbazone (dithizone)	Pb	2/-	8/3
	α α′-Dipyridyl 0·1 *gm.*, 4/6	Fe	24/-	—
	Dithio-oxamide (Rubeanic acid)	Ni, Co, Cu	2/6	10/-
	Fluorescein	Br	-/6	1/2
	α-Furildioxime	Ni	5/-	20/-
	Gallocyanine	Pb	1/-	4/-
	8-Hydroxy-quinoline (oxine)	Mg, Zn, Cd, Al	-/6	1/3
	4-Methyl-1 : 2-dimercapto-benzene (dithiol)	Sn	7/6	30/-
	β-Naphthoquinoline	Cd	2/6	10/-
	p-Nitrobenzene-azo-resorcinol (Magneson)	Mg	-/6	1/6
	p-Nitrobenzene-diazo-amino-azobenzene (Cadion)	Cd	5/0	20/-
S1	3-Nitro-4-hydroxyphenyl-arsonic acid	Cd	4/6	18/-
	Nitron	Nitrates	2/6	9/10
	α-Nitroso-β-naphthol	Co	-/6	1/-
	Nitroso-R salt	Co, K	-/6	1/-
	m-Phenylene-diamine	Br and Bromides	-/6	1/-
	Phenyl-trimethyl-ammonium-iodide	Cd	-/6	1/4
	Picrolonic acid	Ca	1/4	5/6
	Quinaldinic acid	Cu and Zn	3/3	13/-
	Quinalizarin	Be, Mg, Al, B	-/6	1/6
	Rhodamine B	Sb	-/6	1/-
	Rhodizonic acid (sodium salt)	Ba, Sr	5/-	20/-
	Salicylaldoxime	Cu, Ni	1/4	5/6
	Sodium-diethyl-dithio-carbamate	Cu	-/6	1/-
	Thioglycollic acid	Fe	-/6	1/3
	Thiourea	Bi	-/6	1/-
	Titan yellow	Mg	-/6	1/-
	Uranyl magnesium acetate solution	Na 250 *ml.*, 4/6 ; 500 *ml.*, 8/6	—	—
	,, nickel acetate solution	Na ,, 5/- ; ,, 9/6	—	—
	,, zinc acetate solution	Na ,, 5/- ; ,, 9/6	—	—
	Xanthydrol (10% w/v in Methyl alcohol)	Urea 10 *ml.*, 2/6 ; 25 *gm.*, 5/8	—	—
	2 : 4-Xylen-1-ol	Nitrates	1/6	6/3

STANDARD SOLUTIONS FOR VOLUMETRIC ANALYSIS

		Litre.	W. qt. (2¼ Litres)
P2	**Acid, Hydrochloric,** N/1, N/2, N/5, N/10	2/–	4/9
P2	,, **Nitric,** ,, ,,	2/–	4/9
P1	,, **Oxalic,** ,, ,,	2/–	4/9
P2	,, **Sulphuric,** ,, ,,	2/–	4/9
	Ammonia, ,, ,,	2/–	4/9
	Ammonium Thiocyanate, N/10	2/6	6/–
S1	**Barium Hydroxide,** N/5, N/10	2/6	6/–
	Calcium Chloride, for Clark's soap solution, 1 ml. = 0·75 mg. $CaCO_3$	2/6	6/–
	,, ,, for Wanklyn's soap solution, 1 ml. = 1 mg. $CaCO_3$	2/6	6/–
	Fehling's Solution (in two solutions)	6/–	—
	Iodine, N/1	20/–	—
	,, N/10	5/–	12/–
	,, **Wij's**	9/–	22/–
	Nessler's Reagent	10/–	—
	Potassium Carbonate, N/1, N/10	2/6	6/–
	,, **Dichromate,** N/1, N/10	2/6	6/–
	,, **Hydroxide,** N/1, N/2, N/10	4/–	9/6
	,, ,, alcoholic, N/1, N/10	8/–	19/6
	,, **Permanganate,** N/10	2/6	6/–
	,, **Thiocyanate,** N/10	2/6	6/–
	Silver Nitrate, N/1	30/–	—
	,, N/10	6/6	15/9
	Soap Solution, Wanklyn's	5/–	12/–
	,, ,, **Clark's**	5/–	12/–
S1	**Sodium Arsenite,** N/10	3/–	7/–
	,, **Carbonate,** N/1, N/10	2/–	4/9
	,, **Chloride,** N/10	2/–	4/9
	,, **Hydroxide,** N/1, N/2, N/10	2/–	4/9
	,, ,, for cheese-making 1 ml. = 0·01 gram lactic acid	2/–	4/9
P2	,, **Oxalate,** N/10	2/6	6/–
	,, **Thiosulphate,** N/1, N/10	2/6	6/–
	Uranium Acetate, 1 ml. = 0·005 gram P_2O_5	6/–	14/3
	,, **Nitrate,** 1 ml. = 0·005 gram P_2O_5	6/–	14/3

INDEX

KEY TO ABBREVIATIONS

A.C.	=	Alternating Current
App.	=	Apparatus
Attch.	=	Attachment
Calr.	=	Calorimeter
C.G.	=	Centre of Gravity
Coefft.	=	Coefficient
Compar.	=	Comparison
Compn.	=	Composition
Cond.	=	Conductivity
C.P.	=	Constant Pressure
C.V.	=	Constant Volume
D.C.	=	Direct Current
Demn.	=	Demonstration
Detn.	=	Determination
Distilln.	=	Distillation
Effn.	=	Effusion
E.M.F.	=	Electro-Motive Force
Equiv.	=	Equivalent
Expn.	=	Expansion
Expt.	=	Experiment
Exptl.	=	Experimental
Formn.	=	Formation
H.F.	=	High Frequency
Insts.	=	Instruments
Max.	=	Maximum
Mechs.	=	Mechanics
M.I.	=	Moment of Inertia
Min.	=	Minimum
Mol. Wt.	=	Molecular Weight
Opt.	=	Optical
Press.	=	Pressure
Proj.	=	Projector
Pt.	=	Point
S.G.	=	Specific Gravity
Sp. Ht.	=	Specific Heat
Temp.	=	Temperature
Univ.	=	Universal
U.V.	=	Ultra Violet

If the apparatus you require is not found in this catalogue, please write to us for quotations and specifications.

The names, addresses or trade marks on the illustrations in this catalogue indicate ownership of the blocks and are not to be taken as indicating the place where the goods are manufactured.

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