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OF THE

ROYAL MICROSCOPICAL SOCIETY;

CONTAINING ITS TRANSACTIONS AND PROCEEDINGS,

AND A RECORD OF CURRENT RESEARCHES RELATING TO

INVERTEBRATA, CRYPTOGAMIA, MICROSCOPY, &c.

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Volvox minor.*—One point left undecided in Cohn's otherwise exhaustive researches on the life-history of *Volvox* was the mode of germination of the oospores. This has now been observed by O. Kirchner in the case of *V. minor.* In February the contents of the oospore escape from the ruptured exospore in the form of a sphere, the endospore at the same time swelling up greatly; and are first divided by two walls at right angles to one another. The four cells thus formed separate from one another in such a way that they maintain their connection only at the posterior end. This forms one pole of the subsequently spherical cell-family, the other end closes up only after a large number of cells have been formed. A new family is thus directly derived from each oospore by the division, and the subsequent peculiar mode of displacement of the cells. The distinction does not appear to hold good which was previously considered to obtain between *V. globator* and *V. minor*, that the latter is diœcious; the families go through first of all a female and later a male condition, and are therefore proterogynous.

MICROSCOPY.

Professor Huxley on Work for Microscopists.†—In his presidential address to the Quekett Microscopical Club, Professor Huxley said that having been asked to indicate those courses of inquiry which might best be commended to members of such a Society, he thought that what was desirable was "the following up of details, tracing out minutiæ of structure, and such questions as are only to be solved by long and patient devotion of time and dexterity, and a thorough knowledge of instrumental-manipulation—it is exactly there that men of science find their difficulties, because the amount of time consumed is so great.

"Take, for example, the application of persistent watching to the unravelment of the life-history of a vast number of low organisms; that is a process which has been adopted in respect to certain fungi in order to ascertain whether they are parasites or variations. In such a case the plan pursued is that of taking the spores and watching them step by step, and there is no other way of doing it; it involves enormous expenditure of time and great instrumental dexterity, but those who can follow it obtain results which are to be obtained in no other way. The work of Mr. Dallinger and Dr. Drysdale, for instance, affords us a very remarkable example of this kind of observation. These two gentlemen mounted guard alternately over a Microscope for days and days, and watched one identical monad through all its stages; and they succeeded in tracing out its entire life-history, and made an epoch in our knowledge of these lowest forms. Now suppose this kind of observation was to be directed to the Infusoria in general, what an opportunity there is for some of you! There is not a single genus or species of which we may say that we know the whole history. The common *Paramecium*, for

* Cohn, 'Beitr. Biol. Pflanzen,' iii.; see 'Bot. Zeit.,' xxxvii. (1879) p. 693.
† 'Journ. Queк. Micr. Club,' v. (1879) p. 250.

instance, is one of the commonest things that exist, yet nobody certainly knows whether it has any other mode of reproduction except by fission. The skill which I have seen displayed here is of immense value in such kind of work, and if only applied to it must very soon bring some good results. The like is true also of the *Acinetæ;* we know something about them, but nothing like a complete history: and it is a perfect opprobrium to science that nobody knows what an *Amœba* is. I do not mean to say that we do not know the things we call by that name when we see them, but that we are unable to say with certainty what are their modes of reproduction, what are their various states, which are animal and which are vegetable.

"Turn to the study of development, the whole of which is in a progressive state. We are now carrying it so far that we can trace back a single group of organs to a particular portion of the dividing yolk mass, and the ultimate result will probably be to trace out each group of organs to the blastomeres from which it has proceeded. . . . . This is the kind of service which those members of the Club may perform who feel inclined for it; it is work which may be of very great value, and which certainly cannot be undertaken by those who have to occupy themselves with science as a whole."

Curiosities of Microscopical Literature.—The increase of cheap periodicals, and the demand for "popular" articles on scientific subjects, has unfortunately been the ready means of disseminating a vast amount of error, which it will be far more difficult to eradicate. The turn of the Microscope appears now to have come, judging from a series of articles * which have recently appeared, and from which we extract the two following paragraphs out of many more of a similar character.

"Turning from the practical and useful applications of the Microscope to the human subject, we find that among the scientific questions settled by its means it has correctly defined the line between the vegetable and animal kingdoms. This was a matter of some moment; it had occasioned endless discourse, contradiction and arguments, and, although now put conclusively at rest, some people would consider it erroneous to class a moving isolated body as a vegetable."

"In the lower forms of life, found in ponds and ditches, so deep have the researches into every available form been carried by studious observation, that the minute animals and vegetables more generally distributed throughout the country have been classified, named, and their natural history as correctly related as those of the mammalia. These minute organisms, before invisible and unknown, have been observed by indefatigable and acute observers as closely as we can observe the larger animals. The result of this has been that the information respecting them is as complete, perfect, interesting, and almost as useful as that of any other department of nature."

Kossman's Glass Photograms.—Professor Kossman, of Heidelberg, has superintended the preparation of a series of 250 "photograms," on glass, intended for exhibition by the sciopticon, and to

* 'Design and Work,' vi. (1879) p. 68, &c.

save the cost and inconvenience of wall charts. From the list, which is all that we have seen, it appears that the photographs have been taken from the works of the various standard authors on the particular subject represented. Thus for the 17 protozoa, Claparède and Lachmann, Ehrenberg, Haeckel, Schulze, and Stein have been referred to. There are 20 representations of cœlenterates, 20 of echinoderms, 43 of worms, 21 of crustacea, 20 of insects, myriapods, and arachnids, 22 of mollusca, and 17 of vertebrata.

Bachmann's Guide for making Microscopical Preparations.—This book (in German, 196 pp., with 87 woodcuts), after a description of the necessary instruments and reagents, explains the methods of preparing slides of plants, insects and spiders, mollusca, blood-corpuscles, microscopical inhabitants of water, hard substances, trichinæ, entozoa, bacteria, and preparations of vertebrate normal histology.

The author enforces the importance of keeping a "Preparation Journal," and gives an extract from his own, which is arranged as follows:—

No.	Description of the Object.		Date Found.	Where Found.	Preliminary Treatment.	Further Treatment.	Preserved in	Observations.
	General.	Special.						
34	*Gryllus campestris*, L.	Transverse Section of Gizzard	12th Nov., 1878.	München.	Hardened in Müller's fluid for 10 days.	Stained with picro-carmine and cut in paraffin.	Canada balsam.	Not sufficiently stained.

Beauregard and Galippe's Practical Micrography.—This is a book (in French) of 900 pages, with 570 woodcuts. Besides the usual preliminary chapter on "Microscopes and their Employment," it consists of two parts, "Vegetable Histology," and "Animal Histology." In the former are included (in separate chapters) the anatomical elements, tissues, structure of stems, roots, and leaves, and the organs of reproduction of Cryptogams and Phanerogams. The latter deals with blood, pus, sediments of urine, milk, semen, fæcal matters, parasites, mucus, vomited matters, stains of various kinds, and the examination of water and the atmosphere and of hairs from a medico-legal point of view.

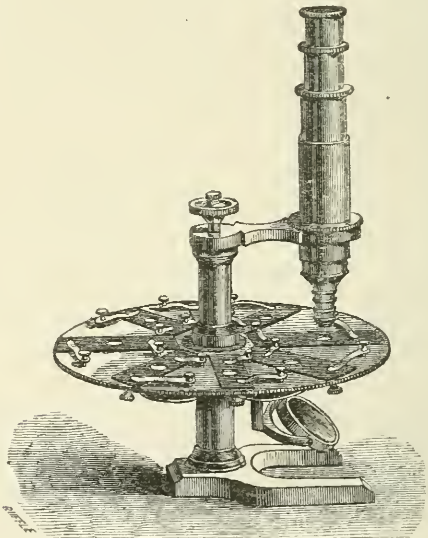
Microscopical Journals.—We have received no parts for a long time of the German 'Zeitschrift für Mikroskopie,' or of 'Brebissonia, a Journal of Algology and Microscopical Botany.' The last number of the French 'Journal de Micrographie' is August, and of the 'American Journal of Microscopy' September. The 'American Quarterly Microscopical Journal' ceased to appear on the completion of its first volume, but we are glad to hear that Professor Romyn Hitchcock (one of the Fellows of this Society), who so ably edited it, is about to issue a new monthly microscopical journal.

We are also pleased to welcome the 'Quarterly Journal of the Microscopical Society of Victoria' (of which Society Mr. T. S. Ralph, A.L.S., is the President). The contents of the first number were noticed in our last Bibliography, and included papers on new species of Polyzoa by Messrs. Maplestone and Goldstein, and by the Rev. J. E. Tenison-Woods on the Radula of Australian Mollusca.

Klönne and Müller's Demonstration Microscope.—This instrument is represented in Fig. 9. Its speciality consists in the addition of a circular stage revolving round the pillar of the Microscope as a centre, and arranged so that eight objects can be examined.

This contrivance does not appear to us to be by any means so con-

Fig. 9.



venient as that of the late Mr. Lobb, who constructed a revolving stage nearly identical with that shown in the figure, not, however, attached to the Microscope, but on a separate stand, so that it could be brought into operation at any time, and when not required, the Microscope was available for use in the ordinary way.

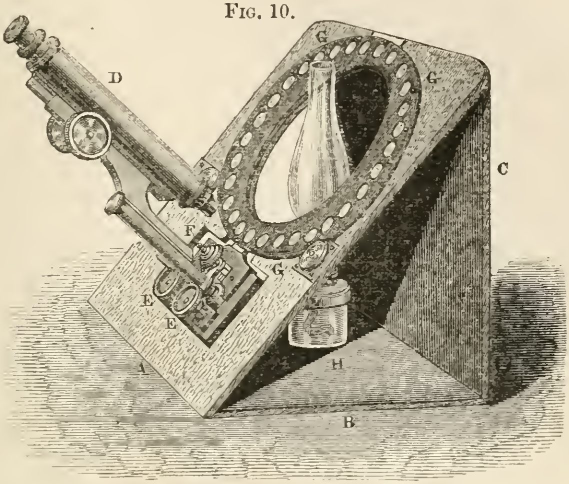
Microscope with revolving Object-holder.—This instrument, for showing transparent objects, which was exhibited at the December meeting (from Mr. Crisp's collection), is a modification of the Hett Microscope, described by Professor Quekett,* the latter being, however, available for opaque objects only.

It consists of an inclined frame A, supported by an upright and base-piece B, C, as shown in Fig. 10. The frame carries a brass

* 'A Practical Treatise on the Use of the Microscope,' 3rd ed., 1855, p. 538.

ring G, in which thirty objects are placed, the ring being rotated by means of catches fixed to its outer margin, and each object can thus be brought successively into the field of view.

Fig. 10.



The Microscope tube D can be focussed by the ordinary rack and pinion movement, and also (for fine adjustment) by the milled head F. It is moved in two rectangular directions by other milled heads, E E, so as to adjust the object in the field. A lamp H can be used if desired.

New Binocular Microscope and Achromatic Objectives.—A preliminary announcement has been made of a binocular Microscope "which is entirely new and original in its application of optical principles as well as in its mechanical construction, and entirely overcomes the difficulties and defects of the Wenham plan." Also a "globe lens," made on a "newly discovered optical principle, which enables the highest corrections to be obtained by an adaptation of the relative thicknesses only of the materials used."

Steinheil's "Aplanatische Loupen."—These achromatic triplet lenses are constructed so as to be used at a greater focal distance from the object than most of the existing high-power lenses. They are "Aplanatic," as their name implies, and it is claimed that they give excellent definition over the whole field, even to such an extent that they may be tilted to almost any angle without distortion, so that the highest powers may be readily used. The different focal lengths of the lenses mounted for the pocket are $1\frac{5}{8}$, $1\frac{1}{10}$, $\frac{11}{16}$, $\frac{1}{2}$ and $\frac{3}{8}$, magnifying from $5\frac{1}{2}$ to 24 times.

They can be fitted in bronzed brass cupped mounts with holder, for dissecting purposes, with magnifying powers from $3\frac{1}{2}$ to 24.

Improved Illuminator for Diatoms and other Test Objects.*—Mr. Wenham describes this contrivance as simple, easy to construct,

* 'English Mechanic,' xxx. (1879) p. 279.

and effectually answering its purpose, without any difficulty in use. The idea has long been exploded that it is necessary to use as illuminators achromatic lenses having but little spherical aberration; lenticular arrangements uncorrected for chromatism act quite as well—in fact, some of the best effects are by the chromatic bands of ordinary lenses—and for the purpose of intensity mere condensation, irrespective of any image-forming focus, is quite sufficient.

In March 1856, Mr. Wenham described several forms of immersion illuminators. The first was a right-angled prism connected with the slide by an intermedium of oil, turpentine, or oil of cloves, which, however, had the fault of requiring the addition of some extraneous means of condensing and intensifying the light; for this reason a nearly hemispherical lens was used, connected with the slide, in the same way as the prism. This lens gave more light, and was in every way preferable. A cylinder and a cone of glass were also tried, and found to be a great improvement, but there still remained a difficulty in concentrating the most light towards the object above the centre of the base. A narrow line of light thrown across the object is very efficient for the purpose of developing striæ, and to obtain this line the form was finally adopted, shown full size in the annexed woodcuts, Fig. 11 being a side view, and Fig. 12 an edge view. It consists of a semicircular disk of glass of $\frac{1}{4}$ inch radius; the edge is rounded and well polished to a transverse radius of $\frac{1}{10}$ inch, for the reason that the focus of a spherical surface on crown glass falls within its substance to nearly three times the radius, consequently the line of light will be in the most concentrated position at $\frac{1}{20}$ inch above the centre of the semi-disk, which distance is sufficient to reach objects mounted on slides of the usual thickness, to the under side of which it is connected with water or more refractive oil. The sides of the semi-disk are grasped by a simple kind of open clip attached to the substage. This illuminator is complete in itself, and requires no supplementary condensing lens; the obliquity is simply obtained by swinging the ordinary mirror sideways, and by this means the *Amphipleura* mounted in balsam can be at once resolved.

Fig. 11.

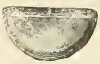
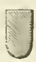


Fig. 12.



The disk illuminator is very easy to make. The polished edges of two suitable pieces of glass are cemented together with shell-lac. One face is then ground flat and attached to a brass chuck with sealing-wax, seeing that the line of junction falls in the centre; the disk is then turned or ground down to a circle $\frac{1}{2}$ inch in diameter. The edge is next rounded and ground true by means of a piece of brass having a channel cut in it of $\frac{1}{10}$th radius, then smooth with the finest emery, rocking the brass grinder and reversing it frequently to equalize the curve. The polisher is a stick of wood with a $\frac{1}{10}$th radius notch cut in the end; this is held on the T rest, and pressed on the edge of the glass with a rocking motion from side to side, occasionally turning it over, using crocus and water, and as it is important that there should be no rings visible in the polish, the last finish must be given by melting some hard pitch or polishing-wax into the groove in the stick, and finish with this and fine rouge. The half-disks, when separated, produce two illuminators of equal form.

Mr. Wenham says,* that while he was never successful in the patient manipulation required to bring out the striæ of *Amphipleura*, yet with the new illuminator he succeeded at once, and on every subsequent occasion. This simple piece of glass, that looks something like the half of a broken button, collects and concentrates a surprising amount of light, and is in a great measure a substitute for the costly achromatic condenser, and can be used either in fluid contact with the slide or not.

The disk should be set in an independent rotating fitting, so that if the object is turned by the rotation of the stage the disk may be moved round to meet it, which movement also serves to modify or cut off light.

Powell and Lealand's Immersion Condenser.—Messrs. Powell and Lealand exhibited, at the Scientific Evening on 3rd December, their new immersion condenser. It is non-achromatic, and by means of a large back lens an angle of light of about 130°, measured in crown glass, can be utilized. Diaphragm slots are fitted beneath, by which two beams of light at right angles can be used either together or separately. The makers claim for it, that the most difficult known test objects requiring oblique illumination can be resolved with the mirror in the optic axis, the required obliquity of incidence being produced by refraction through the condenser.

Mr. Bolton's Tubes of Living Organisms.†—Mr. Bolton recommends that as soon as the tubes (which are mostly $\frac{1}{3}$ inch in diameter, and $1\frac{1}{2}$ inch long, holding $\frac{1}{2}$ drachm of water) are received by post they should be opened, uncorked, and, if they cannot be examined at once in the Microscope, a hole should be bored by a cork borer in a bung cork, and the tube passed into the hole so that the top is level with the top of the cork, and the tube and its contents thus floated on the surface of some water in a tumbler, basin, or still better, in an aquarium. In this way much danger to the life of the more delicate animal organisms will be avoided from variations of temperature, which are not unlikely to occur in so small a body of water as the tubes themselves contain. Many of the advantages of a large body of water are thus obtained without any danger of the objects being lost, or diffused over too large a field to be readily found again.

In the examination of the tubes under the compound Microscope they are awkward to fix, and the aberration of the light is so great as to prevent the possibility of seeing anything with fair clearness except through the centre of the tube. This difficulty may be in great measure overcome by having a *trough* in which the tubes will just lie diagonally. A tube being placed in such a trough filled with filtered water, the aberration arising from its cylindrical form is approximately counteracted, and it is surprising how easily its contents can be examined to the very sides and bottom.

As a *dipping tube* for the transfer of objects under the Microscope he uses a short curved capillary glass tube, the upper end of which is blown out into a little funnel, and the mouth covered with a piece of stretched sheet indiarubber. A small orifice is pierced in the tube

* 'English Mechanic,' xxx. (1879) p. 360. † Ibid., pp. 262, 288.

just below the funnel. The advantage of this over the ordinary dipping tube is that by first pressing the indiarubber with the finger (when the orifice is closed with the thumb), and thus forcing out air, small quantities of water together with minute objects will, when the finger is withdrawn, be taken up out of shallow vessels, such as watch-glasses, &c. In addition there is perfect control over the water, and it can be expelled by the mere touch of the finger on the indiarubber; whereas in the old form of tube the water has to be blown out with the mouth, entailing the removal of the eye from the Microscope, which sometimes is very inconvenient.

Mr. Bolton in writing to us says that he wishes to add that by the aid of this tube a larger quantity of water can be drawn out of a small bottle or tube than could be accomplished with the old form; in fact, it can be used as a kind of syringe, but for this purpose he now prefers a small tube with a capillary point to which an india-rubber teat is attached.

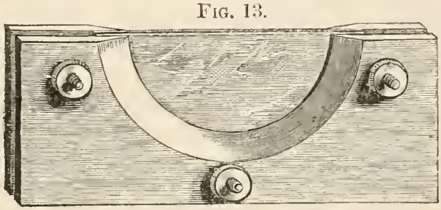
Wills' Compressorium.—In the same paper Mr. Bolton describes a simple form of compressorium that we do not remember having seen previously described. Two pieces of thin glass are cemented to a glass slip in the shape of the letter L, but with the two strokes of the letter about equal in length, and another thinner and longer one is fixed longitudinally, thus L——. The L serves to retain in position a square slip of cover-glass placed, not on the L, but inside it; the horizontal piece, which should be ground to a bevel on its top edge before fixing it, serves to carry a fine needle, the point of which is inserted beneath the edge of the cover-glass. This point being tapered, it is easy to increase or diminish the thickness of a film of water carried between the cover and the slip by pushing the needle further in or out, and so to form a cheap and effective compressorium. Those who try it will be surprised at its efficiency.

Graham Compressorium.—This consists of a brass plate somewhat larger than the ordinary slide, but about the same thickness, with a central hole $\frac{3}{4}$ inch in diameter, slightly recessed on the upper side so as to admit of a $\frac{7}{8}$-inch circle of thin glass being cemented in. Near one end a stout screwed pillar is riveted inside a small brass cylinder, containing a spiral spring. A brass cap fits over the cylinder, having at its lower end an arm carrying the upper ($\frac{7}{8}$-inch) circle of thin glass. A milled head working on the fixed screw presses down the arm while the spiral spring raises it, when the milled head is turned the reverse way. The glasses are perfectly parallel, and can be turned quite clear of each other for cleaning, and if broken can be very readily replaced. The thinness of the bottom plate allows the paraboloid or achromatic condenser to be used.

Botterill's Live Trough.—The advantages claimed for this form of trough, which is shown in Fig. 13, are the facilities it affords (1) for being cleaned, (2) for replacement of broken glass, (3) for arranging the objects in the best position for examination, (4) for reversal, and, lastly, the minor one that it will stand upright without support.

It consists of two brass plates, which can be separated and screwed together again at pleasure, and hold between them two plates of glass, which are kept apart to any desired distance by indiarubber. The plates—say 3″ × 1¼″, and about $\frac{3}{32}$ inch thick—should be of *hard* brass, so as to bear screwing up without bending, and so causing leakage. The curve of the trough may vary, but the semicircular—say 1½″ × ¾″—is the most economical, as the two plates can be turned in the lathe at once, and this shape is also a convenient one for use. The bevel should be wide, so as to allow objectives to work close to the curve. The screws should be of equal length, that the trough may be level

FIG. 13.



and steady when reversed, and be long enough to allow the plates to be set about $\frac{3}{16}$ inch apart. The nuts should be milled, and as small as can be conveniently handled. The glasses may be semicircular, but oblong ones 2″ × 1″ seem to answer equally well. It might be an advantage to cement the lower one to the plate, but this is not essential. The edge of the bottom glass should be even with the edge of the plate, and the upper one about $\frac{1}{16}$ inch from edge of plate, which will be found convenient when filling troughs from a dipping tube, &c.

The best thing to separate the glasses is half of a circular flat indiarubber band of the thickness which will give the required distance between the glasses. These bands, notwithstanding the sulphur, &c., contained in them, have not been found to act injuriously on living organisms.

The trough may be put together, and then used in the usual way, or, as is generally better, the following plan may be adopted:—The lower glass and rubber band being in their place on the lower plate, the object is arranged on the glass with needles in a little water, so that it may be best examined, and the upper glass and plate being put on, the whole should be screwed up, care being taken that the pressure (which need not be excessive) is equal, and the plates kept parallel; the trough can then be filled up with water.

Teasdale's Test Slide for Dark-Ground Illumination.—This consists of ten or more parallel lines, 2000 to the inch, disposed as a symmetrical pattern of eccentric radials. The lines are ruled under perfect equality of circumstance, and with a conchoidal fracture and not a "cut," so as to give a maximum of brilliancy.

On applying this test, if the field be equally illuminated by the spot lens or centrally-stopped condenser, the bands will appear all equally bright; but if the illumination be in any way faulty or one-sided the eye instantly detects it, the bands being so ruled that those which lie at right angles to incident unilateral light are best seen.

X.—*On a Petrographical Microscope.**

By A. Nachet, F.R.M.S.

(*Read* 10*th March*, 1880.)

A Microscope intended for petrographic investigations should have a quality somewhat difficult to obtain, that is, the perfect centering of the stage beneath the objective so that a crystal examined by polarized light is always in contact with the crossed threads placed at the focus of the eye-piece.

If the stage is made to revolve under the objective the latter must be perfectly centered, that is to say, it must be placed in absolute coincidence with the axis of rotation of the stage. Several methods have been proposed to accomplish this, but they have all a grave inconvenience, viz. that when the objectives are changed it is necessary again to find the axis of rotation, to which the axis of the new objective no longer corresponds, thus causing considerable loss of time.

If, however, the objective is turned with the object there is no longer any displacement of the image. To accomplish this it is only necessary to arrange the optical part so that it is divided into two sections, the objective forming part of the stage and turning with it, and the *eye-piece remaining fixed* with the crossed threads and the analyzer.

A Microscope designed on this principle is shown in Fig. 15. The column A carrying the fine and coarse movements, only supports in reality the objective, and the whole turns with the stage and the object, the upper tube containing the eye-piece and the analyzer remaining immovable. The latter tube slides into a collar at the end of the arm fixed to the column B, so that it is not affected by the rotation of the body nor by the focal adjustment which acts only on the objective.

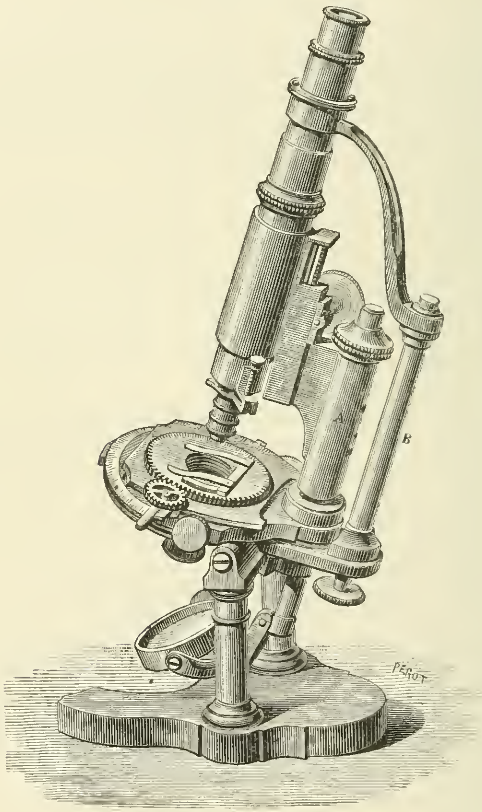
The advantage of this instrument is shown by the fact that the greater the amplification the more precise the centering is, contrary to what is the case when the stage alone turns beneath the objective. In fact the sole cause of deviation which can exist in the new system arises from a small alteration of coincidence between the axis of the eye-piece and objective, but this want of coincidence is almost imperceptible.

In examining rocks it is necessary to change the objectives very frequently—a revolving nose-piece can scarcely be employed in consequence of the flexion which exists in those for three or four objectives, notwithstanding every care in construction. I

* The original paper is in French.

have therefore adopted the system of spring pincers of Professor Thury—the adjusting ring allows an exact centering and the application of the objective is effected instantaneously.

Fig. 15.



The stage of the instrument has a circular division with a vernier for the exact determination of the point of extinction in the plane of polarization. It also has two transverse divisions serving as a finder as well as a second rotating plate, the utility of which is not absolute and is only suitable for special mineralogical observations.

and pliability; to exclude decomposition for years; to maintain the consistence of the various parts; and to give the same results with the lower animals and with all sorts of vegetable substances. Morbid formations removed by an operation will appear after months as if in a fresh state. The Prussian Minister of Instruction has recently officially published the formula for the benefit of the scientific world.

The liquid is prepared by dissolving

100 grammes of alum,		
25	„	common salt,
12	„	saltpetre,
60 grammes of carbonate of potash,		
10	„	arsenious acid,

in 3000 grammes of boiling water, allowing the solution to cool, and filtering: to 10 litres of this liquid are added 4 litres glycerine, and 1 litre methylic alcohol.

The guiding principle for its use is that of impregnating and saturating the bodies with the liquid. Substances intended to be kept hereafter in a dry state are soaked in it from six to twelve days, according to size, and dried in the air. Hollow organs, as lungs, are filled with the liquid previous to immersion in it, then emptied and dried: intestines should be inflated after emptying. Small specimens, such as crabs, beetles, frogs, &c., if the natural colours are to be preserved unchanged, are not to be dried, but put immediately into the liquid.

Microphotographical Notes.*—According to Dr. Carl Seiler's experience, there is no advantage in objectives specially constructed for photography over other good objectives, provided monochromatic light is used, which brings the visual and the chemical focus in the same plane.

Having found some difficulty in making a cell to contain the solution of ammonio-sulphate of copper, through which the sun's rays are passed before they enter the substage condenser (the copper salt dissolving almost any cement, and if exposed to the action of the air very rapidly becoming decomposed and turbid), the author uses a cell made of a brass ring lined on the inner side with lead, and having a thread cut on its outside, to which flanged rings are screwed. Upon the edges of the inner ring a ring of rubber packing is applied, and upon it a disk of plate glass is laid, which is tightly pressed upon the rubber by the flanged ring. Thus a cell is obtained very similar to the round, flat spirit level, and which will hold the ammonio-sulphate solution for months without change. In filling the cell, care should be taken to leave room for a small air bubble, for if the cell is completely filled, the heat of the sun's rays will expand the solution sufficiently to cause leakage.

At the present time, when dry-plate photography has been developed to such an extent that it has superseded in a great measure the old wet process, it has been thought that it would be the most simple, economical, and satisfactory process for photomicroscopy; but after repeated trials by Dr. Seiler, as well as by others working in the same direction, it is found that it is not only more expensive, but also takes more time in the long run. The reason of this is, that it is

* 'Am. Journ. Micr.,' iv. (1879) p. 159.

impossible to judge with any degree of certainty as to the actinic power of the light forming the image on the screen by merely looking at it, and that a trial plate only will give an idea as to the length of exposure of the plate for a given day, time of day, and subject to be photographed. It is true we can expose a dry plate for trial, but then we must develop it immediately, and the time it takes to develop a dry plate is about three times that of developing a wet plate, and a dry plate is also about three times as costly as a wet one. Therefore the old wet process is, he considers, the best.

Micrometre or Micromillimetre.*—Dr. J. Phin points out that about ten or fifteen years ago the prefix *micro* came into general use in English in certain departments of physics denoting the *millionth* part of the unit, and about five years ago the British Association adopted this term, which was embodied in the report of the Committee on Dynamical and Electrical Units. This report, which includes the relations of weights and measures to all measurable quantities, has been generally adopted by the scientific men of Great Britain and America. It will therefore, he thinks, be a very unfortunate thing if microscopists retain the word "micromillimetre" for the *thousandth of a millimetre*, as that special use of the word *micro* will give rise to endless confusion and misunderstanding, and will tend to separate microscopists from the rest of the scientific world.

As the author concludes by saying that he "cannot see the advantage which is claimed for such a term, as the expression two micromillimetres is not more intelligible than ·002 millimetres," we gather that the remedy he proposes is to drop any special designation for a division of a millimetre. The same reasoning on which this conclusion is based leads us, however, to recommend the adoption of "*micrometre*" instead of "micromillimetre," which would secure the uniformity desired, besides being a more convenient word.

Museum Microscope.—This Microscope, which has not previously been figured, is shown in Fig. 16.

It consists of a brass drum A B, 20 inches long, and 14 inches in diameter, in the interior of which are six hollow cylinders, one of which is shown in Fig. 17. Each of these cylinders can be rotated independently by means of the milled heads shown at I, and traverse as they rotate, so that each of the apertures with which they are pierced, and which are arranged spirally, are successively brought under the Microscope body C.

The latter can be monocular or binocular, or better still a double or treble-bodied tube, so that two or three persons can see the object at the same time. The adjustment for focus is made in the ordinary way by the milled head F, and rectangular movements are given to the body by the four milled heads at E E, so as to bring any desired part of the object into the centre of the field of view.

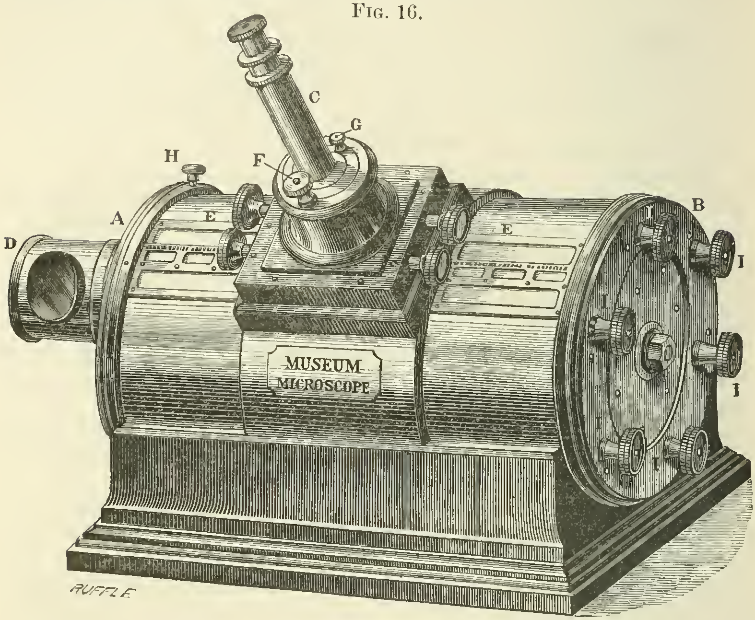
Two additional objectives of different powers can be used by moving the catch G to the right or left of the central point.

Illumination of the objects is effected by means of the mirror D,

* 'Am. Journ. Micr.,' v. (1880) p. 19.

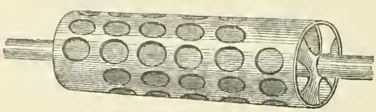
which reflects light to a mirror placed in the interior of each of the cylinders, whence it is reflected to the objective.

Fig. 16.

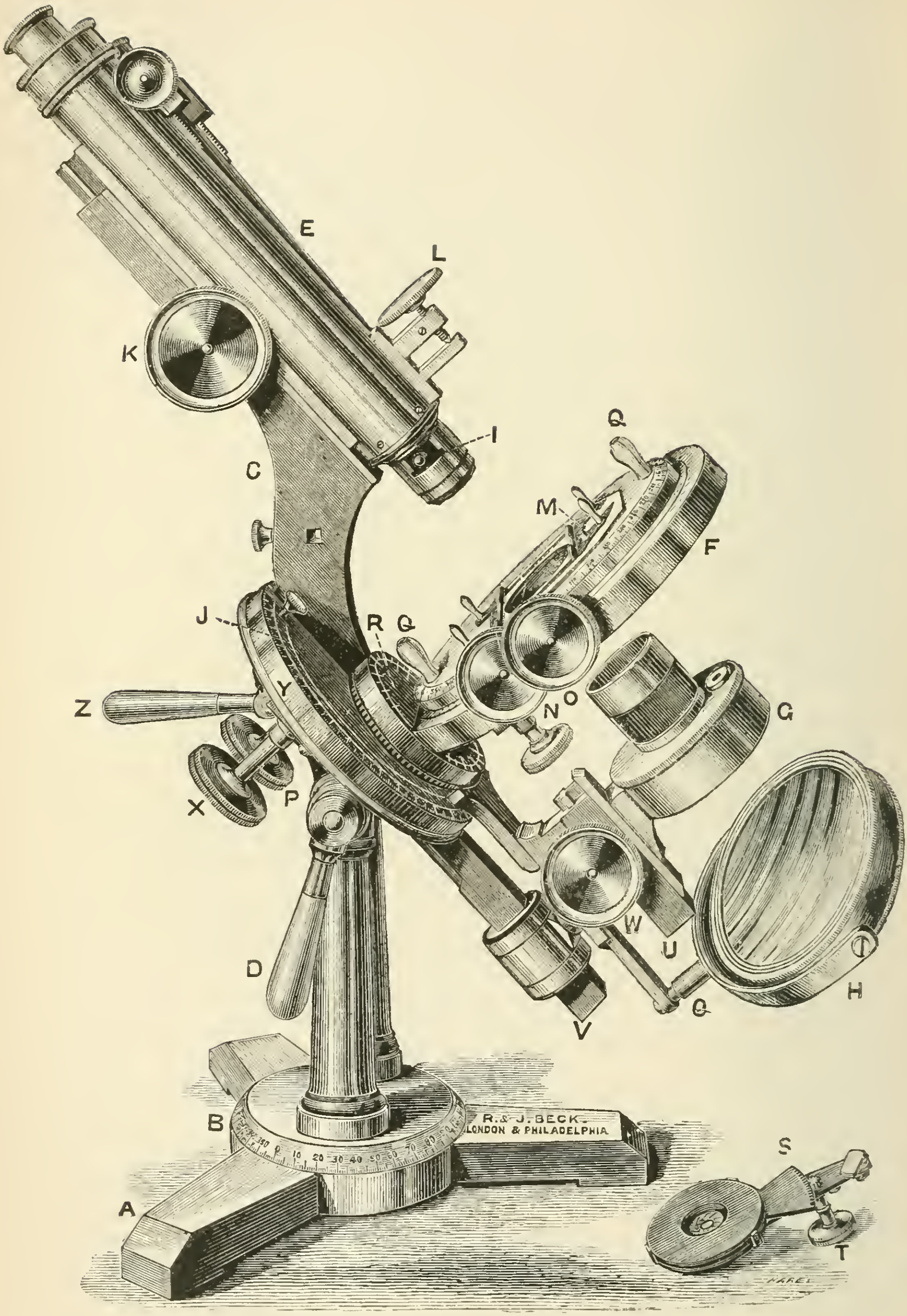


The drum holds five hundred objects, and when those in one cylinder have been examined, the pin H is pressed and the cylinders can then be revolved collectively within the outer case (the "heads" of the drum revolving also), and another cylinder brought under the objective and rotated by its milled head as before.

Fig. 17.



The instrument (made by Messrs. Beck) was exhibited at the last International Exhibition. and is now in Mr. Crisp's collection. The report of the jurors (Class XIII. p. 24) says that "this elaborate contrivance is well adapted for the purpose for which it was designed, and will effectually protect the collection of objects from dishonesty as well as from carelessness." It has also been found invaluable as a means of gratifying the desire of friends to be "shown something through the Microscope," without the loss of time which the ordinary process so often entails, the instrument having for this purpose the further advantage that as each object comes into the field of view its name appears at one of the six openings below E E.



Beck's Improved Microscope-Stand, with Swinging Sub-stage

Beck's Improved Microscope-Stand with swinging Substage (Plate IX.).—The *Stand* has a tripod A for its base, upon which is placed a revolving fitting B, graduated to degrees, so that the Microscope can be turned round without being lifted from the table, and the amount of rotation registered; upon this fitting are two pillars and between them the limb C can be elevated or depressed to any angle, and tightened in its position by the lever D. The limb carries at one end the body E, with binocular prism I, and coarse (K) and fine (L) adjustments; in its centre is the compound stage F, beneath which is the circular plate J, carrying the swinging bar U with the substage G, and at the lower end of the limb is another triangular bar V carrying the mirror H.

The compound *Stage* is of a new construction. It is attached to the limb on a pivot, and can be rotated so as to be set at any inclination, the angle being recorded on the divided plate R, or it can be turned completely over, so that the object is then underneath and can be viewed by light of any obliquity without interference from the thickness of the stage. It revolves in a circular ring by the milled head P, or this can be drawn out, and then it turns rapidly by merely applying the fingers to the two ivory studs Q Q fastened on the top plate, which is divided into degrees to register the amount of revolution. M is the usual spring-piece for clamping the object, and N, O the milled heads of the rectangular movements. Beneath and attached to the stage is an iris diaphragm S, which can be altogether removed from its dovetailed fitting, so as not to interfere during the rotation of the stage. The variations in the aperture of this diaphragm are made by a pinion working into a racked arc and adjusted by the milled head T.

Of the two triangular bars beneath the stage, V is rigid in the optical axis of the instrument, the other, U, swings to either side and carries the *Substage* G which is racked up and down by the milled head W. The bar U is attached to an arc J working in the circular fitting Y, and is revolved by a rack and pinion X, the amount of angular movement being recorded on the upper surface of the plate. This allows of illumination being used at any angle beneath the stage, or if desired the bar U can be carried round and above the stage for opaque illumination. Having once fixed the angular direction of the light, the focussing of it is effected by the lever Z, which moves the circles J, Y up and down, on a dovetailed fitting, and with them the arm U (carrying the illuminating apparatus) *in the optical axis of the instrument*, the amount of the elevation and depression being registered on a scale attached to the limb.

The *Mirror* H is carried on the bar V when the illumination is required to be concentric with the optical axis of the Microscope, and independent of the movements of other illuminating apparatus; when desired, however, it slides on U, and can then be moved below or above the stage in the same way as the substage. It revolves on a circular fitting for giving greater facilities in regulating the direction of the reflected beam, and is made to reverse in the socket so as to bring the centre of the mirror concentric with the axis of the instrument in either case.

Ahrens' Arrangement for using the Wenham Prism with High Powers.—One difficulty in using the Wenham prism with the higher objectives arises, as is known, from the fact that the prism is at some distance from the back lens of the objective, part of the field being thus cut off. Mr. Wenham some years ago constructed some small prisms (one of which was shown at the February meeting), which were attached to a tube fitting into the objective and bringing the prism very close to the back lens: this method, which is otherwise entirely successful, requires each objective to be specially fitted, and an arrangement for turning the prism so that it is in the proper position.

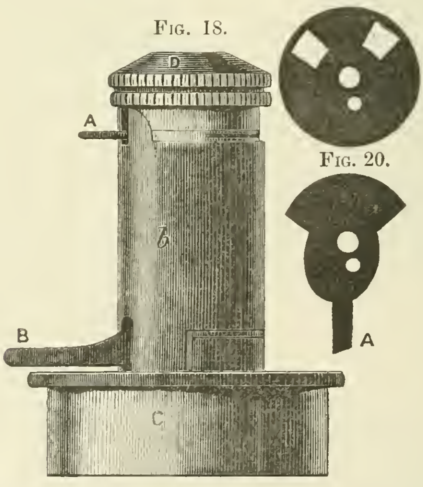
Mr. Crisp at the same meeting showed (with an $\frac{1}{8}$) an arrangement devised by Mr. Ahrens, which enables the prism to be brought close to the back lens with any objective. The tube of the Microscope, instead of terminating in the ordinary way with the universal screw, has two grooves, in which slide two adapters, having the universal screw at one end to receive objectives. One of these carries a Wenham prism, mounted in a projecting tube, so that when the objective is screwed to the adapter the prism dips into it, and is thus brought closer to the back lens.

When it is desired to use the Microscope as a monocular, the adapter containing the prism is slipped off, and the other, which is without a prism, takes its place.*

FIG. 19.

FIG. 18.

FIG. 20.



Powell and Lealand's Improved Immersion Condenser.—Messrs. Powell and Lealand have improved the arrangement of the dia-

* At the March meeting, Dr. Gibbes exhibited a $\frac{1}{12}$-inch homogeneous-immersion objective, with the ordinary Wenham prism, both fields being fully and equally illuminated. See Proceedings of Meeting of 10th March, *infra*.

phragms of this instrument.* As at first made, it was provided with a diaphragm for using one or two oblique pencils only. The necessary movement was made by means of a small projecting arm A (Fig. 18), which was inconveniently near the stage.

The diaphragms (Figs. 19 and 20) now have a central aperture, and the movement is made by means of an outer sliding tube *b* with a slot at the top, in which the arm A fits, and another arm B is placed at the lower end so as to give ready command of the rotation. The new plan allows of the use of either central light alone, or one or two oblique pencils incident 90° apart in azimuth. D is the optical part of the condenser, placed immediately above the diaphragms, and in oil-immersion contact with the base of the slide. The circular diaphragm is fixed into the inner tube attached to the substage tube C, just below the position of the arm A; and the other diaphragm is screwed to it by a screw in the excentrical hole, shown in each. It will be seen that when the diaphragms are placed together in this manner, the movement of the arm will produce the changes in the light as above mentioned.

Illumination with High Powers.—At the March meeting, Mr. James Smith explained a simple and effective method which had occurred to him of illuminating *Podura* scales, diatoms, &c., under powers as high as the $\frac{1}{16}$, by using the ordinary bull's-eye condenser only. The mode in which Mr. Smith prefers to use the condenser is to place the lens just above the stage with the flat side uppermost, a lamp being in front at a distance of 2 or 3 inches. The light enters the condenser, and is reflected from the plane surface at a very oblique angle upon the slide.

West's Universal-Motion Stage and Object-holder.†—Mr. R. G. West proposes a new arrangement for examining those bodies which, when seen obliquely, show some features of colour or structure that are invisible when they are viewed perpendicularly to their surfaces. Morris's object-holder has the drawback that, with the exception of rotation of the carrier in a horizontal position, every movement involves a lateral and vertical displacement of the object, which is thus continually thrown out of the field and out of focus.

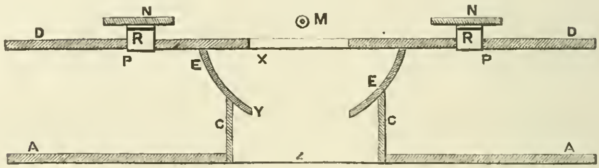
The principle of Mr. West's arrangement is that the object is placed *in the centre* of a movable sphere, so that all lateral displacement is abolished, and the small inevitable focal displacement of the margin of the object is reduced to a minimum, while the centre remains undisturbed.

Figs. 21 and 22 represent the apparatus, the latter figure being a transverse section of the former. A A is a base plate, with an aperture Z in its centre. To this plate is soldered a short brass tube C C. D D is the carrying plate (with a central aperture X) and to the lower side of which is soldered a brass hemispherical shell E E, which has also a circular aperture Y, on the under side for about a third of

* See this Journal, *ante*, p. 147.
† 'Journ. Quek. Micr. Club,' vi. (1880) p. 25.

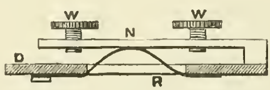
its extent. The dot M indicates the centre of the sphere, and should be fully $\frac{1}{10}$ of an inch above the upper surface of the plate D.

Fig. 21.



The carrier plate is provided with brass forks N N, and a narrow transverse opening P P, through which springs R R press the object slide against the lower surfaces of the forks N N. As these surfaces are in line with the centre M of the hemisphere, minute objects mounted on an ordinary glass slide can readily be placed in that centre, and will be practically free from displacement, lateral or vertical, in any position of the carrier plate. It will be seen that this arrangement automatically compensates for the varying thickness of slides, and that of objects may be compensated for by the screws W W. Two of the screws may be tapped into one of the forks N, and one into the other fork.

Fig. 22.



The weight of the upper part of this arrangement is sufficient to retain it in any position, especially if the upper edge of the tube C be finished square or bevelled outwards so as to give a better bite on E.

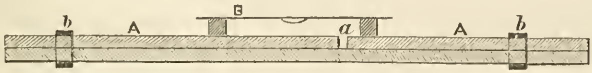
Mr. West describes another form, available only for opaque objects, in which E E is secured to C C by springs, and also a modified form for disk-mounted objects.

In each form of the apparatus the point M must be kept in the axis of the Microscope. The carrier plate D should therefore be large enough to permit of any necessary movement of the slide upon it; and for use with non-mechanical stages, a tubular projection from the lower surface of the base plate A, to fit the "well" of the stage, would be advantageous.

Modification of Stephenson's Safety Stage.—At the March meeting of the Society, Mr. Washington Teasdale exhibited a modification of this stage made of ebonite, which was generally commended for its lightness, the material also allowing of a considerable reduction in the cost. An arrangement is provided for introducing and revolving selenites, diaphragms, light modifiers, &c., beneath the object.

Deby's Growing Slide.*—This slide is shown at Fig. 23, in longitudinal section. A is a 3 × 1 glass slip, having a glass ring cemented to it so as to form a cell of about $\frac{1}{8}$ inch deep and $\frac{3}{4}$ inch diameter.

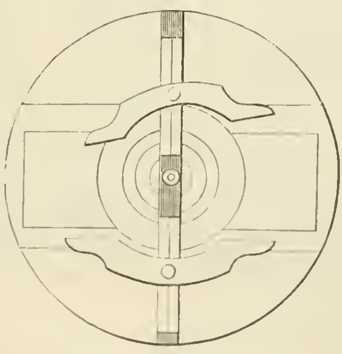
Fig. 23.



A small hole is bored through the slip at *a*, inside and near the edge of the cell. The objects, such as *bacteria*, &c., are placed with a very minute drop of water on a thin glass cover B, which is attached to the top of the cell by a little lard. The slip is then laid upon another of the same size but not perforated, and a couple of indiarubber bands *b* are passed over the ends. One end of this arrangement is then placed in a little water, which, by capillary attraction, will occupy the space between the two slips, and by evaporation will rise into the cell, and prevent the minute drop of water on the glass cover from drying up. By this contrivance a drop of water no larger than a pin's head can be retained of nearly the same size for weeks together, and the development of *bacteria* or other minute organisms kept constantly under observation.

Dunning's Turntable.—Mr. C. G. Dunning suggests a form of turntable to enable the operator readily to centre any slide for mounting up to 2 inches in width, and also to apply the finishing varnish, or repair the same where necessary, to slides, the covering glasses of which may have been placed *away from the centre in either direction.* The apparatus, which is shown in Fig. 24 (half size),

Fig. 24.



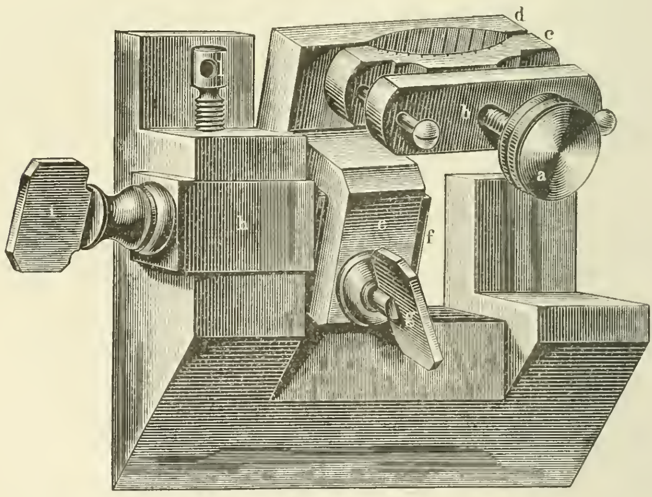
consists of the usual circular table, with the addition of a dovetail groove across the centre, in which work the guides of two clips. One of these clips is fixed to its guide, and the other works on a pivot in order that it may adjust itself to any little irregularity in the width

* 'Journ. Quek. Micr. Club,' v. (1880) p. 28.

of the slides, the sides of which are frequently not quite parallel. The ends of the guides are cut and "sprung," so as to give sufficient tension in the groove to obtain a firm grip of the slide. Guiding lines and circles are ruled on the table to facilitate the centring, and all that has to be done after placing the slide in position is to bring the clips together by means of the pins until the requisite grip is obtained.

Further Improvements in the Rivet-Leiser Microtome.*—Although this microtome is still superior in its chief points to previous instruments, particularly in the substitution of an inclined plane for a screw, and in the guidance (controllable by the hand of the operator) which is given to the knife, Dr. Spengel found that further modifications were needed. A model used at the Zoological Station at Naples (now some years old) has the advantage of allowing increased thinness in the sections, which is accomplished by lengthening the instrument to 20 cm. instead of 10 cm., so that a movement of $\frac{1}{4}$ mm. of the object slide (the rise being 1 in 20) elevates the object $\frac{1}{80}$ mm. More recent attempts have resulted in the production of an instrument shown in the annexed figures.

Fig. 25.



The first improvement consists of an arrangement for moving the clamp, which holds the object, in two directions independently, the object being capable in consequence of far more delicate adjustment as regards its position than with an immovable clamp.

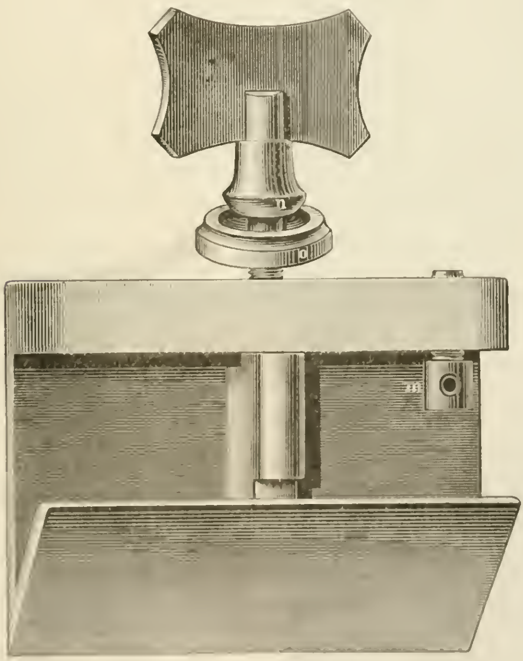
The clamp and object-carrier are shown in Fig. 25. By the screw a passing through b (which is connected with d by two pins), the

* 'Zool. Anzeiger,' ii. (1879) p. 641.

movable piece *c* is made to approach to or recede from *d*, so that a more convenient and secure fixing of the object is obtained. By means of the bent arm *e* the clamp is attached to the block *f* (the upper surface of which is rounded), to which it can be secured by the screw *g*. When the latter is loosened the clamp can be moved through a small arc in a plane parallel to the middle plate of the instrument, and so set in an oblique position. The block *f* is connected with a second (fixed) block *h* by a screw passing through the latter, and can be secured to it by *i*, or when the screw is loosened *f*, with *e* and the clamp, can be rotated in a plane at right angles to the middle plate and placed in the oblique position shown in the figure.

By the combination of these two movements the object can be placed in any desired position, and, as they act independently, there is no danger that in correcting the position in one direction the other will be interfered with. For cleaning the block *h* can be separated from the carrier by loosening the screw *l*.

Fig. 26.



Several clamps can be used with one microtome, which is very useful in large laboratories.

The second improvement is in the construction of the knife-carrier (Fig. 26). To obviate the tendency of the knife to be more depressed

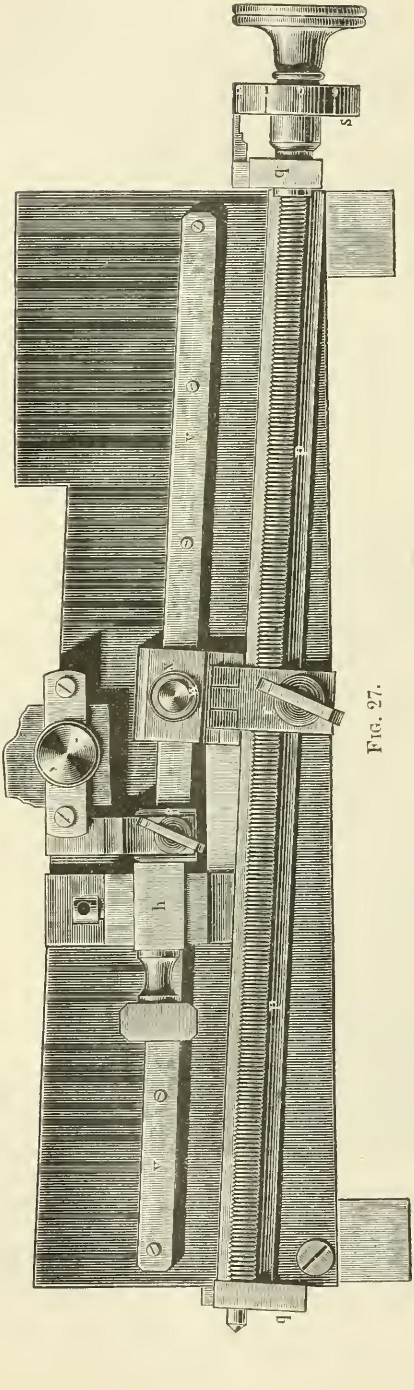


Fig. 27.

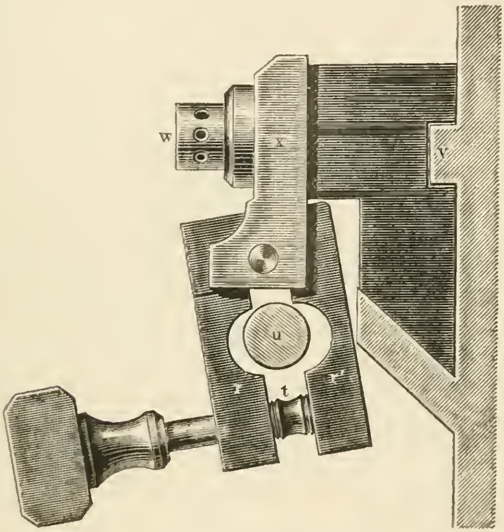
at the free end, which results in its ineffectually passing over the object (the latter merely tilting it up), a screw *m* is inserted in the horizontal plate of the knife-carrier which serves to raise the free end of the knife more or less. The alteration of angle caused by an elevation of one end of the knife without that of the other may be compensated by a corresponding inclination of the object clamp.

In theory the best position for the knife is horizontal, but in practice this has the disadvantage that the under side of the knife drags on the surface of the object. This can be remedied by raising the back of the knife, which can also be done by the screw *m*. To clamp the knife when set otherwise than in a horizontal position, the ordinary form of screw, with an under surface of fixed inclination would be useless; a spherical form is therefore given to the under surface of the screw *n* so as to fit into a corresponding collar *o* inserted between the knife and the screw. The collar can then be made to follow the inclination of the knife, and is readily fixed by the clamping screw.

The third improvement consists in the movement of the object clamp by means of a micrometer screw instead of by the hand (Fig. 27). This screw *p* as it turns in the sockets *q q* moves the piece *r*, which is attached to *x* and the latter by the screw *w* to the object-carrier, so that each turn of the screw moves the latter through a certain small distance. One turn of the screw (which has a wheel *s* attached to it divided into ten parts) moves the carrier 1 mm., and each of the divisions represents $\frac{1}{10}$ mm., and gives an elevation of $\frac{1}{200}$ mm. to the object.

In order to be able to place the carrier at any desired point of the instrument, a "coarse adjustment" is necessary. This is accomplished by the arrangement shown in Fig. 28, which represents a vertical section of the apparatus taken at the point *r* of Fig. 27. The piece *r* is seen to be in two parts, *r* and *r'*, forming a clamp round the screw *u* (= *p* of Fig. 27), and hinged in such a way that, by means of a partly right-handed and partly left-handed screw *t*, they can be

FIG. 28.



separated or brought together. By loosening the screw, the piece *r* with the object-carrier can be moved freely by the hand, until the latter rests at any desired point. The piece *r* can be screwed up to *p* (*u*) again, the instrument being then ready for use as before. (*v* is a "guide" along which the object-carrier slides.)

Thin Covering Glass.*—At a meeting of the Section for Microscopical Science of the Royal Society of New South Wales, Mr. Hirst is reported to have "exhibited some very thin glass suitable for the covering of micro-objects. This glass is simply blown from ordinary glass tubing, is incomparably thinner than the thinnest covering glass, and is so elastic that it is easier torn than broken, and may be readily cut to any shape with scissors."

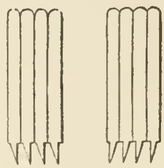
* 'Journ. and Proc. Roy. Soc. N. S. Wales,' xii. (1879) p. 262.

Refractive Index of Cover-glass.—In reply to a query by Mr. J. Mayall, jun., as to the nature of the glass used as cover-glass, Dr. Hopkinson, F.R.S., writing on behalf of Messrs. Chance of Birmingham, states that it is ordinary crown glass having a mean refractive index of 1·5 to 1·525, and that they have never used flint glass for the manufacture of microscopical covering glass. This is noted as many microscopists are under the impression that it is flint glass.*

* See 'Mon. Micr. Journ,' viii. (1872) p. 271.

Improvements in Cell-cutting.*—Cells cut from thin sheet wax or lead are rapidly coming into use in America. They can be built up one upon another to form deeper cells, but are most applicable where great thickness is not required, and have the great advantage that they can be prepared, as wanted, by anybody, of any required size, with very little trouble, and almost without expense. The elegant preparations of Mr. Merriman at the Buffalo meeting of the American Society of Microscopists were mounted in cells of wax cut by Streeter's punches.

Fig. 29.



These instruments, as subsequently improved and as now made, are represented in section by Fig. 29. There is a set of four concentric tubes of iron or hard brass, of equal length, fitting smoothly within each other, and turned to a cutting edge at the lower end. When using the punches, the cutting edges are to be moistened with water to prevent sticking to the wax, and the wax laid on some book-leaves or writing-paper to form a firm, smooth cushion. The smallest punch is then pushed through the wax sheet with a slightly rotating motion, and then the next one is placed over it and pushed down in the same manner, and so on, to the largest. The

Fig. 31.

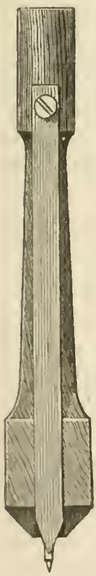


Fig. 30.

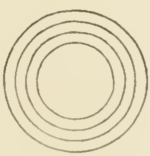
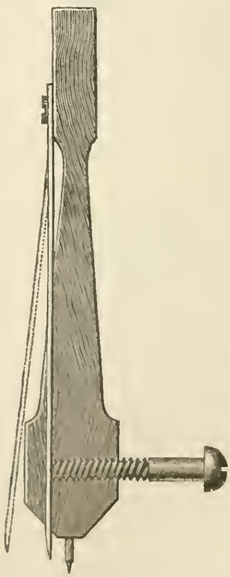


Fig. 32.



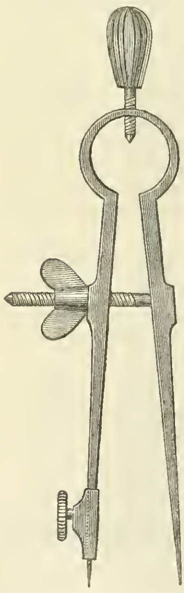
inner punch is next withdrawn by a wooden peg or pencil thrust into it, and the others drawn out one after the other by the little finger. Each ring of wax is then pushed out of its punch with the top of

* 'Am. Nat.,' xiv. (1880) p. 65.

the next smaller punch, leaving it flat and true. The three rings (Fig. 30) thus prepared are suitable for use with cover-glasses of one-half inch, five-eighths inch, and three-quarters inch diameter. They may be fastened to the slide by a little warmth and pressure only, or by some kind of cement, which will not only form a coating to the wax, but also secure it to the slide.

Of instruments adapted to cutting both wax and sheet-lead cells, two very convenient forms were brought forward by Dr. R. H. Ward, at a recent meeting of the Troy Scientific Association. The first was designed by Mr. C. M. Vorce, of Cleveland, O., and is represented in front view and in section in Figs. 31 and 32. It can be readily made by amateurs for their own use. It consists of a wooden body of such size as to be easily held and twirled between the fingers, with a short needle point inserted in the centre of the lower end. On one side a longitudinal slot or groove is cut through the wood deep enough to allow the cutting edge to approach nearly to the needle. The cutter should be ground to a triangular point, and ground only on the outside, leaving its inner face flat and smooth. A screw passes through the body of the instrument, and bears against the spring, regulating its distance from the needle point. Greater firmness might be secured by changing the form of the body so as to support at its two edges the cutter when forced out to its farthest limit.

Fig. 33.



The other instrument, shown in Fig. 33, was suggested by the Vorce instrument, and was contrived by Mr. F. Ritchie, of Troy. It possesses greater power and precision than the other, but is not so easily made by an amateur. It consists of a pair of spring dividers about three and a quarter inches long, from one leg of which half an inch of its length has been cut off and replaced by a brass socket with a binding screw to hold a small knife-blade. A knob is also added at the top for convenience in manipulation.

The method of working these two forms of apparatus is precisely the same. A sheet of wax may be laid on a sheet of heavy white paper, and both together tacked to a piece of smooth hard wood. The instrument, with its legs set three-sixteenths inch apart, is used to cut out a series of disks of three-eighths inch diameter. How near together these can be safely cut will soon be learned by experience. The legs are then set one-quarter inch apart, and using the same centres as before, a series of rings can be cut suitable for one-half inch covers. By successively spreading the legs one-sixteenth inch further each time, rings may be cut around the same centres for five-eighths and three-quarters inch covers, and larger if desired. The concentric rings around each centre are cut out without waste, as shown in Fig. 30. Not only wax, but also sheet lead, cardboard, and guttapercha can be cut with facility in this manner. The various tools sold by hardware dealers for cutting washers of leather, &c., have often been employed for this work, but they have proved too clumsy to be useful.

How to make the new Wax Cell.*—Dr. F. M. Hamlin uses for making the wax cell, "which has so suddenly come into favour," only a turntable and a penknife. Placing the slide upon the turntable, a square or circular piece of sheet wax (such as is used in making artificial flowers) is put upon the slide and carefully centered. The outer edge should then be pressed firmly upon the glass with the thumb or fingers. Having determined the exact size of the cell, turn the slide very slowly and hold the knife with the blade slightly moistened so that the point will cut from the upper surface of the wax downward and outward, gradually pressing the point of the knife down upon the glass. This manner of holding it causes it to serve as a wedge, the outer shaving of wax being generally thrown up and entirely off the glass. If a circular piece of wax from a punch is used, its outer edge should be trimmed off to make it perfectly circular, the pressure of the fingers being likely to distort it somewhat. Any superfluous wax that may remain may be removed by means of a bit of cloth held over the end of the finger or on a stick.

The next operation is to cut out the centre, and is done in the same way, only that the knife is held so as to cut from the top of the wax downward and inward, toward the centre of the cell, so that the bottom of the wax ring shall be wider than the top, which should be about one-tenth of an inch in width. As the point of the knife goes down it throws up the different thicknesses of wax till the last is reached, which it removes, leaving the glass inside the ring almost perfectly clean, unless too much pressure has been used in fastening the wax to the slide.

These wax cells possess certain advantages over others, among which is the slight cost of the necessary apparatus for making them. It might be thought that wax alone is too soft for durable mounts, but this is not the case. Being made and fastened upon the slide at one operation, they are not liable to that distortion which removal from the punches is likely to cause. They can also be made of any size.

According to Mr. C. C. Merriman the wax must be carefully covered with some cement, whether used for fluid or dry mounts; as it is said that certain volatile portions will ultimately collect upon the glass cover of dry mounts or mingle with the preservative media in liquid mounts, and thus spoil the work in either case. His experience is, that the best cement to cover the wax with is Müller's liquid marine-glue. After coating the ring with this it is used in the ordinary way.

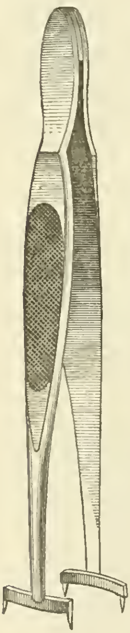
Device for Mounting.†—Mr. A. L. Woodward applies to a Cox turntable a slender arm of brass which is attached at one end to the hand-rest of the turntable by a milled-head screw. The other end extends over the centre of the turntable at a suitable height above it. A pointed screw comes down through the end of the arm exactly over the central dot. In mounting in glycerine, for example, after

* 'Am. M. Micr. Journ.,' i. (1880) p. 16. † Ibid., p. 57.

the cover is applied to the object, the slide is transferred to the turntable, the cover is brought to the centre, and the pointed screw is turned down upon the cover, compressing the object and expelling the superfluous fluid. After a rough cleaning a ring of gelatine-solution may be applied, as directed in Marsh's treatise on Section-cutting, p. 41. After a couple of applications of the gelatine and time allowed for it to set, the screw may be loosened and the slide removed from the turntable.

Chase's Mounting Forceps.*—Having experienced the inconvenience attendant upon the use of the ordinary methods of placing glass covers upon objects, Dr. R. H. Chase devised the forceps shown in Fig. 34, consisting of an ordinary pair of surgeon's spring forceps, either straight or curved, having attached to each blade a circular strip of metal, which carries a short pin-shaped foot. The feet being attached to the outer sides of the circular cross pieces, leave a ledge upon which the glass cover rests.

Fig. 34.



The method of mounting with the forceps is as follows:—Having placed the slide upon a self-centering turntable, and the object carefully arranged upon it in the balsam, place with a clean pair of forceps the thin glass cover (which has previously been cleansed and set aside for use) in the jaws of the mounting forceps. Put a drop of balsam upon the side of the cover that is to come in contact with the object, and invert it over the object on the slide. Allow the feet of the forceps to rest upon the slide, and adjust them by the rings upon the turntable that are seen through the glass.

When the cover is thus carefully centered over the object, relax the grasp of the fingers upon the forceps, and the cover falls in place, causing a wave of balsam to radiate from the centre in every direction. The result is that the cover is accurately centered, and "the object peers up at you—gratifying sight—from the centre of the cover."

In this manner delicate tissues can be mounted that would be inevitably washed to the edge of the cover by the old method; and which are too delicate to be moved back in safety to their proper positions. Those also who have occasion to mount groups of two or more objects under one cover, will find this method of great advantage, as the objects retain their relative positions as arranged upon the slide.

Cleaning Slides and Thin Covers.†—Dr. C. Seiler describes an easy method which he employs of effecting this object. He places new *slides* for a few hours in the following solution:—

Bichromate of potash,	2 oz.
Sulphuric acid,	3 fl. oz.
Water,	25 fl. oz.

* 'Am. Journ. Micr.' v. (1880), p. 64. † Ibid., p. 50.

in such a manner that the brown liquid covers them completely; then rinses them under the tap, and stands them on edge on several thicknesses of blotting paper. When dry, they are chemically clean and require no further rubbing. Before mounting on them, the dust should be brushed off with a camel's hair brush.

With new *covers*, an ounce or so of them are placed in a wide-mouthed vial, and covered with the cleaning solution, shaking them up occasionally, so that they become separated. After three or four hours, pour off the acid solution and wash the covers in the bottle with water, pouring it on and off until the water remains colourless, after continued shaking of the bottle. When wanted for mounting, a cover can be taken out of the bottle with a pair of forceps, and wiped dry with a linen rag. Cleaning covers in this way gets them thoroughly clean, and breaks very few of even the thinnest.

When it is desired to clean off specimens which have been mounted, either in balsam or in a watery medium, so as to save both the cover and the slide, slightly warm the specimen over a spirit lamp, and push the cover with a pair of forceps into a vessel containing alcohol and hydrochloric acid in equal proportions. After having scraped off the balsam or cement with a knife, drop the slides into the bichromate of potash solution, in which they must remain several days, when they can be washed under the tap and dried on blotting paper like new ones. The covers also should be left a few days in the acid solution, and are then transferred to the bichromate of potash solution, and treated like new ones.

Conditions of Aplanatism of Systems of Lenses.*—Prof. Abbe publishes an interesting paper under this title.

As hitherto defined, aplanatism is simply the "elimination of spherical aberration for a pair of conjugate points on the axis;" the word, however, as practically applied is used with a wider meaning, denoting the capacity of a system of lenses to produce a well-defined image of an object by a cone of rays of appreciable (i. e. not infinitesimal) divergence; and by object is meant, not a *point* on the axis, but a *surface* perpendicular to the axis.

On analyzing the conditions under which an image is produced with large angles of divergence, it appears that even when spherical aberration is perfectly corrected for the axis, images of unequal linear amplification may be formed by the various portions of the available aperture of the lens-system. The image of an axial element (or minute portion) of an object, which is formed by a pencil of rays inclined to the axis (through any excentric part of the aperture), has a different linear amplification to that which an image has which originates simultaneously from the rays nearer the axis (through the central part of the aperture). In fact, the image produced by a cone of rays of wide aperture is the result of the superposition of the innumerable images which the various elements of the free aperture would produce *singly*, and these may be shown isolated by the aid of diaphragms. If the linear amplification of these "partial"

* 'SB. Jen. Gesell. Med. und Naturw.,' 1879, p. 129. Revised by Professor Abbe, with diagrams (Figs. 35, 36, and 37).

images of which the whole image is composed be different, they may still coincide in the axial point of the image-field, if the spherical aberration is completely corrected, but at a distance from the axis, and in proportion to that distance, they will separate from one another more and more. The image of a point at some distance from the axis resolves itself into a circle of confusion, whose diameter bears a finite—in some cases a large—ratio to its distance from the axis, and consequently to the dimensions of the portion of surface viewed, however small that may be. When, for example, the linear amplification through the central portion of the aperture is 10 diameters, while the amplification through a marginal portion is 12 diameters, the overlapping of the image produced by the latter over that produced by the former would introduce circles of confusion whose diameter is one-fifth of their distance from the centre at every part of the field. Hence a system, to be aplanatic, besides having its spherical aberration corrected for a pair of conjugate points, must satisfy the further condition of uniform amplification through all parts of the available aperture, that is, for rays in every direction which the angle of aperture embraces.

By a geometrical analysis it may be demonstrated that the required identity of amplification through different parts of the available aperture only subsists when there is a definite ratio between the convergence of the two conjugate pencils of rays whose centres are the axial points of the object and of its image; the *sines* of the angles of inclination of mutually corresponding rays towards the axis must have a constant ratio throughout the whole range of both pencils. By this property aplanatic points are contrasted with a second kind of characteristic points which are important in the formation of images by rays of appreciable divergence, viz. those points on the axis in which the *tangents* of the angles of inclination of conjugate rays are in a constant ratio. These may very properly be called *orthoscopic* points, as on them depends the possibility of forming orthogonal, or similar, images of extended (i. e. not infinitesimal) objects.

The amended definition which Professor Abbe gives is therefore as follows :—" Aplanatic points in a lens-system are those conjugate points on the axis, the spherical aberration of which has been corrected for a cone of rays of appreciable angular aperture, the sines of the angles of inclination of conjugate rays being also proportional."

The essential part of this definition was published by Professor Abbe in 1873.* Professor Helmholtz independently established the same principle, and showed † that the constant ratio of the sines was the condition required if the quantity of light proceeding from the object was to reach the image without loss or gain. Since " quantity of light," according to the undulatory theory, is the energy of an oscillatory movement, this mode of deriving the above theorem connects the action of optical apparatus with the most universal principle in modern physics.

In microscopical objectives of large angular aperture the aplana-

* 'Arch. f. Mikr. Anat.' ix. (1873) p. 420.
† 'Poggend. Annalen, Jubelband,' p. 566.

tism which has just been defined, becomes a matter of vital importance. When the error in the convergence is considerable and affects the whole aperture, the defects arising from ordinary aberration, curvature of the field, and other causes, sink into insignificance—the image of a flat object appears then not merely as a curved surface, but rather as the apex of a cone viewed from the axis.

In the case of large angles of aperture the second condition of aplanatism cannot be so completely satisfied, either theoretically or practically, but that evident traces of the error in divergence are left in the image even when the best means of construction are employed. Microscopists have given to this the very unsuitable name of "curvature" or "unevenness of the field of view," by which it is commonly known. It may, however, be easily shown by experiment that the defects in the image thus described increase in amount, not with the second, but with the first power of the distance from the axis, and therefore in the main have nothing to do with the actual curvature of the image surface.

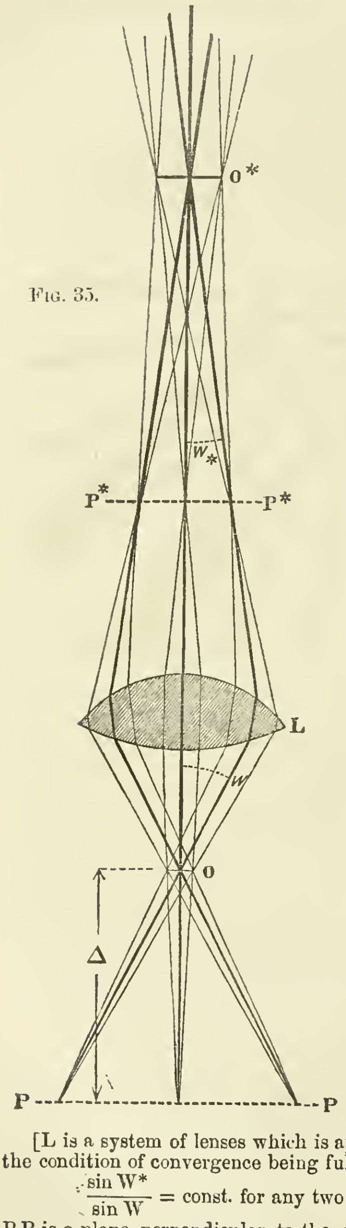
By the simple experiment about to be described, the characteristic relation of convergence of rays at aplanatic points may be observed, and the fact that it persists universally becomes confirmed in a striking manner. This experiment is founded on the contrast between the *aplanatic* points and the *orthoscopic* points of the lens-system, and is deduced from the following considerations.

If an optical system is to produce a correct image of an object extended in a plane, the principal rays proceeding from points of the object and crossing at a point on the axis, and the corresponding principal rays of the image-forming pencils which cross in the conjugate point on the axis and proceed to points of the image, must maintain a constant ratio between the *tangents* of their angles of inclination. It is only when a lens-system satisfies this condition for a pair of conjugate points on the axis (as e. g. a properly constructed eye-piece should do for the place of the objective-opening and the point of vision conjugate to it) that it is orthoscopic, and can produce images which are orthogonal and free from distortion when the object or the image, or both, are shown under a large angle. But aplanatic points, by virtue of the condition of aplanatism, are in antagonism with this property of orthoscopic points, and consequently an aplanatic system, from its peculiar relation of convergence, must give a distortion of the images, *which can be determined beforehand*, when we produce the image of a plane *distant* from the aplanatic point while the principal rays of the image-forming pencils cross in this aplanatic point.

It will be enough if we determine the form which parallel lines assume under these circumstances, or *vice versâ*, find what curves will appear as straight lines in the resultant image.

By a simple calculation it is found that a set of parallel lines in a plane perpendicular to the optical axis, will, with an aplanatic system, form a number of ellipses having the same major axis, but different minor axes (the line at infinity forming a circumscribing semicircle). On the other hand, a set of hyperbolas (of determinate

Fig. 35.



form to be described later on), with the same centre and conjugate axis but with different transverse axes, will be reproduced in the image as a system of parallel straight lines. It is here assumed that the pencils of rays which form the image, cross on entering the lens-system in the aplanatic point which is situate on the side next the object, and for the sake of simplicity the angle of convergence of the rays in the conjugate aplanatic point on the side next the image is assumed to be so small that sine and tangent may be regarded as equal.

These conditions are fulfilled if with an objective of large aperture, the pupil of the observer's eye—or whatever opening admits the rays to the eye—is brought to the axis of the system, and at the spot where the conjugate aplanatic focus on the side next the image is; because in this case no ray can reach the eye which has not passed, on its entrance into the system, through that element in the object which is on the axis conjugate to the pupil or other opening. The assumption as to the angle of convergence in the aplanatic point next the image is evidently satisfied sufficiently in microscopic objectives.

The hyperbolas above referred to are constructed from the equation

$$y = \frac{\Delta}{a} \sqrt{x^2 - a^2},$$

where Δ (the common conjugate axis for both sets of hyperbolas) represents the distance of the plane of the object from the correspond-

[L is a system of lenses which is aplanatic for the conjugate points O and O*; the condition of convergence being fulfilled,

$$\frac{\sin W^*}{\sin W} = \text{const. for any two conjugate rays through O and O*}.$$

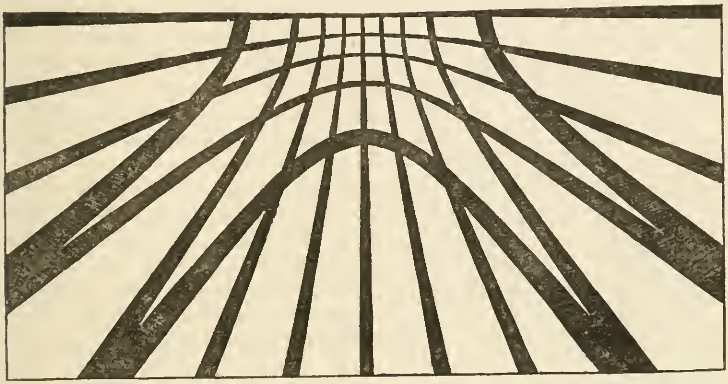
P P is a plane perpendicular to the axis, at a distance Δ below the aplanatic focus O; P* P* is the image of this plane, depicted by pencils whose principal rays cross at O and O*—under these conditions the image P* P* shows the distortion described above. The thicker lines indicate the principal rays.]

ing aplanatic focus; and the value of a in both the sets is taken from the formula

$$a = \frac{\Delta \cdot u}{\sqrt{1 - u^2}},$$

the increments of u being equal; e.g. the values of $u = 0 \ldots\ldots 0{\cdot}2 \ldots\ldots 0{\cdot}4 \ldots\ldots 0{\cdot}6 \ldots\ldots 0{\cdot}8$. Provided the common centre of all the curves in the diagram Fig. 36 is adjusted to lie on the axis, and its plane is perpendicular to the axis and at the proper distance Δ

Fig. 36.

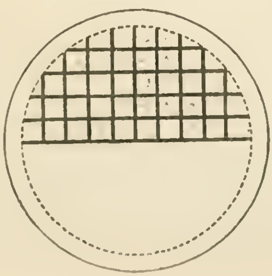


(Δ = 12 mm.)

from the aplanatic focus, the diagram appears in the image as two sets of equidistant parallel lines intersecting at right angles.* The parts of the diagram bounded by curved lines and increasing continually towards the extremities in size and distortion appear as equal squares; the intersections of the hyperbolas (forming angles which towards the outside become increasingly acute and obtuse) are repro-

* Image of the hyperbolic curves, as depicted by a wide-angled aplanatic system, under the conditions named above—the dotted circle indicates the limit of the telescopic field corresponding to an air-angle of 180°.

Fig. 37.



duced as right angles; even the more distant curves of both systems of hyperbolas whose branches do not intersect in the figure but evidently diverge from each other (e.g. those for $u = 0 \cdot 8$), intersect at right angles in the image, though their point of intersection—corresponding to an imaginary point in mathematics—is at a distance from the centre of the image which no rays of light emerging from air can reach, outside the circle on the plane of the image which corresponds with the boundary of a cone of rays of 180° in air.

With objectives whose focal distance is not very short—down to about 3 mm.—the appearance described may be seen with the naked eye by removing the eye-piece from the tube of the Microscope and looking down the open end, keeping the eye as much as possible in the centre, and near the spot where the real image would be formed when the Microscope is used in the ordinary way, and viewing the air-image floating above the objective.

With objectives of very small focal distance, an auxiliary Microscope of low power must be inserted in the tube, and a diaphragm placed in a position conjugate to the aplanatic focus.

This method converts the whole optical system into a telescope with a terrestrial eye-piece through which the drawing which serves as the object is viewed. The microscopic objective which is being tested acts as a telescopic objective, its aperture angle gives the angle of the field of view of the telescope, and what in the ordinary use of the Microscope is the field of the object, the element of surface in its aplanatic focus, acts as entrance aperture when thus used like a telescope.

Numerous trials have been made by Professor Abbe with objectives of various construction and by different makers, and the results have invariably confirmed the theory above laid down. With the exception of the objectives manufactured by Zeiss, there are probably none that have been constructed with this principle avowedly in view. If in spite of this the objectives of all opticians on the Continent, in England, and America satisfy this condition, the fact shows more convincingly than any theory could do, that this peculiar convergence of the rays is undoubtedly an essential constituent of aplanatism in a lens-system.

The above experiment is instructive in many other respects. It illustrates practically some theoretical deductions regarding the image produced by a cone of rays of large angle, as for example, the influence of the angle of aperture on microscopic vision. The portions of field between the hyperbolic curves which are so extremely dissimilar, (the area of those on the outside being many times the area of those in the interior,) appear as squares of equal dimensions, and when the diagram is uniformly illuminated no difference in the brightness can be discerned, although in the squares on the margin the rays are compressed which proceed from an illuminating surface many times larger than that corresponding to the middle squares. This fact shows plainly the great inequality in value of the different parts of the angular aperture with respect to their share of the quantity of light which the system receives.

It is obvious, in fact, that the peripheral portion of the aperture conducts very much fewer rays of light into the objective in proportion to the central parts than would correspond with the measure of their angles, and that consequently the *angle* of aperture cannot be a correct expression of the real aperture—that is, of the capacity of the optical system to receive light. This leads us empirically to the conclusion which results from theory, viz. that "numerical aperture" is the rational measure of aperture, and the only one from which an estimate of its practical effects can be formed.

Systematic Examination of Objectives for the Microscope.—Dr. G. E. Blackham, of Dunkirk (N.Y.), U.S.A., in a paper read at the last (Buffalo) meeting of the American Society of Microscopists, says that the microscopist dealing with minute quantities, is peculiarly liable to be aided or hindered by slight differences in the quality of his instruments; for while it is doubtless true that an expert can do very fair work with instruments of only moderate quality, and the tyro cannot do first-class work with instruments even of the most superlative excellence, it is also true that, other things being equal, the better the instrument the more reliable the results obtained, and that the *best* work cannot be done even by the most expert worker except with the best instruments. The comparison of instruments must therefore always, if properly and skilfully done, be of value to the worker, who may thus be enabled to select the most fitted for his work.

The most important optical part of the Microscope, and that most subject to variation of quality, is the objective; but the ordinary methods of describing these seem to the author to lack precision. For instance, we often see the recommendation to beginners to purchase a stand and a 1-inch and a $\frac{1}{5}$-inch objective. On referring to the catalogue of some makers we may find the latter thus described:—Student's series, $\frac{1}{5}$-inch, ap. 100°, non-adj., price $15; in another, Student's series, $\frac{1}{5}$, ap. 85°, non-adj., price $12. How is the student to choose between them?

The descriptions are insufficient to enable him to compare them. Which glass has the greatest resolving power, which the flattest field, which the longest working distance, and which the greatest amplifying power? Of course if objectives were all truly named the last question would be answered, as all $\frac{1}{5}$'s would have the same amplifying power, viz. × 50 at 10 inches from optical centre of the objective, but such is not the case.

In order to meet this requirement and answer these questions, Dr. Blackham has elaborated a system of examination and prepared a form for recording the results, which gives at a glance most, if not all, the points necessary to the comparison of objectives.

The first column gives the record number for convenience of reference, the second the owner's name, and the third the maker's and the year in which made. This latter is important, as in these days of rapid improvement in construction, it would be obviously unfair to compare an objective made five or even three years ago with one of same nominal grade made this year, without stating the fact.

Record No.	Owner.	Maker, and When Made.	Price.	Maker's Description. Designation.	Cover Adjustment.	Dry or Immersion.	Equivalent Focal Length.	Angle of Aperture. Air.	Water.	Balsam or Crown Glass 1·525.
			$ c.	in.			in.			
1	G. E. Blackham ..	R. B. Tolles, 1876	30 00	1	None	D	1	30°	—	—
*2	" " ..	" "	70 00	Duplex 1/6	Collar moving back.	I	1/6	180°	—	95°
3	R. B. Tolles ..	" "	15 00	Student 1/4	Front lens.	D	1/4	110°	—	—
4	Bausch & Lomb Optical Co.	Bausch & Lomb Optical Co., 1878.	15 00	Student 1/5	None	"	1/5	108°	—	—
5	" "	" "	20 00	1	"	"	1	36°	—	—
6	" "	" "	20 00	4/10	"	"	4/10	110°	—	—
7	J. W. Queen & Co.	Carl Zeiss, 1878 ..	15 00	3/5	"	"	3/5	—	—	—
8	" "	" "	19 00	C.C.	"	"	1/4	90°	—	—
9	" "	" "	40 00	G.	Collar moving back.	I	1/8	—	108°	—
10	" "	" "	47 50	H.	"	"	1/11	—	108°	—
11	Edward Pennock	C. H. Spencer & Sons, 1878.	15 00	Professional 1	None	D	1	30°	—	—
12	" "	" "	20 00	Professional 1/2	"	"	1/2	65°	—	—
†13	Bausch & Lomb Optical Co.	Bausch & Lomb Optical Co., 1879.	18 00	Student glycerine 1/4	Front lens.	"	1/4	105°	—	—
14	" "	" "	28 00	Professional 1/6	Collar moving back.	"	1/6	170°	—	—
15	" "	" "	25 00	1/2	None	"	1/2	85°	—	—
16	G. E. Blackham ..	" "	25 00	1/2	Front lens.	"	1/2	85°	—	—
17	J. W. Sidle	J. W. Sidle, 1879	10 00	2/3	None	"	2/3	34°	—	—
18	"	" "	18 00	3/10	"	"	3/10	110°	—	—
19	"	" "	Not stated.	1/5	"	"	1/5	Not given.	—	—
20	Prof. A. H. Tuttle	Chas. A. Spencer & Sons.	"	1	"	"	1	50°	—	—
21	R. & J. Beck ..	R. & J. Beck, 1878	27 50	3	"	"	3	12°	—	—
22	" " ..	" "	27 50	1½	"	"	1½	23°	—	—
23	" " ..	" "	25 00	2/3	"	"	2/3	32°	—	—
24	" " ..	" "	60 00	4/10	Collar moving front lens.	"	4/10	90°	—	—
25	" " ..	" "	50 00	1/10	"	I	1/10	160°	—	—
‡26	" " ..	" "	8 00	1	None	D	1	19°	—	—
‡27	" " ..	" "	10 00	1/2	"	"	1/2	38°	—	—
‡28	" " ..	" "	12 00	1/4	"	"	1/4	75°	—	—
‡29	" " ..	" "	20 00	1/8	"	"	1/8	95°	—	—
‡30	" " ..	" "	30 00	1/16	"	"	1/16	110°	—	—
31	James W. Queen & Co.	H. Crouch	12 00	2	"	"	2	15°	—	—
32	" "	"	12 00	1½	"	"	1½	20°	—	—
33	" "	"	12 00	2/3	"	"	2/3	30°	—	—
34	" "	"	7 25	1	"	"	1	16°	—	—
35	" "	"	12 00	1	"	"	1	25°	—	—
36	" "	"	18 00	1/2	"	"	1/2	40°	—	—
37	" "	"	13 50	1/4	"	"	1/4	100°	—	—
38	" "	"	28 00	1/4	Collar moving back lens.	"	1/4	100°	—	—
39	Bausch & Lomb Optical Co.	Bausch & Lomb Optical Co., 1879.	18 00	2	None	"	2	20°	—	—
40	R. B. Tolles ..	R. B. Tolles, 1879	80 00	1/8	Collar moving back lenses.	§I	—	—	—	—
						‖"	1/8	—	—	120°

* Glycerine immersion. † Compensation adjustment by varying thickness of *internal* film of glycerine.
‡ National Series. § With glycerine immersion. ‖ With cedar oil immersion.

Results of Measurements and Tests.

Extreme Angle for Admission of Light.			True Aperture. Extreme Angle for Good Definition.			Nominal Amplifying Power.	Actual Amplifying Power.	Frontal Distance.	Working Distance.	Clear Aperture, Front Lens.	Diameter of Field.	Flatness of Field.	Chromatic Correction.	No. resolved on Probe-platte.	Lines per 1/1000 in. on ditto.	No. glimpsed on ditto.	Lines per 1/1000 in. on ditto.
Air.	Water.	Balsam or Crown Glass 1·525.	Air.	Water.	Balsam or Crown Glass 1·525.												
30°	—	—	30°	—	—	10	10	·309	·307	·360	·034	5¼	Slightly under.	4	24·5	5	26
180°	114° 35′	95°	180°	114° 35′	95°	60	54 to 75	·017	·015	·031	·006	5¼	”	20	95·2	—	—
108°	—	—	108°	—	—	40	45	·015	·013	·077	·007	4½	”	11	47	13	53·5
108°	—	—	100°	—	—	50	50	·012	·010	·080	·006	5¼	”	13	53·5	14	62
36°	—	—	36°	—	—	10	8·33	·416	·414	·400	·040	5	”	3	16	4	24·5
110°	—	—	100°	—	—	25	25	·021	·019	·200	·013	4½	”	11	47	13	53·5
36°	—	—	36°	—	—	16⅔	14	·281	·279	·210	·025	5¼	”	4	24·5	5	26
90°	—	—	80°	—	—	40	36	·018	·016	·105	·010	5¼	”	11	47	12	61·6
180°	108°	90°	180°	99° 38′	84°	80	85 to 90	·015	·013	·075	·004	5	”	14 & 15	62 58	18	86·2
180°	108°	90°	180°	102° 13′	86°	110	100 to 112	·012	·010	·055	·003	5	”	14 & 15	62 58	18	86·2
33°	—	—	33°	—	—	10	10	·308	·306	·240	·033	4¾	Slightly over.	3	16	4	24·5
65°	—	—	65°	—	—	20	22	·050	·048	·260	·015	4	”	9	46·4	10	49·2
100°	—	—	100°	—	—	40	35	·016	·014	·108	·009	5	Slightly under.	13	53·5	14	62
140°	—	—	120°	—	—	60	60	·008	·006	·044	·006	4¾	”	16	67	17	63
85°	—	—	85°	—	—	20	18½	·036	·034	·260	·018	5	”	11	47	13	53·5
98°	—	—	92°	—	—	20	20 to 22	·026	·024	·240	·015	5	”	13	53·5	14	62
32°	—	—	32°	—	—	15	15	·199	·197	·200	·022	5¼	”	4	24·5	5	26
120°	—	—	102°	—	—	33·3	33·5	·030	·028	·160	·009	5	”	13	53·5	14	62
115°	—	—	81°	—	—	50	50	·022	·020	·100	·007	5	”	14	62	15	58
50°	—	—	50°	—	—	10	10	·137	·135	·300	·034	5¼	”	8	33·1	9	46·4
12°	—	—	12°	—	—	3·33	3	2·442	2·440	·520	·120	4¾	”	1	3·7	2	13
23°	—	—	23°	—	—	6·67	6·67	·652	·650	·460	·051	5	”	2	13	3	16
32°	—	—	32°	—	—	15	15	·325	·323	·260	·022	5¼	”	3	16	4	21·5
90°	—	—	80°	—	—	25	30 to 32	·052	·050	·130	·011	5¼	”	10	49·2	13	53·5
152°	93° 1′	—	140°	89° 24′	—	100	95 to 100	·031	·029	·021	·003	5	”	14	62	16	67
16°	—	—	16°	—	—	10	10	·291	·289	·300	·031	5¼	”	2	13	3	16
38°	—	—	38°	—	—	20	22	·163	·161	·200	·015	5	”	4	24·5	5	26
74°	—	—	70°	—	—	40	45	·028	·026	·086	·008	4½	”	10	49·2	11	47
90°	—	—	80°	—	—	80	90	·026	·024	·037	·004	4½	”	11	47	12	61·6
108°	—	—	95°	—	—	160	170	·010	·008	·020	·002	4½	”	14	62	15	58
17°	—	—	17°	—	—	5	5½	1·173	1·171	·440	·062	5¼	”	2	13	3	16
23°	—	—	23°	—	—	6·67	7	·737	·735	·400	·047	5¼	”	3	16	4	21·5
25°	—	—	25°	—	—	15	15	·395	·393	·220	·025	5	”	3	16	4	24·5
14°	—	—	14°	—	—	10	11	·780	·779	·300	·032	5½	”	1	3·7	2	13
20°	—	—	20°	—	—	10	10	·415	·413	·280	·032	5½	”	2	13	3	16
50°	—	—	40°	—	—	20	22·5	·102	·100	·240	·015	5½	”	8	33·1	9	46·4
100°	—	—	90°	—	—	40	50	·015	·013	·070	·006	5½	”	11	47	12	61·6
110°	—	—	80°	—	—	40	45 to 55	·024	·022	·062	·006	5½	”	11	47	12	61·6
22°	—	—	22°	—	—	5	5	·870	·868	·440	·067	5½	”	2	13	3	16
180°	—	105°	180°	—	105°	80	82 to 100	·012	·010	·020	·0035	5½	”	20	95·2	—	—
180°	—	110°	180°	—	110°	80	80 to 100	·015	·013	·020	·0035	5½	”	20	95·2	—	—

The next eight columns give the description of the objective as obtained from the maker; viz. its price,* designation, adjustment for cover (if any), dry or immersion, equivalent focal length, and its aperture in air, water, or balsam. The remaining columns show the results of examination. The first group shows the extreme angle for the admission of light from the centre of the field, measured in air, water, or balsam; the next group the extreme angle for *best definition*, also measured in air, water, or balsam. This latter value is usually, though not always, less than the extreme angle for admission of light; and the difference between them, which is sometimes very considerable, shows the extent to which the nominal aperture of the lens could be profitably reduced by diaphragms as proposed by Dr. Royston-Pigott. The next column gives the nominal amplifying power, that is the amplifying power of the objective alone at 10 inches from the optical centre of the objective. Providing its nominal equivalent focal length were correctly given, this would be for a $\frac{1}{2}$-inch × 20, &c. The next column shows the actual amplifying power, measured at 10 inches from front surface of front lens, of the objective. It would have been more absolutely accurate to measure from the optical centre, but the exact position of this point could not be ascertained without a knowledge of the formula on which the objective was constructed, and in lenses possessing adjustment the position of the optical centre varies with every movement of the adjustment. The front surface of front lens being a fixed and easily determined position, and the results obtained by using it differing but slightly from those obtained by using the true optical centre, it was selected as, on the whole, the best position from which to measure the 10 inches. The method of measurement has been to compare the image of a Rogers' stage micrometer with that of an eye-piece micrometer placed exactly 10 inches from front lens, both micrometers being magnified by means of a Bausch and Lomb (Gundlach) periscopic eye-piece, in which the field lens is placed within the focus of the eye lens, and the eye-piece micrometer placed below the field lens and in the focus of the eye-piece, as a whole. The ordinary Huyghenian eye-piece will not answer for this kind of work. The actual and nominal amplifying powers of objectives are often very closely identical, and where variations occur, the actual will sometimes be found in excess of the nominal, and *vice versâ*. The next column gives the frontal distance of the objective, that is, the distance from front of front lens or of brass setting to the object; and the next column, the "working distance," which is frontal distance minus thickness of cover-glass (in all cases here being ·002 inch, the same cover being used with all objectives). The next column gives the clear aperture of front lens, that is the diameter of the light-spot seen when the objective is reversed—held with front lens towards the eye and the posterior combinations pointed at a brightly illuminated white surface, such as a sheet of

* The price is given as a matter of justice to makers whose cheap objectives appear in the list, as it would be unjust to compare the work of a cheap objective with one of same nominal power costing twice or three times as much, without making the fact apparent.

paper. The clear aperture of front lens is always much less than the diameter of exposed front surface which is free of the setting.

The next column gives the diameter of field, which often varies considerably with objectives of same nominal power. The next column shows the flatness of field, indicated by an arbitrary standard of 1 to 6; the latter representing an *absolutely* flat field, not yet found in any objective examined. The next column shows the chromatic correction, in regard to which Dr. Blackham says he has been unable to devise any numerical method which would fairly represent this quality, and has been forced to content himself with such vague notes as "slightly under," "slightly over," &c.

The next two columns give the number of the diatom on Möller's balsam-mounted probe-platte clearly and fully resolved by the lens with light from lamp and mirror, and the number of lines per ·001 inch, as per Professor Morley's measurements. The next two columns, the number of the diatom on same platte which could be just glimpsed under same conditions, and the number of its striæ per ·001 of an inch. The last column is for remarks.

It is of course understood that many of the results given would vary with different eye-pieces; but all except the actual amplifying power have been obtained with Tolles' $\frac{1}{2}$-inch solid eye-piece, the field of which is small enough not to be affected by the size of the tube of the Microscope.

The annexed Table shows the results of the examination of forty objectives of various makers. It was intended that this table should be as complete as possible, but at least two important omissions were discovered as the work progressed.

1st. The diameter of the exposed face of front lens should have been given.

2nd. The number of the diatom on the Möller platte resolved with direct *central* light, should also have been recorded.

There are probably other points which have been overlooked; but the table is submitted as an earnest and honest endeavour to remove the examination of objectives from the domain of mere opinion to that of carefully ascertained and accurately recorded *fact*. The attempt has been to ascertain and record the details of the best performance of each objective for itself, rather than to express an opinion as to its excellence or defects as compared with some standard, ideal or actual, and it is hoped that not only these records, but more especially the *method* may prove of interest, and possibly of service, to users and makers of objectives.

Unit of Micrometry.*—At the Buffalo Meeting of the American Society of Microscopists, the Committee on this subject (representing a large number of the American Microscopical Societies), presented the following report:—

"This Committee, as a result of individual consideration of the subject, and correspondence with Microscopical Societies and students, would respectfully and unanimously tender a report of progress to the

* See this Journal, ii. (1879) p. 154.

American Society, and respectfully request this Society to rescind its approval of the one-hundredth millimetre as a unit for Micrometry, and to refer that question, together with those of securing precision and international uniformity, to the Committee for further action."

This report was accepted.*

Micrometre or Micromillimetre.—Referring to the note on page 327, the adoption of the term "micro-metre" is objected to † on the ground that independently of the extreme similarity of the word to "micrometer," which is evident at a glance, the terms already in vogue in our popular treatises on arithmetic meet the case. For example, in Hensly's 'Scholar's Arithmetic,' published in the Clarendon Press Series (p. 174), an example is cited, and it is stated that, "if there were more decimal places in this case, they would be tenths, hundredths, and thousandths; then ten-thousandths, hundred-thousandths, millionths of a millimetre." This terminology seems simple enough, and cannot fail to be understood.

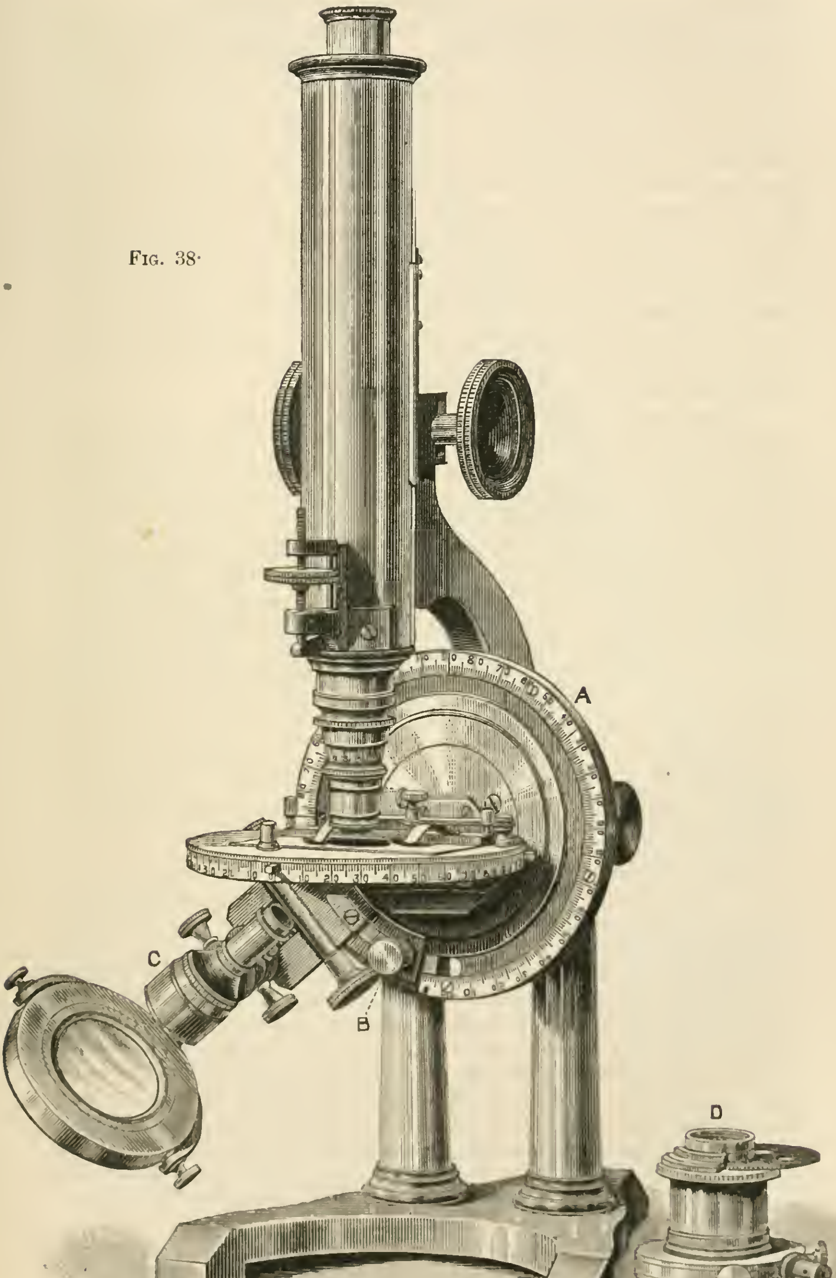
Tolles-Blackham Microscope-Stand.‡—A writer in the 'English Mechanic' compares this stand (which was made some two or three years ago by Mr. Tolles, of Boston, U.S.A., for Dr. Blackham §) with the Beck form.|| The stand is shown in Fig. 38. Its speciality consists in the vertical disk A fixed rigidly to the main limb of the Microscope. The substage C is fitted to the zone carrier near the edge of the disk, and is moved circularly by means of the milled head B. When central light is required the extra substage D, with centering adjustments, is used. The stage is fixed to the centre of the vertical disk.

The main differences between the two stands are (1) that the vertical disk in Beck's is *not* fixed to the main limb, but is provided with a vertical sliding motion to allow for different thicknesses of object-slide, so that the swinging motion of the substage may be made strictly concentric with the object examined. This requires the manipulator to make the vertical centering adjustment with accuracy. (2) The stage itself can be turned laterally (or inverted) with rack and pinion, and thus enables the observer to obtain different views of the object. The cost is necessarily augmented by the extra difficulties in overcoming errors of centering and parallelism, and in producing steadiness and freedom from flexure.

Referring to the preceding communication, Mr. J. Beck says that, during extensive travels amid scientific men in the United States he has never seen one of these stands, and was ignorant of its existence. He has never claimed as a novelty the disk carrying the illuminating apparatus; this was virtually designed and carried out by Mr. Grubb, in 1854. What he does claim as a novelty is, that this disk is *not* fixed to the main limb, which he considers is a great improvement. In all the plans hitherto contrived, if the manipulator wishes to

* 'Am. Journ. Micr.,' iv. (1879) p. 210.
† "Cypher" in 'Engl. Mech.,' xxxi. (1880) p. 212.
‡ 'Engl. Mech.,' xxxi. (1880) p. 134.
§ See this Journal, i. (1878) p. 392. || See *ante*, p. 329.

Fig. 38.



raise or lower the beam of light under oblique illumination, he moves this beam out of the optical axis of the instrument to either one side or the other; whereas by the new plan the beam is raised and lowered *in the axis of the instrument.* Any one who will work with oblique light on the one system or the other, will at once perceive the advantage and practical utility of it. Instead of the character of the illuminator being changed by the increased or decreased proportion from the one side or the other, it remains perfectly the same. The only value of these contrivances for the use of oblique light rests in their perfect accuracy; and anything that leads thereto is a step in advance. If there is any advantage in accuracy, as it must be considered that there is, the Grubb, the Zentmayer, and the Tolles-Blackham plans are only accurate for viewing an object on a slide of a definite thickness; any variation throws them out at once, whereas, by the new plan, the rotation can readily be made exact for an object mounted on glass of any thickness.

Jaubert's Microscopes.*—It may be new to many microscopists to learn that, some years ago, M. Jaubert, optician, of Paris, proposed to mount—and did actually mount—the Microscope limb, carrying the optical body, on a joint that permitted its inclination to either side. If a suitable object were placed some distance above the level of the stage, the optical body could be inclined so as to view it from one side of its horizon to the other, or even beyond. The side-inclination of the stage can only be regarded as a tentative process of examining the object from side to side, when compared with M. Jaubert's method. Not that the general adoption of M. Jaubert's idea is to be approved, but when we are seeking the best means of making a special examination, we must take cognizance of apparatus that has already been designed for that purpose.

M. Jaubert is also said to have made and published, and provisionally patented in England, a practical binocular Microscope, before either Professor Riddell's or Mr. Wenham's, or even Sir Charles Wheatstone's binocular projects were published.

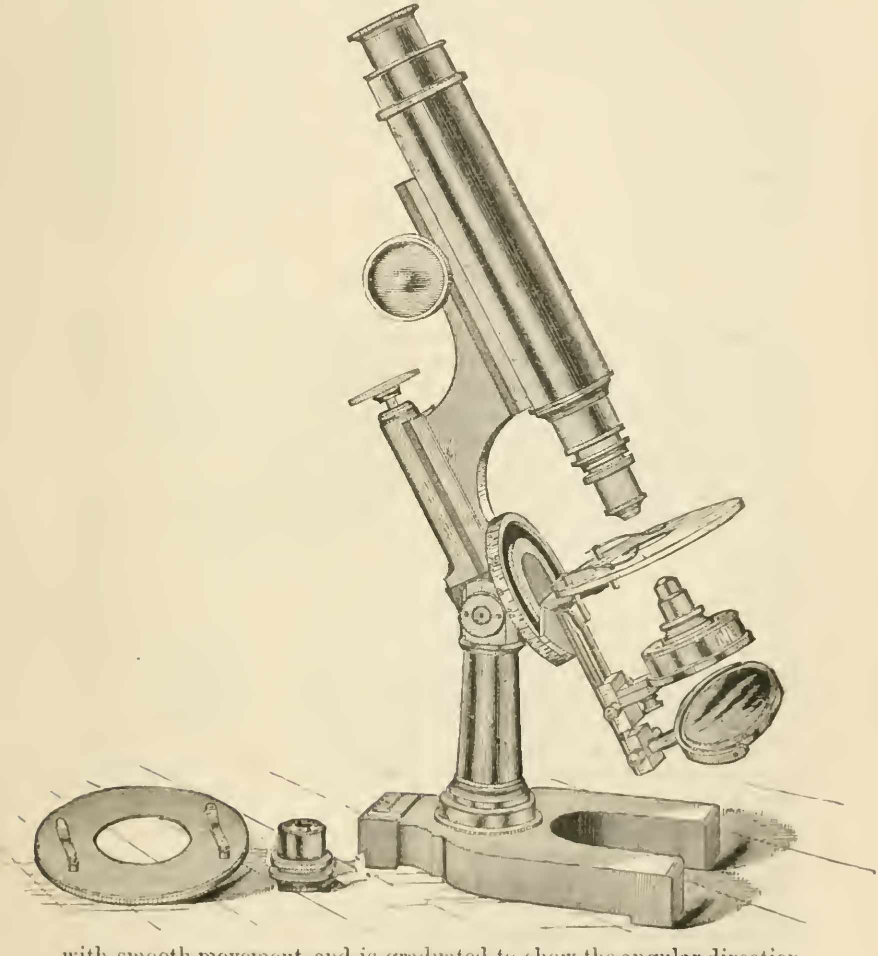
Sidle and Poalk's Acme Microscope.†— This Microscope, shown in Fig. 39, is the first cheap instrument that we have seen with a swinging substage.

The general form of the instrument hardly needs any description, but it may be mentioned that the *stage* is made of two thin, circular brass plates, the upper one (shown in the lower left-hand corner) fitted to turn upon the lower, so that the object can be rotated in the field of view. The stage can be centered. The upper plate can be removed, and two spring clips attached to the lower one, either above or below, thus making a stage for use with oblique light. The aperture in the stage has a standard-screw thread, to receive various accessories for illumination when it is desired to have the mirror move independently of them, and also to afford a means of mounting the selenite so that it can be revolved without turning the Nicol prism.

* 'Engl. Mech.,' xxxi. (1880) p. 135.
† 'Am. M. Micr. Journ.,' i. (1880) p. 8 (1 fig.).

The *mirror and substage* are both attached by sliding fittings to the same bar, which carries them around the object as a centre. The circular piece at right angles to the stage, gives steadiness to the bar,

FIG. 39.



with smooth movement, and is graduated to show the angular direction of the illuminating pencil.

The horseshoe *base* is reversible, so that greater steadiness can be ensured when the stand is used in a horizontal position.

Powell and Lealand's new $\frac{1}{8}$ Water-immersion and $\frac{1}{25}$ Oil-immersion.—At the Conversazione of the Royal Society, on April 28, Messrs. Powell and Lealand exhibited their *new formula* $\frac{1}{8}$ water-immersion on *Amphipleura pellucida* (dry) illuminated with oblique light from their oil-immersion condenser. The new objective has an aperture, measured in crown glass, of 112° (= 1·27 numerical aperture, nearly), which is stated to be the highest aperture hitherto produced in Europe for a water-immersion. It is understood that these opticians have also produced $\frac{1}{4}$ and $\frac{1}{16}$ objectives on similar formulæ, and of nearly equivalent apertures.

At the last scientific evening of this Society, Messrs. Powell and Lealand also exhibited their new $\frac{1}{25}$ oil-immersion on *Podura* and *P. angulatum* with central light from their achromatic condenser. The aperture of the new objective, measured in crown glass of mean index 1·525, is 110° (= 1·26 numerical aperture, nearly); the covering-glass used was stated to be ·004 inch, and the working distance also ·004 inch, giving a clear object-distance of ·008 inch from the plane surface of the front lens. In consequence of this increased working distance the objective will be found far more convenient to use than the $\frac{1}{25}$ on earlier formulæ by these opticians.

Zeiss's Adjustable Objectives.—These objectives, in which the magnifying power can be varied from that of a 5-inch to a 2-inch lens, have been further improved. In the original form the adjusting screw pushed the *back* combination upwards, which necessitated an alteration in the diaphragm usually placed at the objective end of the tube. In the improved plan the screw pushes the *front* combination forward so that the objectives can be used with any stand.

Durability of Homogeneous-Immersion Objectives.*—Professor Abbe writes that Dr. Woodward's homogeneous-immersion and the few others returned to Zeiss for repairs were "not damaged at all," the oil it would seem having entered at the screw at the lower part of the setting, and *not* at the edge of the front lens. Only two instances are known in which the setting of the front lens became leaky, the objectives being some of Zeiss's earliest productions. No homogeneous-immersions now leave the works until the tightness of the front lens has been ascertained by several prolonged exposures to oil.

Professor Abbe considers that the durability of homogeneous-immersion objectives is in no way inferior to that of other objectives, and remarks that the cedar oil supplied by Zeiss does no injury to the varnish of stands, or other brasswork, as shellac is not dissolved by it.

Wenham's Dry Paraboloid and Amphipleura pellucida.—Mr. George Williams has succeeded in satisfactorily resolving, on bright ground, the transverse *striæ* of *A. pellucida* with Zeiss's water-immersion objectives (G $\frac{1}{8}$ and K $\frac{1}{20}$), using as a condenser only Wenham's ordinary dry paraboloid, having a diaphragm at its base, or a stop in its cup, such diaphragm and stop having respectively an eccentric aperture. Both diaphragm and stop are made of sheet metal, Figs. 40 and 41 being forms of the diaphragm; Fig. 42, of a shutter laid over the apertures (of Fig. 40) not intended to be used; and Figs. 43 and 44, of the cup stop. The figures are drawn to full size.

The diaphragm and stop are not used in combination, but separately; and the forms figured have been adopted as giving the best

* 'Engl. Mech.,' xxxi. (1880) p. 135.

results, one being the more effective upon certain frustules, or with a particular paraboloid, or a given objective.

The diaphragm is a circle of the exact diameter of the tube in which the paraboloid is mounted, and rests upon the ring in which the lens is set, and is therefore in close contact with its base, excluding all light except such as may enter through the aperture. It is supported by a slight inner tube sliding conveniently tight within that holding the paraboloid. The stop fits the cup accurately, dips into it, and completely lines its inner surface, admitting rays only perpendicularly through the eccentric opening. The stop is thus substituted for that usually supplied with a paraboloid (which has to be removed), and a flat-headed pin passed through its central hole into the perforation in the paraboloid (fitting moderately tight), suffices to maintain it steadily in position. No stop is needed with the diaphragm.

Fig. 40.

Fig. 41.

Fig. 44.

Fig. 42.

Fig. 43.

A slide of *A. pellucida* being placed upon the stage, the paraboloid, carrying its diaphragm and shutter, or stop, is inserted in the substage and racked up to focus, and the concave mirror manipulated in the axis of the Microscope until the light is thoroughly introduced through the eccentric aperture, the due accomplishment of which causes a brilliant but narrow luminous streak to appear across the slide. This arrangement effected, objective focussed, and valve found (isolated, and appearing to be otherwise well placed), the stage is rotated until the diatom under observation lies exactly lengthwise in the direction of the beam of light; which is made evident by the bluish colour, and equally illuminated and undistorted form, of the outline and midrib of the frustule, the objective being carefully corrected. A few moments' gazing prepares the eye to perceive the fine striæ which are then distinctly resolved, and, if the diatom be favourably placed, over its entire surface. The light is managed to avoid glare, and modified to suit the eye-piece, a somewhat dusky hue being preferable and most conducive to distinctness. The beam admitted through an aperture of any of the sizes figured is found sufficient to amply illuminate the field of the G objective with the fourth eye-piece—(× 1150)—an important consideration, as many valves will scarcely yield to less amplification.

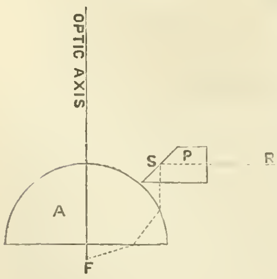
One of the dry strewed slides, at present supplied by Wheeler, is used by Mr. Williams, the specimens in which he is advised are of fair average difficulty. Equally satisfactory results are, however, obtained with slides by Hardman (Baker's), and other mounters; no valve resolved was in any instance specially selected, or "picked."

But very few trials have as yet been made with specimens mounted in balsam. Striæ have, however, been certainly discerned on some valves so mounted; and observations will be continued as appearances would seem to justify the anticipation of completely successful resolution.

It is not pretended that there is any novelty in the use of a diaphragm with the dry paraboloid; but it is believed that a stop as above described and figured has not been before applied to its cup. Diaphragm or stop, however, resolves *A. pellucida*, a little experience of their action demonstrating that in some respects the latter is occasionally preferable to the former. It is further believed that there is no previously published record of the resolution of *A. pellucida* by means of the dry paraboloid, and the result exemplifies yet another use (among the many) to which the Wenham dry paraboloid can be applied, and its consequent great efficiency as an accessory to the Microscope.

Tolles's Opaque Illuminator.*—One of the most ingenious methods of illuminating objects by means of light incident upon the surface under examination with high powers has been devised by Mr. Tolles for Professor W. A. Rogers, F.R.M.S., of Harvard College Observatory, U.S.A. Professor Rogers has given much attention to micrometry and the preparation of diffraction rulings, and in the examination of specimens of his own rulings on steel, &c., he found the need of "opaque illumination," which led to the adoption of the following plan, which he considers to be superior to any other he has tried.

Fig. 45.



In Fig. 45, A represents the front lens of a ½-inch objective (not to scale). P is a small and narrow prism made to side into the brass mount of the front lens to about the position shown. Parallel rays can be projected throughout the prism in the

* 'Engl. Mech.,' xxxi. (1880) p. 135.

direction of the ray R, and will be totally reflected at the internal surface S, whence they will fall upon the spherical surface of the lens A, and be refracted nearly to its focus F.

Spencer and Tolles Camera Lucida.—Mr. Stodder, of Boston (U.S.), sends us a description of a camera lucida, which he says is largely used in America, and although very old has not hitherto been described.

The original form was the design of Spencer, and its construction is shown in the diagram Fig. 46, where A A is the axis of the Microscope, B the lens of the eye-piece, and C a prism, mounted in front of B. The ray D from the pencil and paper passes through the prism and reaches the eye at E, the ray from the eye-piece being reflected at the upper surface of the prism, and also reaching the eye at E.

Fig. 46.

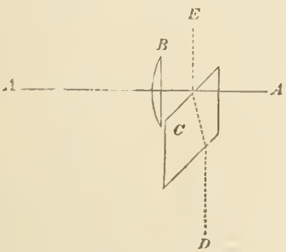


Fig. 47.

Fig. 48.

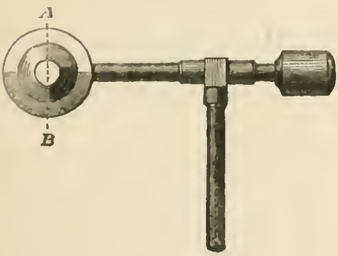
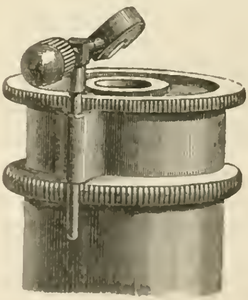


Fig. 49.



The principle of this apparatus is obviously identical with that of Dr. Beale's "Neutral Tint Reflector," but it is claimed to be an advantage that whilst the thin plate is liable to give reflections from both surfaces, the second surface in the Spencer form is so distant that the internal reflection does not reach the eye. The head does not require to be held immovable, but one may leave off work and begin again as often as desired. It can, moreover, be used with high as well as low power objectives.

Mr. Tolles subsequently devised a modification of this camera.

It consists simply of a circular piece of glass, of the form and mounted in the manner shown in Figs. 47 and 48 (Fig. 47 being a section, on the line A B, of Fig. 48), and placed with the plane side in front of the centre of the eye-piece, as in Fig. 49. This plan enables the camera to be placed closer to a deep eye-piece. The effect is, however, precisely the same as in the Spencer form, but a little more trouble is required to get the reflecting surface into the right position, which is however compensated for by the greater economy of construction.

Reflecting Plates for Microscopical Investigations.* — Herr Hilgendorf points out that it is often difficult or impracticable with flat objects to bring the sides (or with elongated objects, the ends) into the proper position for observation. The author uses, in such cases, a small strip of reflecting plate (silver-leaf, such as can be detached from ordinary looking-glass or silvered cover-glass), which is attached to a piece of glass from about $\frac{1}{2}$–1 mm. in thickness. The short side of the latter is ground to an angle of 45°, and the facet thus obtained carries the little reflecting plate. This, turned upwards, is put close to the surface to be examined, which is in a perpendicular position; by looking from above into the reflector, the reflected image can be observed in a position somewhat sideways from the original, and at a lower level. The nearer the object is to the reflecting plate, the sharper and higher the image appears. Direct application to the reflecting surface would therefore be the most advantageous; but in this case transmitted light, or at least central light, must be dispensed with in the examination. Transverse sections of hairs lying horizontally have been shown by the author by this method. The extent of amplification with which the reflector can be used depends not only on the nature of the object, but on the perfection of the reflector. With imperfectly arranged contrivances, the use of an amplification of about a hundred times has been found possible. Considering the cheapness of the reflectors, their application is much to be recommended for preparations whose sides would otherwise be invisible. The author suggests that the same reflectors reversed, that is, with the reflecting surface turned downwards, could be made available for illuminating laterally an object placed close beside them.

Parkes's Microscope Lamp with Cooling Evaporator.—This lamp (designed by Messrs. Parkes, of Birmingham) is shown in Figs. 50 and 51. A is a lacquered brass stand, with heavy foot; B the brass lamp, capable of holding paraffin for eight hours' consumption. This may be raised or lowered on the sliding upright from 4 to 12 inches; that is, the burner is 4 inches from the level of the table, when at its lowest point. C is a bronzed copper cylindrical shade, $3\frac{1}{4}$ inches diameter, with hood at front to prevent the upward reflection of light. At the back is a parabolic reflector transmitting nearly parallel rays, which will slide out for cleaning; when desirable a disk of cardboard may be placed over this reflector, for "white cloud" illumination. At the front is a tinted glass "light modifier," which is secured by a bayonet joint, and may also be removed when necessary.

* 'SB. Gesell. Naturf. Freunde zu Berlin,' 1879, p. 2.

D is the *cooling evaporator*, constructed of thin bronzed copper, and covered with a lid of perforated copper. A layer of thick felt is placed inside for *saturation.* This vessel, filled with water and placed over the shade as soon as the lamp is lighted, at once prevents the radiation of heat upon the observer's head, and its use, during a long evening, "prevents an annoyance which has long been felt by every microscopist." The felt only requires remoistening once in every five or six hours. If a thermometer is placed say 8 inches from the lamp when it is first lighted, and on a *level with the top of shade* (which is the usual position of an observer's head when using the Microscope), it will be found that after the lamp has been burning an hour, the thermometer will only indicate a rise of three or four degrees, whereas with lamps having a terra-cotta or metallic shade the temperature would be raised from twelve to fifteen degrees.

Fig. 50.

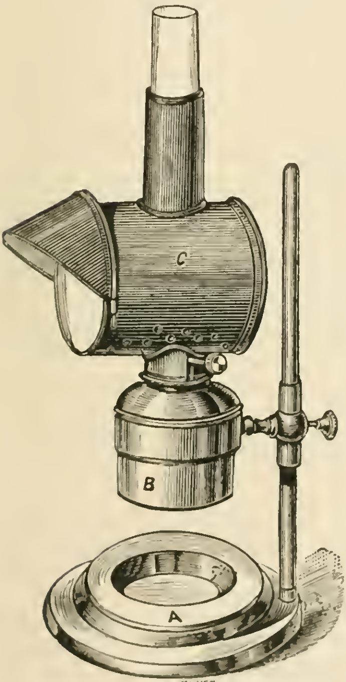
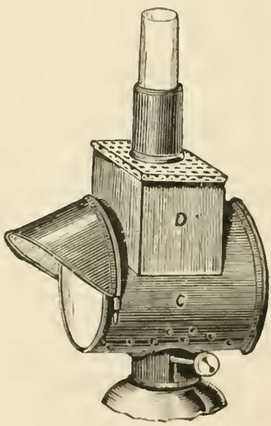


Fig. 51.



It is claimed for this lamp that, independently of the cooling arrangement, it fulfils all the conditions of the most approved lamps hitherto constructed for Microscopic use, with the addition of a more effective shade and reflector. In consequence of more perfect combustion, resulting from the shape of the chimney and arrangement for the ingress of air, an abundance of light is supplied for the higher powers.

JOURNAL

OF THE

ROYAL MICROSCOPICAL SOCIETY;

CONTAINING ITS TRANSACTIONS AND PROCEEDINGS

AND A SUMMARY OF CURRENT RESEARCHES RELATING TO

ZOOLOGY AND BOTANY

(principally Invertebrata and Cryptogamia),

MICROSCOPY, &c.

Edited by

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The addition of a little salicylic acid modifies the delicate purple-rose tint and destroys the dichroism, so that the orange-yellow is no longer seen by reflection; moreover, it only preserves the liquid for a week or two, after which the phenomena alluded to set in as above described. Finally it was found that ether, which has no solvent action on palmelline and does not affect its composition nor coagulate it, may be used with success to preserve the liquid for an indefinite period. It is sufficient to add a small quantity of ether to the solution in a tube, cork it, and turn it over once or twice so as to dissolve as much ether as possible in the liquid, to preserve it with all its properties for several months. As long as the contents of the tube have a strong odour of ether no decomposition sets in, and the optical properties of the palmelline remain intact.

This simple method of preservation may be found applicable to many other organic substances upon which ether exerts no chemical action.

MICROSCOPY, &c.

Localities for Fresh-water Microscopical Organisms. — In the recent discussions on the proposed purchase of the works of the Metropolitan water companies, the case of Birmingham, where they were acquired by the Corporation authorities, has been referred to. London microscopists would have good reason to rejoice if the result that has been obtained in Birmingham were repeated here, so that an abundant supply of rare and interesting species of Rotifers, Infusoria, &c., should be brought to, or rather within, every microscopist's doors, without the drawbacks of pond-hunting. In Birmingham the ordinary supply of water for drinking and other purposes, received through the pipes, has just been found to contain the rare Rotifer *Anuræa longispina*, first found last year by Professor Kellicott of Buffalo, U.S.A.;* also *A. stipitata*, *Triarthra longiseta*, *Salpina redunca*, *Dinocharis pocillum*, and some Tardigrada.

Of other forms, the latest addition to fresh-water life is *Ceratium longicorne*, very plentiful, but few living, though its congener *Peridinium tabulatum* seemed none the worse for its temporary sojourn in the pipes. Large quantities of the curious compound organism, *Dinobryon sertularia*, are also to be noted. The Vorticellidæ and Entomostraca are represented, the former by both branched and simple forms, and the latter principally by *Bosmina longirostris*, with his two long and curved antennæ, evidently much the worse for his compulsory visit to town, either the distance travelled or the mode of transit being unsuited to his well-being.

Diatoms are mostly present in the stellate species, *Asterionella formosa*, with a few specimens of *Synedra* and *Pleurosigma*, while Desmids are fairly plentiful in *Pediastrum granulatum* and *Hyalotheca*; also *Pandorina morum*, *Clathrocystis*, and other algæ.

Mr. J. Levick, from whose paper † the above list of organisms is taken, suggests that their presence should rather be considered as

* See this Journal, ii. (1879) p. 157. † 'Midl. Nat.,' iii. (1880) p. 166.

indicative of the general good quality of the water than otherwise, as some of them, at least, are known at home and abroad as the inhabitants of deep, clean water only.

It is curious that hitherto neither *Leptodora hyalina* nor *Hyalodaphnia Kalbergensis* have been found by London microscopists, and yet it cannot be doubted that it must be as plentiful in the neighbourhood of London as of Birmingham. For the former a deep reservoir seems to be essential, the net being dipped 6 or 7 feet.

Collection of Living Foraminifera.*—Having been occupied for some years in the study of the rhizopodous fauna of the coasts of France, M. Vanden Broeck thinks it may be useful to those similarly occupied to publish instructions with a view of facilitating the collection of Foraminifera. The original instructions are very concise and they necessarily suffer in the further condensation which we have been obliged to give them.

In general, the coarse and purely quartzose sand is very poor in Foraminifera, though under certain favourable conditions interesting results may be obtained, when for instance it contains a sufficient quantity of the débris of shells, sponges, algæ, &c.

The tide often washes up on the shores of an indented coast a kind of littoral band, at high-water mark, consisting of algæ and light débris of shells, sponges, &c., which generally furnishes good material for the collection of Foraminifera. The débris, if it contains many algæ, should be washed in an abundance of water, lightly rubbing it between the hands. To preserve the Foraminifera alive, salt water must be used; fresh, if the shells only are desired, the latter preventing the saline efflorescences which would otherwise cover the shells. The floating residue must be thrown away, carefully preserving the sand deposited in the vessel. Precautions must be taken not to throw away the Foraminifera, which, being lighter than the grains of quartz, float above the sand, under (not on the surface of) the water. The water can also be filtered through coarse muslin and the residue of algæ, &c., rejected.

The algæ gathered on the beach, or better still, taken from the place of their growth, give equally good results. It is useful to preserve unwashed a few roots of algæ and flexible polyps, as a great number of living Foraminifera are attached to the leaves and false roots.

We sometimes find on the coast, amongst the shells and Foraminifera of recent fauna, others coming from fossil beds, tertiary, cretaceous or otherwise, which, bordering on the sea, are worn away by the action of the waves, or crumble into it from the cliffs which are undermined at high tide. Thus fossil Foraminifera become dispersed among the recent fauna, and it is therefore very important to take into consideration the neighbourhood in which the sand has been collected.

In the coarse sand and residues of the shore we generally find nothing but rolled and worn Foraminifera belonging exclusively to

* 'Journ. de Microgr.,' iii. (1879) p. 237.

the large, thick-shelled species; those with fragile and delicate shells, that is to say the most numerous and beautiful, can only live and develop properly on muddy bottoms, or where the sand is fine and somewhat slimy, and it is necessary therefore to investigate such deposits also. For this purpose, some of the following indications may be followed according to the locality.

Collect at low water (either with the hand or a small dredge) the superficial portion of the mud or slimy sand found in ports or the mouths of rivers, or higher up in their course if the water is salt. The glutinous coating, generally green or brownish, which covers the mud or slimy sand in quiet places often gives excellent results. The thick black mud beneath is less rich in Foraminifera than the upper portions.

It is also useful to explore the large pools which remain at low water, either on the shore when the sand is not too coarse, or in the estuaries, or even the cavities often met with among the rocks or at the foot of cliffs. It must be remembered that the most favourable spots are always those which are covered with very fine or slimy sand. Sediments which are coarser but rich in fine débris, are also favourable.

Whitish zones are sometimes seen on the margins of pools left at low tide, composed of little heaps accumulated in the numberless ridges produced in the sand by the retreating water. These whitish heaps consist of small organic débris, spiculæ of sponges, spines of echinoderms, fragments of shells, &c., often mixed with a quantity of Foraminifera, of which a great many can be collected by a spoon.

By means of a simple magnifier the presence of living Foraminifera can be established on the spot. If, for example, some of the deposit is examined in a shallow vessel (such as the cover of a tin box) and under a small quantity of water, the Foraminifera will be readily recognized as small coloured points of red, rose, or yellow—tints which are given to the thin shell of many species by the colour of the sarcode within.

The places where the water is relatively quiet are the only really favourable ones for finding Foraminifera. Dredgings from a depth of from 8 to 10 metres (when the water at the bottom is little moved, however rough it may be on the surface), always give good results, unless the bottom consists of purely quartz deposit or gravel, as is the case in regions subjected to rapid submarine currents, as in the Straits of Dover. The interest of the collections increases in proportion to the depth at which they have been made.

For the benefit of those who have not dredges at their command, it may be mentioned that the mud brought on board by the anchors of ships, or the detritus on the nets of fishermen, furnish species which are not found on the coast.

Foraminifera may also be found in the contents of the stomachs of fishes, molluscs, crustacea, actiniæ, medusæ, salpæ, &c.

Certain species of Annelida, *Terebellæ* for instance, form a protecting sheath which often contains Foraminifera not found on the shore.

The sand and slime of salt marshes in periodical communication with the ocean furnish species which almost exclusively inhabit brackish water, and others which present special characters.

In the same way as the cases constructed by the larvæ of the Phryganeidæ give in fresh water a rich harvest of small shells and Entomostraca, so also in brackish water they contain Entomostraca and Foraminifera often of rare and interesting species.

Oyster and mussel beds are also favourable spots, but in examining Foraminifera from artificial oyster-beds it must be taken into consideration whether the oysters are of French, English, American or other origin, as Foraminifera foreign to the region may be found which were originally brought there with the oyster shell.

In a given locality many variations are found in the faunal elements, according to the time of collection; it is advisable, therefore, to collect at different seasons, and during two or three consecutive years, if the fauna is to be thoroughly studied. Changes of temperature are caused by currents, especially deep currents, which thus influence the fauna of the bottoms over which they pass as well as by the foreign matter which they bring. It will be useful therefore to find out whether they are hot or cold, periodical or continuous, and to know their origin and direction.

In conclusion, the author points out that his instructions apply equally to the Entomostraca which generally accompany Foraminifera in their different habitats.

Cleaning Foraminifera.*—After having read Mr. Vorce's article on cleaning Foraminifera,† it occurred to Mr. K. M. Cunningham to use electrical force to extract the shells in the dry way. For this purpose he used a small tin lid, 4 inches in diameter, filled with a preparation of rosin and sealing-wax, the resinous surface of which, for convenience, he excited with an artist's brush, known as a "badger blender." The sand from sponges or foraminiferous marl is spread thinly over as large a surface as convenient; the cake of rosin is then excited by passing the badger's-hair brush over it several times, and then turning the excited surface of the resinous cake down to within a quarter of an inch of the material, and passing it gently over it. The result will be that innumerable light particles will be attracted to the excited surface, and will remain there, while the sand will be attracted and repelled, thereby leaving a large percentage of Foraminifera, spicules, &c., adhering to its surface, which may then be brushed off into any suitable receptacle. The above plan may be tested on a small scale by exciting the end of a large stick of sealing-wax. Damp weather is unfavourable for the experiment.

Wax Cells.‡—Referring to Dr. Hamlin's note on this subject,§ it is suggested (1) that before applying pressure to the outer edge of the disk a little turpentine should be applied to the lower surface with a brush extending to the proposed width of the ring, and (2) that instead of a *slight* moistening of the knife-blade, water should be used *freely*.

* 'Am. M. Micr. Journ.,' i. (1880) p. 88. † *Ante*, p. 497.
‡ 'Am. M. Micr. Journ.,' i. (1880) p. 98. § *Ante*, p. 507.

Carbolic Acid for Mounting.*—Mr. F. Barnard, of Kew, Victoria, writes that some years ago he mentioned the use of carbolic acid (the best crystallized with just sufficient water to keep it fluid) in mounting microscopical objects, and is led to believe that the subject is comparatively unknown in England, though in use in Victoria more than ten years, and to such an extent that turpentine is seldom used in many studios. The first specimen he saw it tried upon was the head and jaws of a spider mounted by Mr. Ralph, the President of the Microscopical Society of Victoria, which led Mr. Barnard to try it in various ways to render objects transparent, and now he seldom uses anything else. Whether it is animal or vegetable tissue the effect will be the same, the acid will in a very short time render the object transparent, and the Canada balsam will when applied run in as readily after it as turpentine.

In the case of such an object as a palate of a mollusc, wash it well in water and remove it to a bottle of the acid for a few hours, or if it is desired to mount it at once, place it after washing on a glass slip in proper position for mounting and drop one or two drops of the acid on it. At first it will look thick and cloudy; warm the slide over the spirit lamp, let it cool, and drain off the acid; if not perfectly clear when cold, apply some fresh acid and warm again; place on a cover if not previously done, and apply the balsam, by means of a little heat it will run under. With polyzoa the easiest plan is to place them in a little hot water which softens them, then lay them out on a glass slip; place another on it which is of sufficient weight to keep them in position while they dry, then drop them into a bottle of carbolic acid and soak for a time; twenty-four hours will render any polyzoa transparent without rendering them brittle, and the author says he has mounted specimens perfectly clear and transparent in ten minutes from the time they were alive in the zoophyte trough, treating them as above recommended for palates. For gizzards and parts of insects he also considers that nothing comes near it.

One great advantage carbolic acid has over turpentine is that it never renders specimens brittle. They can be pulled about as readily as when fresh. Should there ever be any clouding, it arises from the moisture of the object, not from the carbolic acid, but from want of it. It is comparatively inexpensive, far less unpleasant in smell, and not so sticky and dirty in use as turpentine. It is not necessary to let the object dry, which invariably alters the shape more or less; still, should it be dry it is not any time becoming transparent compared with the old process of soaking in turpentine. We all know how difficult it is to render Foraminifera transparent and free from air ready for mounting in balsam. One trial of carbolic acid will convince the most sceptical of the advantages it has over turpentine, benzine, &c. The only drawback to its use is that it often renders some vegetable tissues too transparent.

Double-staining of Vegetable Tissues.†—In this paper the writer (who only gives an initial) says that, having used a number of dyes in

* 'Sci.-Gossip,' 1880, p. 137. † 'Am. M. Micr. Journ.,' i. (1880) p. 81.

double-staining vegetable tissues, the conclusion he has arrived at is, that no rules can be given which will ensure success in every case. The process is familiar to every working microscopist, but the limited number who have fairly succeeded in differentiating the tissues is somewhat surprising. In his own experience he has met with some sections which obstinately refused to act as they should under the operation of the two colours, but even these, with patient manipulation, can be induced to show some results, even though they may not exhibit that sharpness and purity which it is the aim and object of the mounter to obtain.

A writer in 'Science-Gossip' has come nearer to the true laws governing the process than any one who has written on the subject; he has at least indicated the direction in which the practical worker must look to attain success. The theory of the present author is slightly different, and consequently his process varies somewhat, but in the main it is the same. The capacity for staining tissue resides more in the colours than in the tissue itself. A stain may be permanent, unless it is driven out. It may be driven out by some solvent, by some bleaching process, or lastly by some other colour. Some tissues hold the stain more tenaciously than others, probably on account of their varying density. Thus the spiral and bass-cells will retain a colour longer under the influence of a solvent than the softer and more open parenchymal cells. He endeavours to take advantage of this property by giving the whole tissue all of one colour that it can be induced to take, and then driving it out of the parenchymal tissue by a stronger colour, stopping the process at the moment when the second colour has completely replaced the first colour in the soft tissues, and before it has begun to act upon the more dense cells. If a section be stained with roseine and then be left long enough in a solution of Nicholson's blue, the whole section will be blue, with no visible trace of red. If it be taken out before the blue has permeated the entire tissue, the red will show, in some parts, quite clear and well-defined among the surrounding blue tissues. Following out this principle, that exact point must be determined when the blue has gone far enough.

In practice the theory is carried out as follows: A two-grain neutral solution of eosin is used, and in this the prepared sections are preserved until the operator is ready to use them. They keep perfectly well in this solution, and are always ready to undergo the final process, which requires but a very short time before they can be placed, fully finished, under the covering glass. After taking them from the eosin solution, they should be passed through 95 per cent. alcohol, merely to wash off the superfluous colour, and then placed in a half-grain solution of Nicholson's blue made neutral. The time required in the blue solution varies with different tissues, and in the nice adjustment of this time lies the whole success of the operation. Three or four sections of each kind are generally spoilt in determining the exact time required. A section is taken from the eosin, holding it lightly in a pair of forceps, rinsed off rapidly in alcohol, and then immersed in the blue, still in the forceps, while ten can be counted with moderate haste. Then quickly place it in clean alcohol, and brush lightly with a camel's-hair brush. This immersion in clean alcohol seems to check the operation of the blue instantly. It should then be examined under a 1-inch objective to determine whether the exact point where the blue and the red remain distinct has been reached. If the blue has not occupied all the softer cells, another section should be taken and put through the same process, counting twelve, and so on, until the proper point is reached; or, on the other hand, decreasing the count if the blue has infringed upon the red in the more dense tissue. Having thus determined the count for the sections of that particular material, the remainder of the sections are passed through the blue into the alcohol, merely counting off the immersion of each section. Then place the sections for a few moments in absolute alcohol, which seems to fix the colours, then through oil of cloves into benzole, and mount in dammar and benzole. It is sometimes advisable, with delicate tissues, to merely rinse off the blue in 95 per cent. alcohol, and fix the colours at once in absolute alcohol, but every operator will learn the minor details for himself in the manipulation.

Of course, with the "rule of thumb" method of counting off the time slight variations will occur which will mar the beauty of the finished product; besides which minute differences in the thickness of the section will affect the result, and even a distance of a quarter of an inch in the same stem will make a difference in the density of the tissue, which will be obvious in the sharpness of the colours under the objective, so that the operator should not be disappointed if out of a dozen slides only four should be worth preserving. The others can go into the borax-pot to be cleaned for another operation. The beauty of those which do pass inspection will amply repay for the labour on the spoiled ones.

The writer says that he has perhaps been needlessly minute in the description of the process he has employed, but he has been so often hampered by the lack of minuteness in descriptions of processes by others, which he has been endeavouring to carry out, that he deems it better to err upon the safe side, even at the risk of being considered dry or prosy.

A note is added as to the use of eosin. He was attracted to it by its exquisite purity of colour under transmitted light, and its perfect transparency. Sections preserved in its solution were found always to retain their transparency, and did not become clogged or thick with colour, so that when taken out after months of immersion the most dense cells were no deeper in colour than the solution itself. So far as regards its hold upon the tissues, it is as strong as roseine, or any of the heavier colours. He cannot testify as to its permanence, but has some slides that were prepared over a year ago, and appear to be as bright and pure as when they were mounted. Contrary to the experience of some others, he has not found that the benzole has any bleaching effect, and it has been used with dammar in preference to the usual balsam. Slides prepared with dammar, however, should have a thick ring of varnish run around them, as the dammar is brittle, and should not be trusted alone to hold the covering glass.

Wickersheimer's Preservative Fluid and Vegetable Objects.*—Dr. K. Prantl describes the results of his experiments with this fluid,† which, though so valuable for animal substances, he judged beforehand would not be applicable to parts of plants. The density of the fluid removes the turgidity of the cells without hardening the protoplasm quickly; hence the delicate parts of the plant lose their firmness, and consequently their relative position, even in the fluid. The flowers of *Tropæolum*, for example, collapsed after being a few hours in the fluid, and became unrecognizable. The lamellæ in the pileus of different *Agarici* were greatly distorted, not only after being taken out of the fluid, but whilst still in it. Those parts of a plant which possess sufficient consistency alone preserve their shape, as Ferns rich in sclerenchyma (*Blechnum australe*), and the leaves of Coniferæ, objects which can be preserved as well dry. If pine branches, however, are laid in the fluid, the falling off of the acicular leaves in drying is prevented, but this can be done just as well by concentrated glycerine.

Further, the fluid kills the protoplasm, hence the colouring matter held in solution by the cell-sap comes out in a short time. Chlorophyll has hitherto been retained, but changed into a brownish tint.

Hardening Canada Balsam in Microscopic Preparations by Hot Steam.‡—The inconvenience arising from the slowness with which Canada balsam hardens, especially in summer, has been felt by all engaged in making permanent preparations. M. Passauer describes a small and simple apparatus which he made for the purpose of overcoming this objection. It consists of a round vessel of tin, about 18 cm. in diameter and 6 cm. deep, with a tin cover $19\frac{1}{2}$ cm. square (for convenience in placing the slides), to the under surface of which a circular rim about $1\frac{1}{2}$ cm. deep is soldered and made to fit easily into the vessel. On the upper side the cover is also furnished with a rim about 5 mm. deep. In one corner of the lid, but inside the lower circular rim, a tube 6 cm. in diameter and 10 cm. long is soldered and passes through the lid.

In using it the vessel is half filled with boiling water, covered with the lid, and the preparation to be hardened laid on the latter, and the temperature of the water kept at boiling-point by a lamp placed under the vessel. Special care must be taken that the steam does not become too hot, otherwise bubbles would be produced in the balsam and the preparation be spoilt, hence the small chimney is provided, through which part of the steam can escape. By this means the balsam can be hardened in 1 to $1\frac{1}{2}$ hours.

Ringing and Finishing Slides.§—The following article by Dr. C. Seiler gives some useful hints:—"A great deal may be said in favour of and against the careful finishing of microscopical slides, but nobody will deny that a nicely-ringed preparation looks better in a cabinet,

* 'Bot. Centralbl.,' i. (1880) p. 26. † *Ante*, p. 325.
‡ 'Zeitschr. f. Mikr.,' ii. (1880) p. 194.
§ 'Am. Journ. Micr.,' v. (1880) p. 94.

and is better taken care of by its owner and his friends, than one which is not thus embellished, and which shows a greater or less amount of balsam irregularly distributed around the edge of the cover. I will, therefore, jot down a few remarks on the ringing and finishing of slides. After the object has been mounted in balsam and the cover applied, it will be found that there is always a greater or a less surplus of balsam which comes out from under the cover. This should be allowed to dry, and when thoroughly hard it can be scraped off with a knife. If a round cover has been used, the slide is then centered on a turntable, and the cover cleaned with benzole, which is best done by dipping a soft linen rag in the benzole and applying the wet place with the forefinger to the centre of the cover-glass; the turntable being revolved, the finger is quickly drawn toward the edge of the cover and the rag removed. One or two such wipings of the cover will be found sufficient to remove all traces of balsam or extraneous dirt. The slide itself may then be wiped also with benzole, and it is then ready for the application of a ring.

The best ringing medium for balsam mounts is dammar dissolved in chloroform, because if it is inclined to run under the cover it will readily mix with the mounting material without leaving a visible trace behind. I find it best to apply the brush to the edge of the cover almost dry, the slide on the turntable spinning rapidly around, so as to make a track in which the dammar solution will readily flow. The second application is to be made immediately following the first, with the brush full, so that there will be a small drop of solution on the end, which is allowed to touch the edge of the cover without letting the brush itself come in contact with the glass. This is repeated until the ring is built up to the proper size. It should be borne in mind, however, that in drying, the ring of dammar will shrink considerably, and thus it is necessary to make another application after a few hours' drying.

Dammar or balsam dissolved in benzole or benzine is objectionable, because the solution will evaporate too quickly to allow of a proper building up of the ring, and if such is attempted the result will be a ring full of minute air-bubbles. White zinc cement, Brunswick black, asphaltum varnish, and other coloured cements may be employed to cover the first ring of dammar; but they should never be used alone, as they are sure to run in sooner or later, no matter how hard the balsam may be. I think that the glass-like ring obtained with dammar gives a better appearance to the slide and is more durable than any of the rings made with coloured cements.

When glycerine mountings, or objects mounted in a watery medium are to be ringed, it is necessary to first get entirely rid of any glycerine which might be on the cover or slide. To do this I apply a spring clip to the slide, which serves to hold the cover in position after it has been centered, and then wash off the surplus glycerine with a stream of water from a syringe. The slide is then set on end to dry, and a ring of a waterproof cement is applied around the cover. Such a cement may be bought under the name of Bell's cement, the composition of which is a secret. A better and less expensive cement may, however, be made by dissolving 10 grains of gum-ammoniac in 1 ounce of acetic acid (No. 8), and then by adding to this solution 2 drachms of Cox's gelatine. The resulting liquid flows easily from the brush and is waterproof, especially so if, after the ring has set, it is brushed over with a solution of 10 grains of bichromate of potash in 1 ounce of water. But what especially recommends this cement is its great adhesive power to glass, even if there should be a little glycerine on the edge of the cover. After the gelatine ring is dry, any other cement may be employed to cover it, according to the fancy of the preparer.

When a considerable number of different objects are being prepared at the same time, it is of great importance to be able to tell one from the other, so as finally to label them correctly without subjecting them to a careful microscopical examination. A paper label, under the frequent necessary handling of the slide, becomes soiled, and the writing frequently illegible; while a figure or even a full label, written with a pen upon the glass slide, will remain intact throughout the manipulations of cleaning and ringing, and at the same time can easily be removed by a little rubbing with a rag dipped in water.

In order to facilitate the finding of slides in a large collection, it is advisable to place the label bearing the name of the object always on the same end, and if two labels are used to place the one with the preparer's name on the right hand, and the other bearing the description of the object on the left."

Cleaning Cover-glasses.*—Dr. R. U. Piper, of Chicago, has suggested a very simple method of cleaning cover-glasses without breaking them. Upon a glass plate 2 × 3 inches are cemented, in the form of a V, two thin strips of glass. A cover-glass may be laid upon the glass plate, inside of the V, and cleaned by rubbing freely, being held in position from slipping by the sides of the V.

Preparing Sections of Coal.—Mr. E. T. Newton, the Assistant-Naturalist of the Geological Survey, who has successfully examined the microscopical structure of many varieties of coal, gives † the following description of the methods employed by him in making his preparations:—

"One important point to be noticed at the outset is that nothing like *emery* powder can be used for the grinding, as the grains embed themselves in the softer substance of the coal, and, when the section is finished, will be seen as minute bright spots, thus giving to the section a deceptive appearance. For the rough grinding an ordinary grindstone may be used, and for the finer work and finishing a strip of 'pumice-stone' (or corundum stick), and a German hone (or Water-of-Ayr stone). The form of these which has been found most convenient is a strip about 1½ inch wide and about 6 inches long; the thickness is immaterial: one of the broader surfaces of these must be perfectly flat.

* 'Am. Nat.,' xlv. (1880) p. 465.

† F. Rutley's 'Study of Rocks' (8vo, London, 1879), p. 71.

Having selected a piece of coal with as few cracks as possible, cut off a piece with a saw about three-quarters of an inch square and perhaps one quarter of an inch thick. One of the larger surfaces is then rubbed flat on the pumice-stone, keeping it well wetted with water, and then polished upon the hone, also moistened with water. Sometimes it is found to be advantageous to soak the piece of coal in a very thin solution of Canada balsam in chloroform or benzole, as directed for softer rocks, or in a solution of shellac in spirits of wine; in either case allowing the specimen to dry thoroughly in a warm place. The polished surface is next cemented to an ordinary microscopical glass slip (3 inches by 1 inch) with the best marine glue; and this process requires care, for it is not easy to exclude all the air-bubbles, and if they are not excluded the section is very apt in the last stages to break away wherever they occur. The piece of coal is next reduced to about one-sixteenth of an inch by means of a grindstone; some of the softer kinds may be cut down with a penknife. Care should be taken not to scratch the glass in the process of grinding, for most sections of coal, when once ground thin, are too fragile to allow of their being removed from the glass, but have to be covered and finished off upon the same slide. The pumice-stone or corundum stick is next brought into use. The section being turned downwards, hold the glass slide between the middle finger and thumb, whilst the forefinger is placed upon the centre of the slide. In this manner the section may be rubbed round and round over every part of the pumice, using plenty of water, until it is sufficiently reduced in thickness; experience alone showing how far this process may be carried. The section is finally rubbed in a similar manner upon the hone (or Water-of-Ayr stone). It is sometimes found necessary to use the hone even while the section is absolutely opaque, for many coals are so brittle that they crumble to pieces upon the pumice long before they show any indications of transparency. When sufficiently transparent the section may be trimmed with a penknife and the superfluous marine glue cleaned off.

The section is now to be moistened with turpentine, a drop of ordinary Canada balsam (not too hard) placed upon it, and covered in the usual way. Whatever heat is necessary should be carefully applied to the cover-glass by reversing the slide for a moment or so over a spirit lamp, otherwise the marine glue may be loosened and the section spoiled. Balsam dissolved in benzole must not be used for mounting, as the benzole softens the marine glue, and a good section may in this way be destroyed."

Cutting Rock Sections.—Mr. Hanks considers it a mistake to cut a rock section so thin as to be wholly transparent. In some cases this is necessary; but, as a general rule, the section should be left as thick as possible, and strongly lighted by the aid of a parabolic reflector. The beauty of many specimens is destroyed in the effort made to fit them for observation by simple transmitted light. Mr. Attwood's plan * to cement the section to a glass slide, and to examine it from time to time under the Microscope as the work progresses, is very important, as it will enable the student to stop at

* *Ante*, p. 325.

the exact point when light can be passed through it, but before many of the most interesting features are destroyed by over-cutting.

Simple Mechanical Finger.*—The devices hitherto employed as "Mechanical Fingers" depend, Mr. M. A. Veeder writes, upon the lengthening of the part which supports the substage apparatus by means of a tube specially fitted for the purpose, or by means of the paraboloid, so that by a rack movement the slide may be lifted free from the stage into contact with a hair or fine wire, which is held by the stage forceps or by some contrivance designed especially for the purpose. Contact having thus been established, the slide may be lowered, leaving the object adhering to the hair, or by moving the sliding stage the object may be pushed in any direction desired. There is, however, another plan, which he finds to be simpler, and even more effective in certain respects. With many Microscopes a condensing lens is supplied, which is fitted to the limb of the instrument by a ball-and-socket joint and sliding stem-rod. Unscrew this lens and put in its place a piece of cork through which a needle passes at a right angle to the stem. It is well to have two or three pieces of cork fitted with needles having different points; one, for instance, may have a human hair projecting slightly beyond its point, the hair being kept in place by winding with fine thread and coating with gum; another may have a flat point, made by breaking off and grinding the fractured end; other forms will suggest themselves as experience may determine. The ball-and-socket joint should be clamped or wedged, so as to move quite stiffly. Bring the point of the needle into view under the objective, and it may be made to touch the slide, or be lifted away from it by simply turning the stem-rod. Objects which are seen to adhere to the needle are lifted at once, and another slide, slightly moistened by breathing on it, may be substituted for the one on the stage, to which the objects may be made to adhere at any desired point by turning the stem-rod as before. By moving the mechanical stage while the point of the needle is in contact with the slide, objects may be pushed wherever desired on the slide. In this case it is a decided advantage that both needle and object remain within view however the stage is moved. Thus dirt may be scraped away with the greatest ease.

It is evident that such a contrivance, consisting essentially of a ball-and-socket joint, and a sliding stem with a button attached to the latter, so that it may be readily turned, might be fitted to the stand of an ordinary bull's-eye condenser, and thus become available for use with any microscope-stand.

Slides from the Naples Zoological Station.—At the June meeting of the Society some slides were exhibited (for the most part illustrating the early stages of Invertebrates †), sent by the Zoological Station at Naples through Mr. A. W. Waters. Microscopists will be glad to hear that the Station have commenced a department under the management of Mr. Fritz Meyer for the preparation of microscopical objects on a large scale, a list of which they intend shortly to issue.

* 'Am. M. Micr. Journ.,' i. (1880) p. 88.

† See list, *post*, p. 736.

If the slides are generally of the character of those exhibited the supply must, we are afraid, for some time fall short of the demand, as there will be few biologists who will not desire to add some of the slides to their cabinet.

Homogeneous-Immersion Lenses.*—Mr. A. A. Bragdon, referring to the strong impression prevalent among microscopists that objectives having high interior angles, say 90° and upwards, are of no use except to amuse diatomists, says that this is by no means the true state of the case. On comparing the definition obtained with a water-immersion objective of 105° interior angle (by Tolles) with other lenses having 120° or 140° air angle, the image with the latter was shown to be unsatisfactory. And again on comparing the water-immersion with the same maker's recent homogeneous-immersion having 127° interior angle, the advantage was decidedly with the latter. He refers to the series of microphotographs by Dr. J. J. Woodward † of *A. pellucida* mounted in balsam, with Zeiss's $\frac{1}{12}$ and $\frac{1}{8}$ oil-immersions, together with other notable objectives for comparison of their respective merits. Among these lenses were a $\frac{1}{6}$ and $\frac{1}{10}$ inch by Spencer, glycerine-immersion, and a $\frac{1}{10}$-inch oil-immersion by Tolles, and says that "it is only necessary for any unprejudiced person to examine this series of photographs to decide at once as to the superiority of the homogeneous-immersion lenses in defining power."

Mr. Bragdon approves of Mr. Tolles retaining the screw-collar with homogeneous-immersion lenses for these reasons,—that it affords a means of using water as an immersion medium when several preparations are being mounted of one kind, and it is desired to make a cursory examination of them at once with high powers before any change shall have taken place, and without waiting for covers to become fixed by hardening of the balsam; the collar-adjustment is also useful, even with the homogeneous-immersion, to obtain the best image with different lengths of draw-tube.

Fluid for Homogeneous Immersion.‡—Mr. Bragdon finds that the best medium for homogeneous immersion is glycerine brought up to the required index by making a saturated solution with it and sulpho-carbolate of zinc: there is only one, and that not a serious, objection to its every-day use, viz. that it is just a little too thick.

Dr. Blackham also says § that "good heavy glycerine is the best immersion medium he has found out of many; it does not evaporate, soften cement used in mounting objects, nor smell badly, is not poisonous nor irritant, and is in every way satisfactory."

Errors of Refraction in the Eyes of Microscopists.‖—Dr. J. C. Morgan points out that the requirements in construction and adjustment of glasses and the results of work done must vary greatly with

* 'Am. M. Micr. Journ.,' i. (1880) pp. 89-93.
† See this Journal, ii. (1879) p. 672.
‡ 'Am. M. Micr. Journ.,' i. (1880) p. 92.
§ 'Engl. Mech.,' xxxi. (1880) p. 400.
‖ 'Am. Journ. Micr.,' v. (1880) p. 91.

individualities of the workers' eyes, of which one of the most important, but least thought of, is astigmatism. Owing to this defect, the later pictures of Turner are found to be distorted, the tendency being to exaggerate the size of the paler dimension in painting it. On the contrary, in microscopical drawing (as with the camera lucida) the improperly pale line will be perpetuated and the perspective misrepresented. Distortion of dimensions generally may be perpetrated by the most careful observers, and endless disputes may thus arise. A familiar example of this is shown in the case of the *Podura* scale.

Micrometre or Micromillimetre.*—Dr. Phin points out that "micrometre" is inadmissible in America at least, as it would there be spelt "micrometer," and confounded with the instrument of that name, a difficulty which the difference in pronunciation would not remedy. He thinks, therefore, that the proper way is to "fall into line" with the British Association Committee, and adopt the nomenclature suggested by Mr. Stoney, calling the thousandth of a millimetre (or the millionth of a metre) a $\frac{1}{10^6}$ or *sixth-metre*—the prefix *sixth* here indicating the negative exponent of 10 by which the metre is to be multiplied.

Micrometry and Collar-adjustment.†—Dr. Beale, in his 'How to Work with the Microscope,' recommends that scales be drawn or printed, showing the size to which hundredths or thousandths of the inch or centimetre are magnified by each of the objectives used, and one of these scales corresponding to the objective employed, pasted on every drawing. A writer in the 'American Monthly Microscopical Journal' recalls the fact that in all objectives made with a collar-adjustment, the magnification at the "open" and "closed" points varies so much, that attention to this is necessary in making the scales as suggested. Whilst the fact is well known, the amount of the difference does not seem to have been sufficiently taken into account. This will be best illustrated by a table showing the variations in a few objectives of well-known makers, taken with a tube 10 inches in length, measured from the stage-micrometer to the end of the tube proper (not to the end of the eye-piece):—

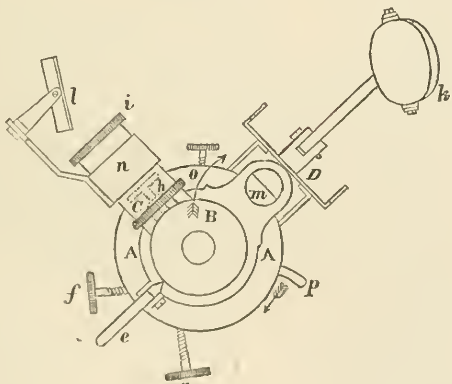
Objective.	Oculars.		
	A.	B.	C.
Geo. Wale, $\frac{1}{6}$ inch, open	262	433	680
,, ,, closed	283	466	725
Powell and Lealand, $\frac{1}{8}$ inch, open	392	650	1025
,, ,, ,, closed	500	833	1300
Spencer and Sons, $\frac{1}{10}$ inch, open	462	750	1200
,, ,, ,, closed	533	887	1400
Wm. Wales, $\frac{1}{15}$ inch, open	517	850	1350
,, ,, closed	733	1200	1900

* 'Am. Journ. Micr.,' p. 117.
† 'Am M. Micr. Journ.,' i. (1880) p. 67.

It will be seen that the range in magnification is greater with some lenses than with others, the difference increasing with the increase of power, but with all it is so great, that scales made without taking it into account would be worse than useless. Accuracy can only be obtained by using the micrometer with the collar-adjustment at the same point at which the object sketched has been examined, unless, indeed, one were willing to take the trouble of compiling a table for each objective, with the magnification noted for each division of the collar through the whole range from "uncovered" to "covered."

Zeiss's Microspectroscope.—This instrument, shown in Fig. 55 (half natural size), has, in addition to a comparison-prism and arrangement for reducing the length of the spectrum, a micrometer by which the position of bright or dark lines in the spectrum is determined by *a direct reading of their wave-lengths.* For this purpose a micrometer scale is projected on the spectrum by reflection, by the divisions on which the wave-lengths at every part of the spectrum (according to Angstrom) can be directly read off in parts of a micromillimetre. The divisions on the scale read to the second decimal place; and the third decimal may be easily estimated by the eye. For convenience of recording observations there are lithographed sheets with ten scales of wave-lengths enlarged to 100 mm.

Fig. 55.



A is a shallow drum between the field- and eye-glasses of an achromatic eye-piece, and contains the 'SGravesande slits, comparison-prism, &c.

B is a cylindrical tube over the eye-piece, and contains the Amici prism. It carries the lateral tube C, which has a small achromatic objective at *o* at the focus of which at *i* is the micrometer scale. B turns on the pivot *m* and is held in the axis of the eye-piece by a catch *e*; by pressing this catch, B with all the parts attached to it may be turned about the pin *m*, so that the eye-piece is free.

D is a stage with spring clips for fixing the preparation whose spectrum is to be compared. The comparison-prism is brought up before one half of the slit by the lever *p*. The screw *f* regulates the *width* and *g* the *length* of the slit; when the latter is opened as wide as possible, the central portion of the field is free; so that the upper part (B C) being turned back, the Microscope may be used in the ordinary way. The screw *h* (underneath the tube C) serves to adjust the scale. This is to be fixed before commencing, so that the Fraunhöfer line D coincides with 0·589. The parallelism of the scale with the spectrum is secured by turning its frame *i*. The mirror *k* throws light on the comparison-prism, and *l* on the scale.

The microspectroscope is inserted in the tube of the Microscope like an ordinary eye-piece, and is fixed in the required position by an attachment screw beneath A. When the object to be examined is of considerable dimensions, no objective need as a rule be used on the tube, otherwise as low a one as possible. As a variation in the distance between the scale and the lens *o* would alter the value of the divisions of the scale, very short-sighted or long-sighted observers must use proper spectacles (or have a spectacle lens placed on B) to produce a medium distance of vision in order to see the lines and numbers on the scale with perfect sharpness of definition. For exact focal adjustment of the spectrum, the eye-glass is movable beneath the collar B. It must be so fixed that the Fraunhöfer lines in the spectrum of daylight plainly appear along with the scale, and on moving the eye there should be no appearance of parallactic displacement towards the division lines.

Ross's Improved Microscope (Plate XVI.).—Since this instrument was first exhibited to the Society * several improvements have been made in the details of the construction by which the stand is rendered more serviceable as a practical working instrument.

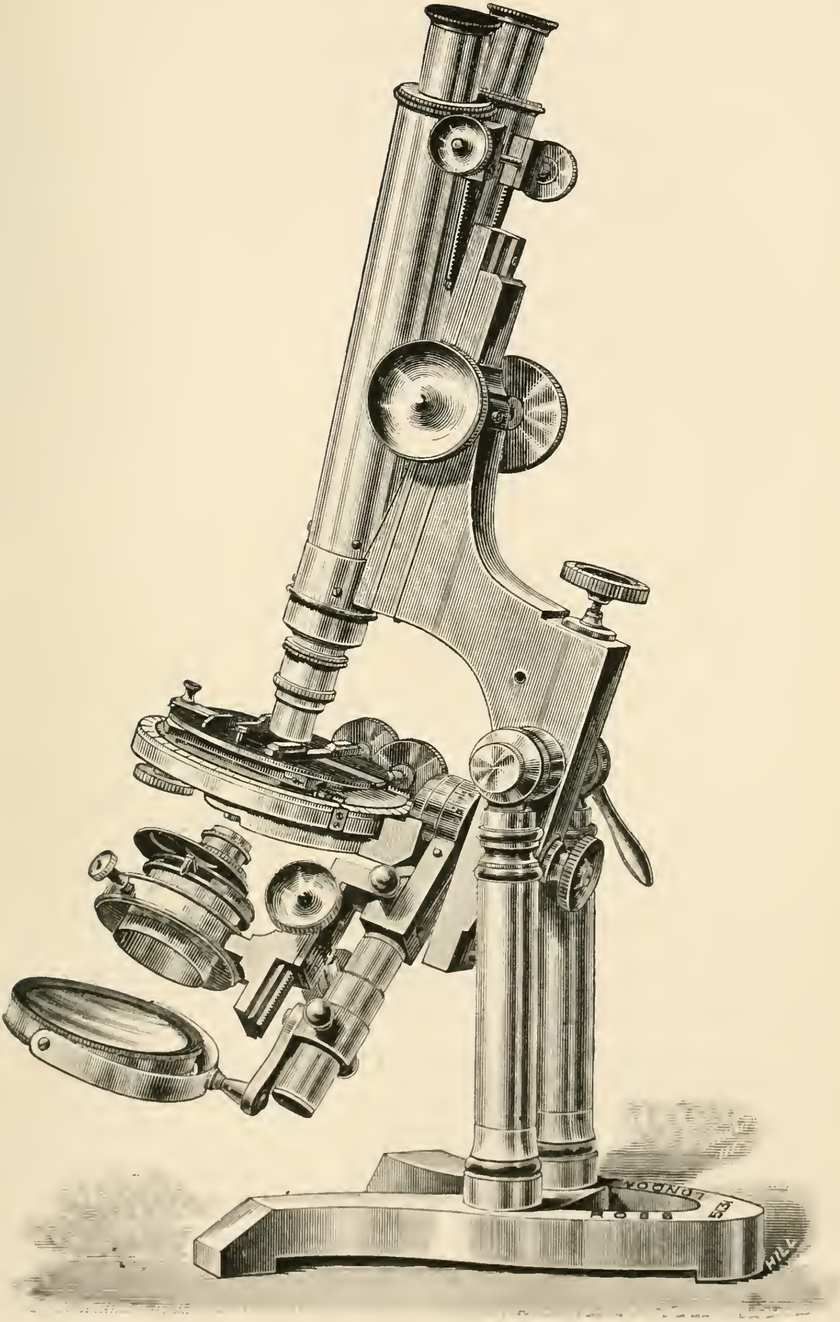
The vertical pillar supports have been adopted for the main limb, an alteration which permits the free use of the swinging substage with the Microscope in a vertical position, a point of special importance for work with fluid preparations.

For central light the substage can now be clamped in the optic axis, and the illumination exactly centered by means of the usual centering screws.

For convenience in using low powers—when the substage condenser may be dispensed with—the substage itself may be entirely removed, the mirror alone then serving as illuminator; for this purpose the focus of the mirror has been shortened, and means have been provided for more readily adjusting it to any required position.

The mechanical stage, with rotatory motion in azimuth and the facility of being inverted, has been considerably altered by the introduction of phosphor-bronze metal in the parts liable to flexure, and the stage has been rendered one of the most rigid and at the same time thinnest yet made. The modifications in the construction of the stage, though making but little change in its general appearance, are specially important in detail.

* See this Journal, i. (1878) pp. 163 and 197.



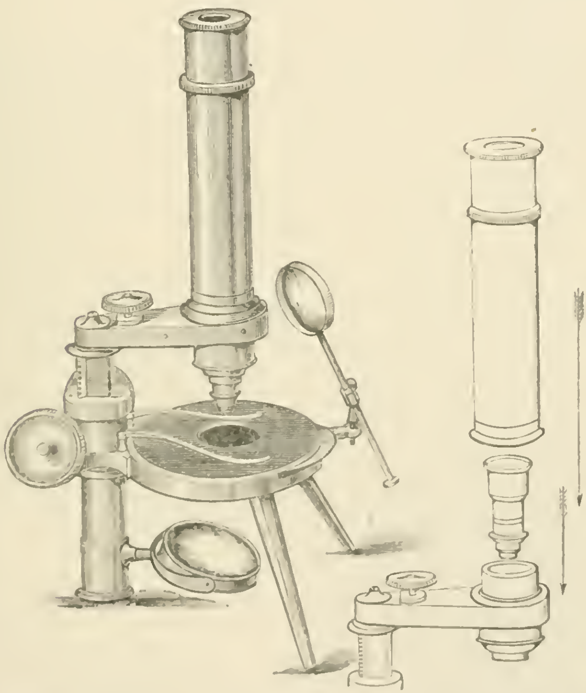
Ross's Improved Microscope.

The slow-motion focussing adjustment has been remodelled so that the focussing is extremely sensitive and yet free from all rocking motion, and the bearings of the rack and pinion movements have been increased in size, and a greater smoothness of motion obtained.

The iris diaphragm can be used either attached to the achromatic condenser or placed in the stage itself immediately beneath the object and almost on a level with the upper plane of the stage, so as to give every facility for regulating the amount of light.

Professor Huxley's Dissecting Microscope.—This instrument (Fig. 56), made by Messrs. Parkes and Son, of Birmingham, was arranged by Professor Huxley, and was shown by him during his term of office as President of the Quekett Microscopical Club. It is designed specially for use either as a simple or a compound Microscope, and arranged with regard to portability for travelling.

Fig. 56.



The stage—which is furnished with rotating diaphragm, and arm for carrying a condenser—consists of a circular disk of black plate glass, with a large central aperture, and is mounted on a brass tripod stand strong enough to bear considerable pressure. The arm, carrying the powers and compound body, has a coarse rack movement, and fine screw adjustment, and can be turned aside if required.

On Professor Huxley's suggestion, that the old plan of *screwing* on the objectives and compound body should be abolished, a new and more expeditious method has been adopted. Instead of screwing the body on to the arm, and then screwing the objective into the body, the objectives are made to slide down smoothly into the arm (as illustrated in the figure), and may thus be used as simple powers, for dissection. When the compound body is required, it may be instantaneously slid over the objective, and is thus ready for use, with a great saving of time and trouble.

Should it be desirable at any time to use objectives having the Society screw, provision is made for so doing, by the lower end of the tube which passes through the arm being cut with such a screw. A loose adapter having the standard screw is also supplied with each instrument, which will receive the objectives belonging to it; by screwing them into the adapter they may be used with another Microscope if necessary.

The following is the (verbal) description which Professor Huxley gave of the instrument:*—

"In a Microscope to be used for delicate dissections, certain qualifications were absolutely essential. In the first place, there must be perfect steadiness, the stand must be firmly and well supported, and be of sufficient strength and weight to bear the pressure put upon it without moving. Next, it must be of convenient height, so that in working the hands may get a steady support; it should fulfil these two conditions, and yet not be so large as to be clumsy. The next point was as to the lenses: they should be of such a form as to give a maximum of power, and yet at the same time afford sufficient distance between them and the object to admit of needles being moved freely to an angle of 60° with the surface of the plate, because the efficiency of the needles obviously depended upon the angle at which they could be used, and if a lens were made with a wide face it would very often interfere with the movements of the needles. Then there was another point of still greater importance: when a careful dissection had been made, it often became desirable to examine it with a much higher power than the one which had served the purpose of preparation, and provision ought to be made to enable as high a power as was desired to be brought to bear without disturbing the object, and this could only be done by placing a compound body above the simple lens.

[The President then exhibited the instrument which he had devised to meet these requirements as described above.]

"In offering the instrument for discussion, the question would arise as to the best form of lens to be employed, and he hoped to receive the opinions of the members upon this and other matters; but at present he used an ordinary low-power achromatic objective, made so as to slip into the arm without screwing; there was great convenience in thus mounting and using a simple lens. . . . Now, supposing they had made their dissection successfully, the point was how to be able to convert the instrument at once into a compound Microscope without disturbing either the lens or the object. One of his aims in life had been to get Microscope-makers to abolish screws, which he regarded altogether as abominable

* 'Journ. Quek. Micr. Club,' v. (1879) p. 144.

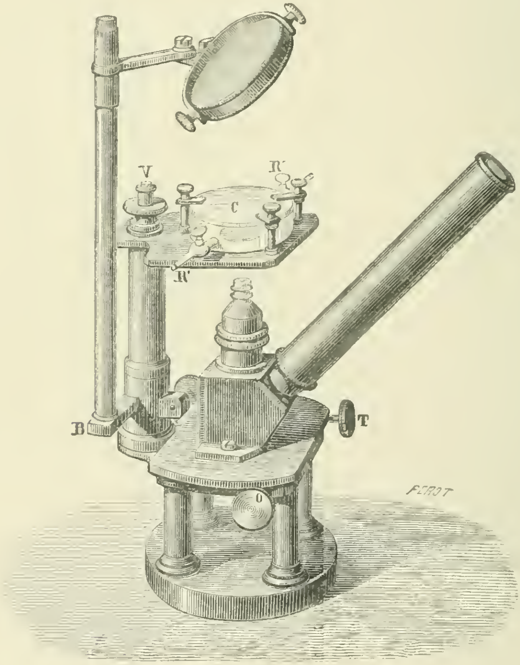
inventions; and in this instance the compound body had been made to slip over the outside of the socket in which the objective had been placed. This plan answered fairly well, but he thought it would be better to have it made to fit rather more easily, and to be secured by a bayonet joint, because, supposing that the power employed was not sufficient for the purpose, then inconvenience arose unless the body could be got off again with sufficient ease to ensure the object remaining undisturbed by any jerk or movement. With the improvement of the bayonet joint it would be easy to remove the body, and having taken out the first lens, and dropped in say a $\frac{1}{8}$-inch, the body would go on again without any disturbance. He had the instrument before them made upon that pattern, to see how the thing would work; he had used it for the past six or eight months incessantly, and he could certainly say that for his requirements it was the best thing he had seen, and he believed that with the little addition of a bayonet joint it would be as nearly perfect as any instrument of the kind could well be. He thought that all persons who had been occupied in making minute dissections would see that it had value, and met all the requirements of the most delicate work. He hoped that the members would examine and criticize it, and make any suggestions that occurred to them for its further improvement, for it was becoming of very great importance to examine thin sections and minute portions of dissections without subjecting them to any such disturbance as to cause the slightest alteration, and it was equally important to be able to bring to bear upon them under such conditions the highest powers that might be needed."

Nachet's Chemical Microscope.*—In this Microscope (shown in Fig. 57) the objective is placed beneath the object on a brass box containing a mirror silvered on its upper surface. To this box is screwed the body containing the eye-piece and a sliding tube which is used as a coarse adjustment. The silvered surface of the mirror is entirely protected from the action of the air, as the two openings of the box are furnished with parallel glass plates. The focal adjustment is made by raising the objective and by the micrometric screw V which moves the stage. On the latter is a circular glass cell C, the bottom of which is pierced with a hole of 18 mm., closed by thin cover-glass well luted with Canada balsam or with silicate of potash. The object to be examined is placed on the thin glass. An arm B carries a mirror which reflects light from above upon the object in the cell. The latter is provided with two glass taps R R′, and is covered by a disk of plane glass hermetically sealed by a little glycerine or grease placed around the edge of the cell. Three small brass uprights keep the cell and its cover in place and immovable. The instrument has a new arrangement for seeing the different parts of the preparation. The body, and consequently the objective, is moved by means of two transverse screws O and T. The plate which supports the box is furnished with two transverse divisions in connection with the movement of the screws, so as to have in effect a finder (the divisions are not represented in the figure).

* Translated (with slight alterations) from note furnished by M. Nachet.

If one reflects, M. Nachet says, on the necessity of attaching india-rubber tubes to the glass taps, and of being assured of the perfect immobility of certain anatomical elements, the advantages of the above arrangement will be at once understood. Experiments on the absorption of gas and on the rarefaction and compression of air could not be more simple. The apparatus gives at the same time a moist, a warm, and a gas chamber, and moreover the highest powers can be employed without any inconvenience. The necessary humidity required for the object is maintained by means of wetted blotting-paper, &c., placed in the cell C.

Fig. [illegible]7



Two parts, as will be seen, are essential in this instrument—first, the moist chamber; and secondly, the arrangement of the instrument itself. As regards the latter, it is very similar to those of Dr. J. L. Smith and Dr. Leeson,* and the one hitherto made by M. Nachet; but there is this capital distinction, that the optical apparatus in the new instrument is movable in all directions, and that the object remains immovable upon the stage.

More recently M. Nachet has replaced the cell above described by smaller cells of the same kind attached to brass plates arranged so

* See Dr. W. B. Carpenter's 'The Microscope and its Revelations,' 5th ed., 1875, p. 108.

as to always have a fixed position on the stage. By means of the two transverse divisions of the plate carrying the optic apparatus, any point of the liquid under examination can be immediately refound. This is very important in researches on the culture of ferments, which are often under observation for several days, and are continually being modified. The form of the cell represented in the figure renders the Microscope inconvenient for many consecutive observations; the new plan allows the systems of culture to be multiplied indefinitely, so as to enable the necessary verifications on any desired point to be made daily. It is only necessary to take precautions when the cell is detached from the stage.

Tiffany's Prepuce Microscope. — Several arrangements have hitherto been devised for showing the circulation of the blood in the human subject, so as to obtain assistance in the diagnosis of disease, amongst which are the "Frænum Microscope" of Dr. Urban Pritchard,* and the apparatus devised by Dr. C. Hueter for examining the lower lip, which we recently described under the title of "Cheilo-angioscopy." †

Dr. Tiffany, of Kansas, U.S.A., suggests ‡ the prepuce as the most suitable part for the examination of the circulation. On account of its thinness, high powers with transmitted light are available for the examination. To hold the prepuce in such a position as to render the examination *very* satisfactory, he uses a thin piece of celluloid, wood, or other light substance, with clamps projecting from the under side, which fasten on each side of the lower half of the prepuce, and by thumbscrews at the free end of the instrument render it tense both laterally and longitudinally. Near the attached end of the instrument is a circular opening, $\frac{3}{4}$ inch in diameter, under which is fastened a thin cover-glass, so that the mucous membrane of the lower half of the prepuce lies in contact with this cover-glass. In this position, with the prepuce spread out nearly as thin as the web of a frog's foot, it is clamped upon the stage of the Microscope, and by transmitted light can be examined by the highest powers. A vessel should be selected which is immediately beneath the mucous membrane, and it should be pressed quite firmly against the cover-glass. Two woodcuts are given, showing the proper manner of applying the clamp and conducting the examination.

Dr. Tiffany has examined several patients, but "having no status as a guide, has scarcely been able to determine whether what was seen was normal or abnormal." He is, however, satisfied that this method will prove a valuable means of making and confirming diagnosis of constitutional diseases, as well as a means of watching the progress and effects of therapeutical agents.

Tolles-Blackham Microscope-stand.—Referring to the description of this stand at p. 520, Dr. Blackham writes that the substage arm is not moved circularly by the milled head B; it slides freely but

* See Dr. Beale's 'The Microscope in Medicine,' 4th ed. (1878) p. 503.

† See this Journal, ii. (1879) p. 916.

‡ 'St. Louis Med. and Surg. Journ.,' xxxviii. (1880) pp. 387–9. See also 'Louisville Med. Her.,' ii. (1880) p. 30.

firmly by hand, B being merely a clamping-screw to hold the substage apparatus in position, and is but seldom needed, though of great importance under certain conditions.

Weber-Liel's Ear-Microscope.*—The following is the description given of this instrument in the 'Berlin Microscopical Journal':—

To the many and varied adaptations of the Microscope an addition has lately been made, the possibility of which was formerly thought to be extremely doubtful, viz. the inspection of internal parts of the human body which are difficult of access. Although such parts, as the oral cavity and auditory passage, have previously been examined by means of a lens and illuminating mirror, the low magnifying power of the apparatus set narrow limits to the examination. Now, however, the instrument of Dr. Weber-Liel has made it possible, at least for the ear, to detect the finer abnormalities of structure and in many cases to discover and remove the cause of disease.

The Microscope, which is shown in Fig. 58, consists of three principal parts:—

(1) The Microscope proper.
(2) The mirror with illuminating lens.
(3) The pneumatic chamber and flexible tube.

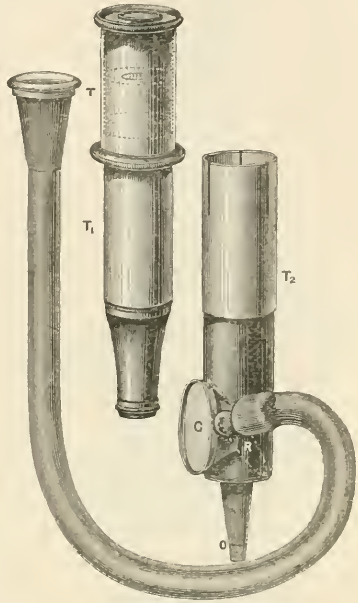
The body of the Microscope T_2 has a conical piece O attached to its lower extremity, several of which of different sizes are supplied with each instrument so that one may be screwed on which is adapted for the particular case and will entirely fill up the auditory passage. Above this is a chamber into the side of which an indiarubber tube opens, having a mouth-piece at its other extremity; this chamber is closed at the upper part by the mirror R which fits air-tight so that when the instrument is introduced into the ear no air has access except through the tube. The Microscope T_1 with the eye-piece T slides into the tube T_2, the eye-piece having a micrometer at *m*. The mirror which closes the pneumatic chamber is inclined at an angle of 45° to the axis of the tube, with its reflecting surface turned towards the illuminating lens G. The reflecting surface has its coating removed in the centre so that a clear view down the axis of the Microscope is obtained through it. The magnifying power of the instrument is about twenty diameters, which is strong enough for viewing the small parts of the ear, as the malleus, stapes, &c.

Besides the parts above figured and described, there should be also the ordinary speculum and two lenses. One of these lenses, magnifying about five diameters, is fixed in a short tube and inserted at T_2 for making a preliminary examination and (what only could hitherto be done) seeing the position of the parts. The second lens, which magnifies about three diameters, is used in making the operations. To give room for the instruments in the latter case, the cone O is replaced by one somewhat longer, which is open at the side; this of course interferes with the complete shutting-in of the pneumatic chamber, a matter, however, of no consequence as this chamber is not wanted during an operation.

* 'Zeitschr. f. Mikr.,' ii. (1880) p. 175.

If whilst the Microscope is in position the air in the external auditory passage is slightly condensed or rarefied by applying the mouth to the tube, it will be seen how the tympanic membrane and the manubrium of the malleus are respectively set in motion; and a more definite judgment can be formed as to anomalies of tension in pathological alterations of tissue. This can be exactly measured by connecting the tube with a mercurial manometer. A most important feature in connection with the instrument is the fact that by means of it the capacity for vibration of the acoustic apparatus can be studied in living persons. For this purpose, the tympanic membrane, or if this is wanting as well as malleus and incus, then the stapes must previously be sprinkled over with powdered starch, by blowing a little into the auditory passage. The starch particles appear under an intense light as strongly reflecting points. On speaking or singing loudly in the mouth-piece of the tube, it will be seen that particular particles of starch are drawn out into small lines, from which the capacity for displacement of the powdered parts, as regards the action of sounds, can be measured by means of the micrometer in the eye-piece.

Fig. 58.



The small mobility possessed by the other segments of the tympanic membrane compared with those of the posterior portions, then becomes very apparent, and especially in certain pathological conditions we are able to detect how the mobility of the parts is not reduced, but considerably increased contrary to what is usually assumed. The instrument will in general lead to conclusions respecting changes of diagnostic importance such as could in no way be supposed with the ordinary mode of examination with intense sunlight; for instance, accumulations of secretion behind the tympanic membrane, which would otherwise be invisible, can be plainly seen.

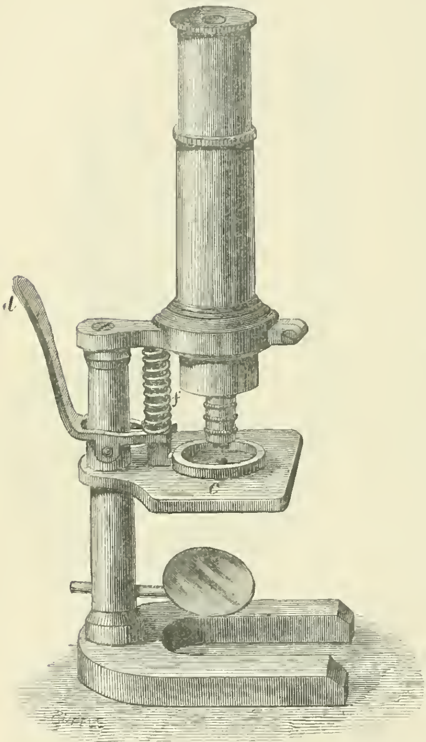
Trichina-Microscopes—Hager's, Schmidt and Haensch's, Waechter's, and Teschner's.—The number of Trichina-Microscopes invented in Germany is continually on the increase. The following are four forms which do not appear to have been hitherto described in this country:—

Hager's * is shown in Fig. 59, and is said to be very useful, not

* H. Hager, 'Das Mikroskop' (8vo, Berlin, 1879).

only in the case of *Trichinæ*, but also for vegetable tissues. It is a Microscope combined with a compressorium. The latter consists of a metal ring *c*, which is pressed upon the stage by a spring *f*, and can be released by pressing the lever *d*. The ring being raised, the object to be examined (placed between two glass plates) is laid upon the stage, and the ring is then allowed to descend gently upon the plates.

Fig. 59.



Schmidt and Haensch's (shown in Figs. 60 and 61) also includes a combined stage (E) and a compressorium (C) (acted upon by two screws), but has in addition a special arrangement for coarse and fine adjustment of focus. The inner tube carrying the eyepiece and objective, which slides within the outer tube attached to the pillar of the Microscope, is provided with a projecting pin which moves in a slot cut obliquely in the outer tube like the thread of a screw, so that by rotating the milled rim (B) of the inner tube it is made to slowly ascend and descend as desired.

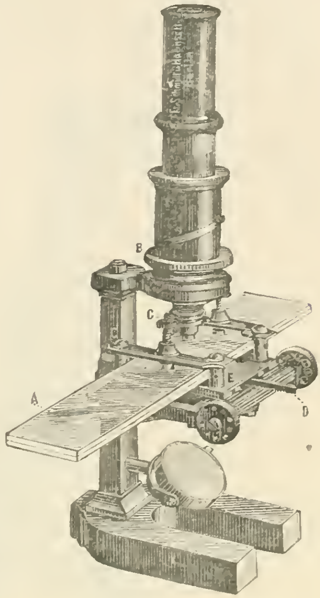
It is claimed * for this plan that it obviates a defect in centering found to exist in Microscopes with the ordinary sliding adjustment, with which it constantly happens that after the tube has been drawn up to change the powers, a suspicious spot which it was desired to examine is found to have disappeared from the field of view. The objection to the arrangement will probably be found in the tendency of the tube to "run down"; at least that was found to be so in the case of an arrangement somewhat analogous in principle, proposed by Mr. Fiddian some years ago.

The second improvement claimed is the movement of the stage in two rectangular directions by the lever A and rack and pinion D. It is pointed out that it is impossible even for a practised microscopist to move the object in the absence of mechanical appliances without missing any portion of the surface. By means of a test plate consisting of a photograph (a square German inch in size) of the numbers 1 to 700, small enough to be clearly legible under a high power, it was found that the error was as much as 30 per

* See 'Industrie-Blätter,' xvi. (1879) p. 289.

cent., and as the figures were more readily distinguishable than *Trichinæ*, the error in the latter case will probably be still greater, and a matter, therefore, of some importance. The construction and advantages of this mechanical stage are described by the inventors somewhat on first principles (much in the same way as the matter would have been dealt with fifty years ago in this country), and appear to show a greater want of familiarity with mechanical stages than we should have supposed to exist.

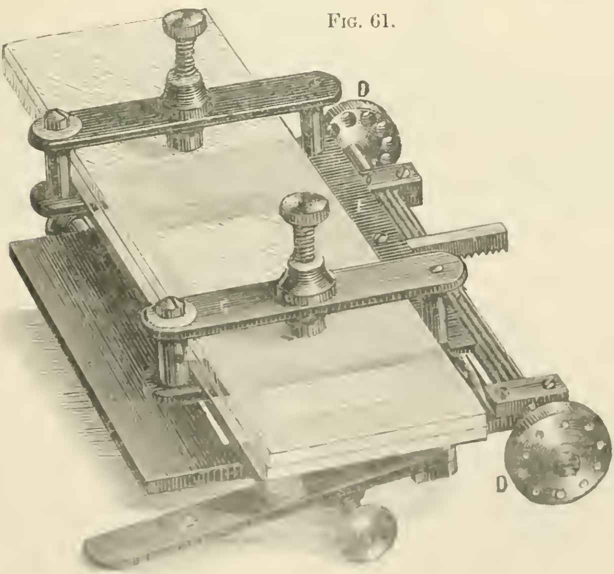
Fig. 60.



With the Microscope are supplied the two long strips of plate glass shown in the figure, between which specimens of the meat to be examined are placed. The lower and thicker one has five squares drawn upon it, each measuring a square (German) inch.

*Waechter's.** — The describer of this form suggests that, ingenious as the construction of the one previously mentioned is, it possesses several drawbacks, one of which is that " it is

Fig. 61.

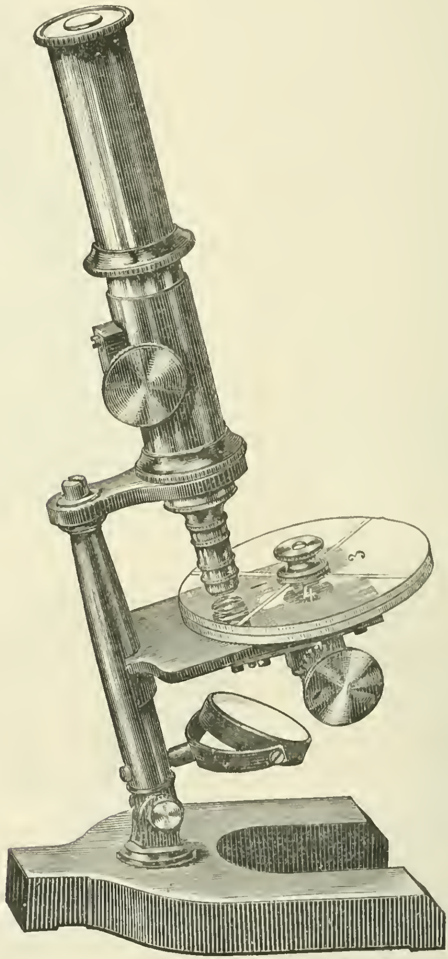


* Pharmaceutische Centralhalle, i (1880) p. 102

rather complicated and if used daily for several hours would be likely to want repairing," and another, that it cannot be used as an ordinary Microscope.

In the new form, shown in Fig. 62, the slide is composed of two

FIG. 62.

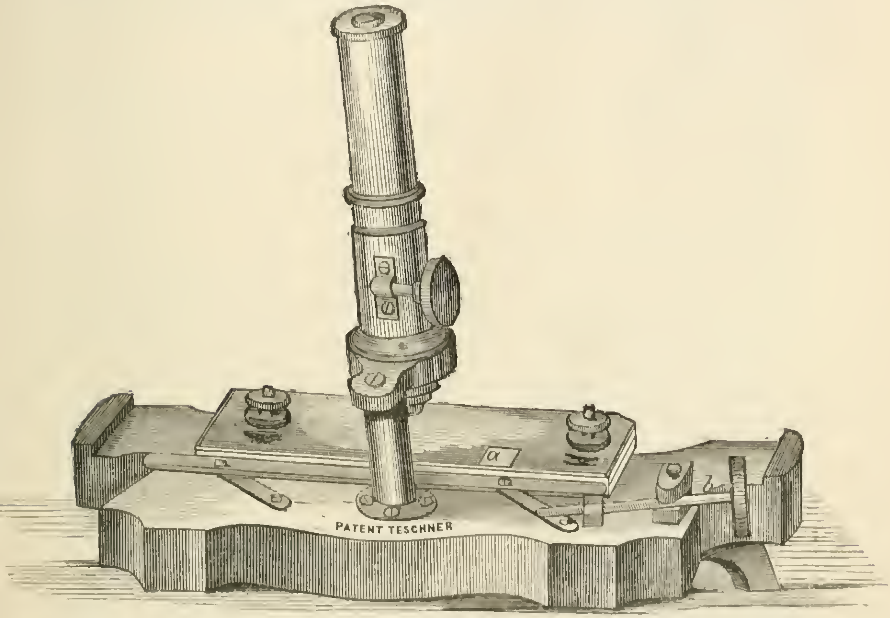


circular glass plates, 5 mm. thick and 8 cm. in diameter, which are pressed firmly together by a metal knob at their centre. They thus form a compressorium at the same time. The under plate, which may of course be thickly covered with the preparations, is divided into four sections, which are numbered for identification. To prevent any fluid coming away, the under plate may be made a very little larger than the upper.

These plates are turned with the finger about their axis (which is fixed to the stage so as to move from behind forwards, and *vice versâ*), an arrangement which allows the examination of a continuous series of preparations lying in the peripheries of different circles 18 to 24 cm. in circumference, whilst by the instrument last described a continuous line of only about 3 cm. in length can be examined.

When one periphery has been examined (which is indicated by a catch-spring), a rack and pinion moves the plates in a radial direction (as a rule it is best to begin with the inner circle), and they are again

FIG. 63.



revolved; and so on until the last periphery has been examined. There is here the great advantage that in adjusting a fresh circle the size of the field corresponding with the power used can be taken into account. Thus the lowest power requires the rack to be moved three teeth, the medium power two teeth, and the highest power one tooth forward.

When the plates are removed from the stage the instrument can be used as an ordinary Microscope.

Teschner's * is a simpler form, of the design shown in Fig. 63. It has a wide inclined stage, on which is a bar attached to two supports, after the manner of a parallel ruler. By means of the adjusting screw *b*, the bar can be moved to and from the aperture

* F. W. Ruffert, 'Mikroskopische Fleischbeschau' (8vo, Leipzig, 1880) p. 51.

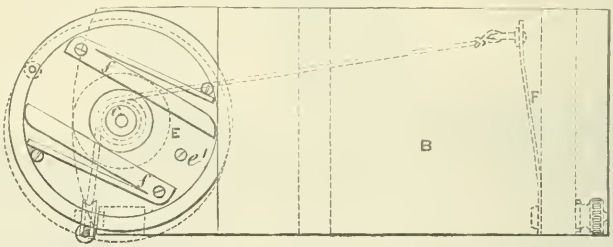
in the stage. Upon the stage is a compressorium. The bar is first brought close to the pillar of the Microscope, and the compressorium moved along it until all the flesh in that strip has been examined. The bar is then, by means of the adjusting screw *b*, advanced for a distance equal to the diameter of the field of view, and the compressorium is then moved in the reverse direction, and so on. The square *a* is said * to be a small scale for the purpose of determining the extent of movement each time. On account of the depth of the compressorium, it must be reversed in order to examine it completely.

Matthews' Improved Turntable. — There have been many improvements suggested in microscopical turntables, most of which have dealt with the means for securing the glass slide upon the table. Very few improvements have been made in the means for imparting the necessary rotatory movement to the table, and none which have come into general use.

Dr. Matthews' invention has for its chief object to provide a ready and efficient means for obtaining a rapid and steady rotary motion to the table, without adding materially to its complexity and consequent cost, as at present constructed. This object he effects thus:—

Fig. 64 is a plan view of the machine, and Fig. 65 a side view of the same, both figures being drawn $\frac{1}{4}$ size.

FIG. 64.

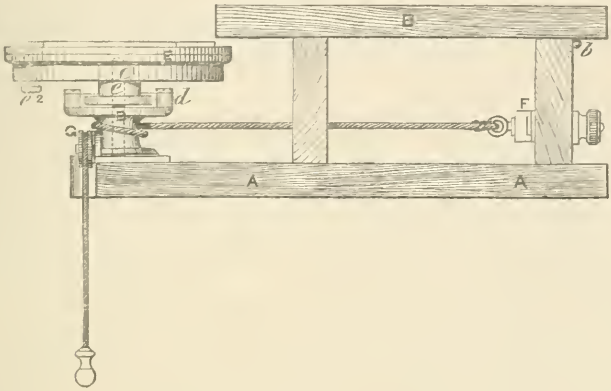


A A is a base-board of mahogany, upon which is erected the platform B which serves as a support for the wrist of the operator. This platform is hinged at *b*, so that it can be turned up out of the way when desired. Near the front end of the base-board A is secured a pivot-pin *c'*. Upon this pivot-pin is mounted, so as to turn freely, a broad flanged pulley D. Above this pulley is mounted the turntable E, also turning freely upon the pivot-pin. The under side of the turntable is provided with a short neck *e*, having a ring of ratchet teeth. The upper flange of the pulley is fitted with a spring pawl *d*, which engages with the ring of ratchet teeth on the under side of the turntable. Underneath the platform B a flat spring F is secured by one of its ends, and to the free end of this spring is attached a cord, which is led forward and passed around the pulley. It is then carried over a second pulley G, from which it hangs pendent.

* The figure is a 'cliché' from the original woodcut.

It will be readily understood from the foregoing description that by pulling downwards upon the cord a rotary movement will be imparted to the pulley D, and through the pawl and ratchet teeth to the turntable E. By relaxing the pull upon the cord, the spring F

Fig. 65.



will draw the cord back again, carrying round the pulley D and pawl *d* in the reverse direction. The weight and momentum imparted to the turntable will be sufficient to maintain its rotation during this backward movement of the pulley, and by a repetition of the process the rotation of the turntable may be continued as long as desired.

In order to hold the slide in a central position upon the turntable, two metal slips *f f* are pivoted at their opposite ends to the surface of the table. These slips are provided with springs which bear against the heads of screws on the upper side of the table. By this means the slide will always be accurately centered laterally. Its adjustment longitudinally can be effected by the aid of a ring engraved in the surface of the table.

It is often desirable, however, to apply a circle of cement excentrically. This is especially the case in re-ringing old slides. The adjustment longitudinally can be readily made as already explained, and can of course be made either central or excentric. To provide for an excentric adjustment laterally, the top of the table is formed of a movable disk, which is pivoted at e^1. This disk is secured in a central position by means of a milled-headed screw e^2. By withdrawing this screw slightly the disk is set free and can be shifted laterally as indicated by the dotted lines in Fig. 64, so that any amount of excentricity can be given to the disk, and consequently to the slide which it carries.

It is obvious that the pulley G may be placed elsewhere on the base-board A, or may be dispensed with altogether, in which case a direct pull upon the cord can be used to impart motion to the turntable.

of Sorby *gradually fades* on the addition of hydrochloric acid and turpentine. . . . . The writer has no doubt (taking his stand almost entirely upon the charts in M. Petit's paper) that the so-called phycoxanthine, in the condition in which M. Petit examines it, consists of the yellow xanthophyll of Sorby, with a slight admixture of chlorofucine, true fucoxanthine, and lichnoxanthine, with contamination by imperfect separation of the chlorophyll, which is itself compound, and a very little of true phycoxanthine. But whilst we are compelled to regret that M. Petit's work is incomplete, we express our thanks to him for having opened up a new field of inquiry for our diatom friends."

MICROSCOPY, &c.

Microscopical Analysis of Water.* — M. Certes observes that recourse must be had to the Microscope in order to discover the nature of the minute organisms of water, whether badly infested by them or not. The great difficulty of discovering these bodies in pure waters is best overcome by the use of osmic acid, which also at once kills and preserves them.

An experiment which shows the efficacy of his method is to place 30 c.c. of distilled water in each of two tubes, and in one of them to agitate a glass tube which has been dipped in water infested with microscopic organisms; to the contents of both tubes equal amounts of osmic acid are added. In examining the water with the Microscope while the one sample shows nothing organized, in the one into which the rod was dipped even the few dead Infusoria are to be found.

In a drinking water, containing but little organic matter, a solution of osmic acid of the strength of 1·5 per 100 is used, and 1 c.c. of this is added to 30 or 40 c.c. of the water; after some minutes as much more distilled water is added as the vessel will contain (in order to check the action of the acid). The length of time after this at which the mixture may be examined varies from a few hours in the case of a highly impure liquid to from twenty-four to twenty-eight for a very pure one; at the end of the time it must be decanted with great care, so as to leave the precipitate in from 1 to 2 c.c. of liquid.

The use of staining materials has some advantages; among the best of these materials, M. Certes considers are Ranvier's picrocarmine, methyl green, eosin, hæmatoxylin. Paris violet has the recommendation of deeply staining minute and transparent objects; it should be very dilute; it then colours cellulose blue, amyloid matters red, and gives a bluish-violet tint to cilia, flagella, and the protoplasm of Infusoria. Whatever staining matter is used, it is advisable to mix some dilute glycerine with it previously to use, care being taken not to allow the organisms to be shrivelled by too rapid action of the glycerine of the mixture; they are thus kept transparent, and may be preserved well in the glycerine.

* 'Comptes Rendus,' xc. (1880) p. 1435.

It is probable that the method may be well employed in examining the tissues and liquids of animals for parasites. The author has thus treated the Anurous Batrachia.

On this subject it may be also noted that Professor Huxley has recently thrown some doubt on the conclusions arrived at by chemists in determining the wholesomeness of water. Organic matter may be either of animal or vegetable origin, the former being dangerous, and the latter much less so, if not altogether innocuous. To distinguish between the two kinds is therefore all-important, but unfortunately it is impossible directly to do this, as both animals and plants yield albuminoid matters, which, chemically speaking, are practically identical in composition. None of the processes in use by chemists can be relied upon as giving any indication of the nature of the organic matter, i. e. whether it is dangerous or not, and yet it is the almost invariable custom to judge of a water by the quantity of organic matter it contains, no matter what its origin, and a variation of two or three times a given amount is held to make the difference between a good and bad water.

It was to this point that Professor Huxley especially addressed himself at a meeting of the Chemical Society, and gave it as his opinion, speaking as a biologist, "that a water may be as pure as can be as regards chemical analysis, and yet as regards the human body be as deadly as prussic acid, and, on the other hand, may be chemically gross, and yet do no harm to any one." "I am aware," he said, "that chemists may consider this as a terrible conclusion, but it is true, and if the public are guided by percentages alone, they may often be led astray. The real value of a determination of the quantity of organic impurity in a water is that by it a very shrewd notion can be obtained as to what has had access to that water."

Mr. C. Ekin, commenting * upon these statements, says that since chemical analysis fails entirely to distinguish between innocuous and deadly kinds of matter, it may be thought a work of supererogation to have recourse to it at all. What, however, analysis fails to do directly it can to a large extent do indirectly. Organic matter in solution in water is more or less prone to oxidation, the highly putrescible matter of sewage being most so, and that derived from vegetation being much less so. Hence it follows that one would expect to find the oxidized nitrogen compounds in a greater excess in the one case than in the other, and that is what we do find. Almost invariably in all waters of acknowledged wholesomeness the quantity of nitrates never exceeds a certain small amount, whereas in polluted well and spring waters the oxidized nitrogen compounds, with other accompaniments of sewage, are to be found in excess. By means, then, of these oxidized nitrogen compounds we get collateral evidence throwing light on the nature and probable source of the contamination, of which a mere percentage estimation of organic matter would fail to give the slightest indication.

The mistake has been hitherto that the discussion has been narrowed by looking at the question almost entirely from a chemist's

* See 'Nature,' xxii. (1880) p. 222.

point of view. It is, however, to the biologist that we must look chiefly for the future elucidation of the subject, and he has a field of the widest range, embracing much untrodden ground, for his investigations.

Brownian Movement.—Similar motions to those shown under the Microscope by small particles in liquids have been attributed to dust-particles in air, and accounted for by the shock of molecules with the particles.

In a paper treating fully of the movements of very minute bodies,* Herr Nägeli calculates (from data of the mechanical theory of gases as to the weight and number, and collisions of molecules) the velocity of the smallest fungus-particles in the air that can be perceived with the best instrument, supposing a nitrogen or oxygen molecule to drive against them. It is, at the most, as much as the velocity of the hour-hand of a watch, since these fungi are 300 million times heavier than a nitrogen or oxygen molecule. The ordinary motes would move 50 million times slower than the hour-hand of a watch. Numbers of the same magnitude are obtained for movements of small particles in liquids. In both cases a summation of the shocks of different molecules is not admissible, as the movements are equally distributed in all directions.

Nägeli therefore disputes the dancing motion of solar dust-particles, and attributes the Brownian molecular motion to forces active between the surface molecules of the liquid and the small particles; but he does not say how he conceives of this action.†

Examining very soft Rocks.—The following process of preparing sections of very soft and friable rocks is communicated ‡ by Mr. J. A. Phillips to Mr. F. Rutley. The chip, which may be to some extent hardened by saturation in a mixture of balsam and benzol until thoroughly impregnated with it, and afterwards dried, should be gently ground or filed down until a smooth, even surface is procured; this surface must then be attached to a piece of glass slide cut about an inch square, and this again fixed in a similar manner by old balsam to a thicker piece of glass if needful, so that it can be conveniently held whilst the grinding is carried on. When it is reduced to such a degree of tenuity that it will bear no more grinding, even with the finest materials, such as jewellers' rouge, and when the removal of the section from the glass to which it is attached would almost inevitably result in the destruction of the preparation, the lower piece of glass should be warmed and separated from the upper piece which bears the section, and this, with its attached section, should be again cemented by the under side of the glass to an ordinary glass slip, covered in the usual way, and if the edges of the section, or its glass, be disfigured by grinding, a ring or square margin of Brunswick black or asphalt may be painted over the unsightly part.

* 'SB. K. Bay. Akad. Wiss.,' 1879, p. 389.
† See 'Nature,' xxi. (1880) p. 350.
‡ F. Rutley's 'Study of Rocks' (8vo. London. 1879). p. 70.

Mr. Rutley himself says:*—In the case of very soft rocks, such as tuffs, clays, &c., useful information may sometimes be acquired by washing to pieces fragments of the rock; in this way a fine mud and often numerous minute crystals and organisms may be procured. The best apparatus for effecting this gradual washing is a conical glass about 9 or 10 inches high, across the mouth of which a cross-bar of metal or wood is fixed. A little hole drilled in the centre of the bar receives the tube of a small thistle-headed glass funnel. Roughly broken fragments of the rock should be placed in the bottom of the conical glass, and the apparatus set beneath a tap, from which a stream of water is continually allowed to run into the mouth of the funnel, the overflow trickling down the sides of the glass, which should consequently be placed in a sink. In this manner a constant current is kept up, and the fragments at the bottom of the glass are continually turned over, agitated, rubbed against one another, and gradually disintegrated. This action should be kept up, often for many days, until a considerable amount of disintegrated matter has accumulated. Samples should then be taken out by means of a pipette and examined under the Microscope.

When the observer wishes to mount either such materials or fine scaly, powdery, or minutely crystallized minerals, the best method is to spread a little of the substance on a glass slide, moisten the powder with a drop of turpentine, and then add a drop of Canada balsam, and cover in the usual manner. If the attempt be made to mount such substances directly in balsam, without the intervention of turpentine or some kindred medium, air-bubbles are almost certain to be included in the preparation.

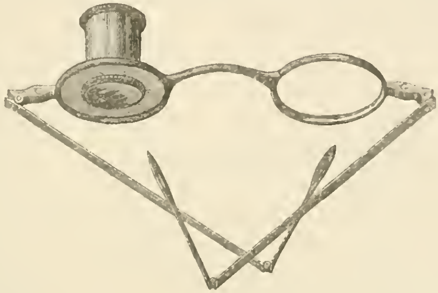
Lenses for Petrographical Work.—Mr. Melville Attwood, in a paper read before the San Francisco Microscopical Society, quotes the following passage from Mr. Frank Rutley's book on 'The Study of Rocks' †: "There is, however, a disadvantage attending the use of lenses when they are applied to the examination of rocks. This lies in the difficulty experienced by the observer when he attempts to examine the streak of minerals under the lens, especially when the minerals occur in very minute crystals or patches, as it is scarcely possible to hold a specimen, with a lens over it in focus, in one hand, and to work with a knife in the other. Laying the specimen on a table, and using a lens in one hand and a knife in the other, is a most unsatisfactory process; while the use of a lens fixed on an adjusting stand is scarcely better. To obviate this difficulty, the author has devised a small lens with a clip, which can be worn on the nose like an eye-glass, and both hands are then at liberty—the one to hold the specimen firmly, the other to use the knife or graver. This clip-lens is moreover better than a watchmaker's eye-glass, because it entails no muscular effort to keep it in place. It is better to have the lens mounted in a horn than in a metal rim as it is less heavy and consequently less liable to be accidentally shifted or displaced by the inclination of the head."

* F. Rutley's 'Study of Rocks' (8vo, London, 1879), p. 73.

† Ibid., p. 44.

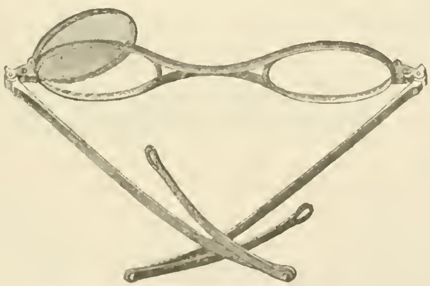
Mr. Attwood adds that instead of a clip-lens he uses a watchmaker's eye-glass, fixed with a screw into a light pair of steel spectacle frames, which he thinks the botanist, also, will find a very useful arrangement. This suggestion was, however, anticipated by the late Robert Brown, whose set of spectacles were some years since (1874) presented to the Society by Dr. Gray. Fig. 75 shows

FIG. 75.



one of the spectacle frames fitted with two double-convex lenses in a short brass tube forming a doublet; one lens being broken, the focus cannot now be determined. Fig. 76 shows another arrangement which allows the magnifier to be turned aside when it is desired to

FIG. 76.



use the naked eye. Two other pairs of spectacles also accompanied the preceding, with lenses of about 3 inch and 4 inch focus, the lens in one unscrewing.

Process for Microscopical Study of very minute Crystalline Grains.*—M. J. Thoulet imbeds the particles of mineral in a cement which, when set, he slices and polishes for microscopical examination. The mineral powder to be examined is mixed with ten times its volume of oxide of zinc, and enough silicate of soda (or preferably, of potash) is added to make a thick paste. This paste is then transferred to a mould, made by laying a thin ring of glass upon a sheet of paper.

* 'Bull. Soc. Min. France,' ii. (1880) p. 7.

In a few days the mass will have set hard, and can be removed from the mould, ground, and polished like a natural rock, as it possesses great tenacity. On examination under the Microscope, the sections of mineral that it contains are easily distinguished in the midst of the surrounding opaque material.

Dr. Matthews's Machine for Cutting Hard Sections.—In the previous volume * we gave a preliminary account of this machine, and now add the full description, with woodcuts, Fig. 77 being a plan view, and Fig. 78 a side elevation.

Fig. 77.

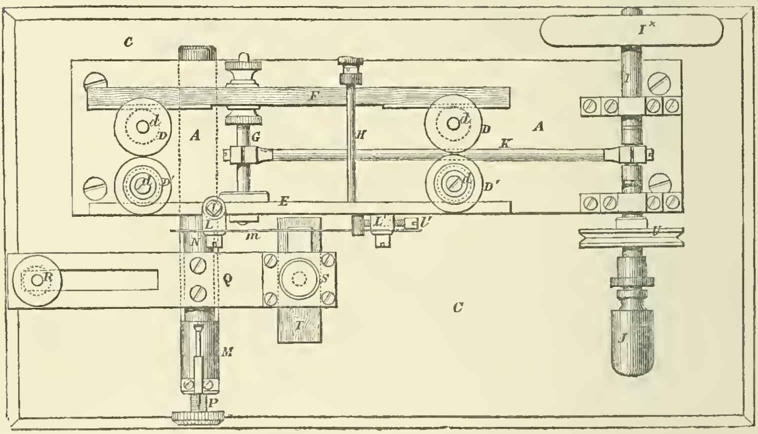
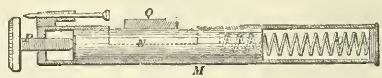


Fig. 79.



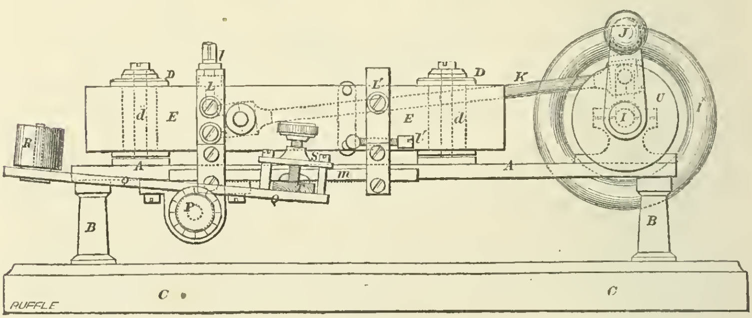


Fig. 78.

The metal stage-plate A is supported upon four pillars B B, and is mounted upon a base-board C. On the upper side of the stage A

* See this Journal, ii. (1879) p. 957.

are four vertical pivots *d*, upon which are fitted, so as to turn freely thereon, the four flanged rollers D D and D′ D′. In front of the rollers D is fitted a flat metal plate E, and at the back of the rollers D′ is similarly fitted a flat strip of wood F, the side of the strip bearing against the rollers being provided with a lining of india-rubber. The plate E and the strip F are secured together by means of the transverse tie bolt G and the clamp H, thus forming a kind of rectangular frame, capable of traversing freely to and fro on the rollers D and D′. At the end of the stage-plate A is mounted in suitable bearings a crank-shaft I, fitted with a flywheel I* and a winch-handle J. This crank is connected by the rod K to the bolt G of the rectangular frame E F. In front of the plate E are secured the metal bars L and L′. The bar L is slotted, and is secured by two screws, so as to be capable of adjustment vertically by means of the screw *l*. The bar L′ is pivoted to the plate by one screw, so as to admit of adjustment laterally by means of the screw *l*′. A fine saw web *m* is clamped by its ends to the two bars L L′.

The saw being clamped in its place, the requisite tension can be given to it by the screw *l*′, while, by means of the adjusting screw *l*, its parallelism can be secured. On turning the crank-shaft I by means of the winch-handle J, a reciprocating motion will be imparted to the frame E F and to the saw *m*.

For holding and imparting the requisite feed to the material to be cut, the following contrivance is adopted:—Beneath the stage-plate A is secured a tube M (shown detached in longitudinal section at Fig. 79). Sliding freely inside this tube is a solid cylinder N. This cylinder is pressed by a spiral spring O against a micrometer screw P. On the upper side of the cylinder N is secured by screws a lever arm Q. This lever arm carries at one end a counterpoise weight R, and is furnished at the other end with a clamp and binding screw S. The material to be cut—say a piece of bone—is fastened by any suitable cement (such as glue) to a slip of wood T, and this slip is clamped, as shown in the figure, to the end of the lever arm Q. By turning the micrometer screw P the cylinder N will be driven forward, carrying with it the lever arm Q and the piece of bone to be cut. The counterpoise R will now cause the piece of bone to bear upwards against the teeth of the saw, and a rapid reciprocating motion being imparted to this latter, as already explained, a thin slice will be cut off. This operation may be repeated until the whole of the material is cut up. The slices can then be removed from the wooden slip by soaking in a little warm water.

A grooved pulley U is provided on the crank-shaft in order that the machine may be driven by a flywheel and treadle if desired, and saws of different degrees of fineness may be employed to suit the various materials required to be cut.*

Bleaching and Washing Sections.†—Mr. S. Marsh, jun., suggests the direct action of free chlorine for bleaching vegetable tissues prior

* See 'Journ. Quek. Micr. Club,' vi. (1880) p. 83.
† Ibid., pp. 51-7.

to staining, avoiding the inconvenience of alcohol which is very slow in action and not always certain in result, and solutions of lime chloride and chlorinated soda (Labarraque's) which so disintegrate that many delicate tissues are utterly ruined. The former solution, in addition to its direct destructive influence, has a great tendency to permit of the formation on its surface of a scum of carbonate of lime; this, sinking into the fluid, settles itself upon the sections, so that if they escape absolute destruction they are in danger of becoming coated with a brittle film, which proves equally ruinous to them.

The apparatus employed for the purpose is shown in Fig. 80, and consists of two small wide-necked (1 oz.) bottles, with a bent glass (quill) tube passing through the centre of sound and accurately fitting corks which are made air-tight by shellac varnish. A notch is cut in the edge of the cork carrying the longer arm of the tube.

Fig. 80.

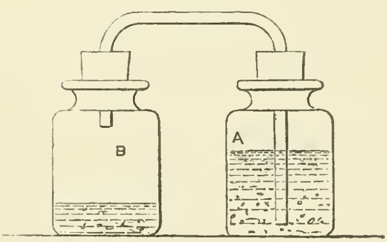
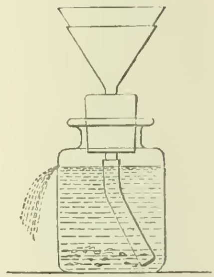


Fig. 81.



To use the apparatus, fill the bottle A three parts full with filtered rain-water, and to this transfer the sections to be bleached. Into bottle B put a sufficient quantity of crystals of chlorate of potash just to cover the bottom, and upon them pour a drachm or so of strong hydrochloric acid, and fit in the corks. Immediately the yellow vapour of chlorine (or, strictly speaking, of euchlorine) will be observed to fill the bottle B, whence it will pass along the connecting tube into the water contained in the bottle A, and effectually and safely bleach the sections. When the water becomes supersaturated, the excess of chlorine will accumulate in the bottle above the liquid, and find an exit through the notch in the cork. As to the time required for bleaching, this of course will vary in accordance with the nature of the sections operated upon. If the apparatus is set to work at night (out of doors, in a covered place), in the morning the bleaching is generally found to be complete; if not, further time may be allowed, without any danger to the sections being incurred.

Decoloration having been effected, the sections must be thoroughly washed to eliminate all trace of chlorine before employing any staining agent. The usual method of effecting this is to put the sections into a large basin full of water, and repeatedly to change the water. As this process is not only tedious, but exposes the sections to considerable risk of being contaminated with dust and other extraneous matter, Mr. Marsh employs a system of continuous washing (see Fig. 81). For this purpose a small wide-necked bottle, as for bleaching, is required, and into the side, half an inch or so below the bottom of the cork, a small hole about an eighth of an inch in diameter is drilled. A well-fitting cork must be pierced through the centre, so as to permit the stem of a small funnel to pass through it. By means of a small indiarubber tubing, the funnel stem is to be prolonged till it reaches the bottom of the bottle on the side *which is opposite to that containing the perforation.*

The bottle is then half filled with filtered water, and the sections put into it, and the cork carrying the funnel fitted in. After having placed a disk of filtering paper into the funnel, this is put beneath the water-tap, and a *gentle* stream allowed to trickle into it. The water will pass to the bottom of the bottle, gradually ascend, and then pass out at the hole in the side, by which means a constant change in the water in the bottle is brought about, and a system of continuous washing established. As in bleaching, so in washing, the apparatus may be left to do its work in the night. If the tap be set running in the evening, the washing will be found to have been most effectually accomplished by the morning.

Wickersheimer's Preservative Liquid.* — Herr Wickersheimer has been continually making experiments for improving this liquid,† and has become convinced that one and the same mixture is not suited for all objects; and he has therefore made four different kinds, for the application of which the following directions are given:—

No. 1 is for injecting whole corpses, including, when still practicable, the injection of separate parts; also for immersing preparations of muscle and nerve, and generally for preserving such preparations as easily become mouldy. The injection is effected by introducing the fluid by a syringe with a blunt tube into the carotid artery, or into any large blood-vessel in separate portions of corpses. For smaller bodies, 100 grammes of the liquid should be allowed for every kilo. in weight of the body, for larger ones 1 kilo. of liquid to 25 kilo. weight. For adult men and large animals, it is enough if ·500 to ·750 kilo. of liquid is used to every 25 kilo. weight.

No. 2 is for preserving and keeping flexible the ligaments of the skeleton; also for preserving Crustacea, beetles, &c., and for lung. The objects should lie in the liquid from two to six days, according to their size, and then be put by dry. Lung must be treated as follows, in order to retain its elasticity permanently. After having first forced out the blood, the lung is filled with the liquid by a funnel which is inserted in the windpipe until it is fully extended. Then, after the liquid has been allowed to drain away again through the windpipe, the lung is immediately treated several times with the liquid on the outside, and inflated; it is then advisable to rinse it once more in a mixture of one part of No. 1 and one part of glycerine, and put it in a

* 'Entomol. Nachr.,' vi. (1880) p. 129.
† See this Journal, *ante*, pp. 325 and 696.

wide glass with a close-fitting wooden lid, as this prevents the external surface of the lung becoming dry in case it is not inflated for a long time.

This is also adapted for permanently preserving plants, especially Algæ, without shrivelling or the chlorophyll changing. The experiments with plants, however, are not concluded, and Herr Wickersheimer hopes to make important advances.*

No. 3 is for microscopical objects. The process is the same as for glycerine. Those which are intended to be prepared later should be kept meantime in No. 2. Although with No. 3 excellent results have already been obtained, experiments are not concluded.

No. 4 is for preserving and hardening brains, and for preserving fishes and birds with their feathers.

The attention of anatomists, &c., is called to the fact that by injecting 2 to 2½ kilo. of liquid No. 1 before dissecting, all possibility of blood-poisoning is prevented, although decomposition may have commenced. In those cases where it is not advisable to use No. 1 fluid, lest traces of arsenical poisoning should be effaced, another liquid can be employed which is quite free from poison, but, like No. 1, renders blood-poisoning in dissecting impossible.

It is not of course remarkable to find it stated that this liquid is "not new," and that it was invented by some one else twenty years ago.†

Preserving the Colours of Tissues.‡—It would undoubtedly be a great advantage if the specimens in our anatomical museums could be preserved with their original colours unaltered; but, unfortunately, hæmoglobin and most of the other pigments found in the tissues are dissolved out or destroyed, to a greater or less extent, by all the preservative fluids which are usually employed. If a piece of fresh tissue be placed in commercial alcohol it very soon becomes bleached, and the fluid becomes at the same time discoloured by solution of the colouring matters. Hæmoglobin is soluble in almost every known fluid, with the exception of absolute alcohol, which, however, causes great shrinkage of the soft parts, and is, moreover, too expensive to be very generally employed. Solutions of chloral hydrate have been used (and with great advantage in many cases); but here again, although the colouring matters are by this means retained unaltered, they are not thereby rendered insoluble, and hence they tend to pass out into the fluid, leaving the tissues partially decolorized. Other media have been tried, but all have a similar imperfection. By baking or otherwise heating the tissues, the pigments are so altered as to be rendered insoluble in alcohol; but, in addition to the tediousness of the process, the action of alcohol is then to turn them black in the course of time, and hence this method is but little employed, except with the object of demonstrating large extravasation and similar changes.

* See this Journal, *ante*, p. 696.
† See Duncker's 'Zeitschr. Mikr. Fleischschau,' i. (1880) p. 100.
‡ 'Journ. Anat. and Physiol.,' xiv. (1880) p. 511.

It is a distinguishing characteristic of hæmoglobin that, although a crystalline body, it is not diffusible; and hence it occurred to Mr. H. Bendall that if specimens could be coated with a transparent membrane of a homogeneous nature, the colouring matters would be preserved *in situ*. For this purpose let a quantity of isinglass or transparent gelatine be taken and steeped in excess of cold water for twenty-four hours, and then, after draining off the supernatant fluid, be dissolved by heating over a water-bath. The specimen is then taken, and, after being carefully wiped to remove superfluous moisture, is either plunged in the liquid gelatine, or brushed thoroughly over therewith by means of a camel's-hair brush. After having received a uniform coat, the specimen is suspended in a cool and dry atmosphere for two or three hours, until the gelatine has had time not only to set, but to dry slightly on its external surface; it may then be suspended in a jar of alcohol, taking care that it be not allowed to rub against the sides of the jar for the first twenty-four hours. The alcohol, by its dehydrating power, rapidly removes the excess of water in the gelatine, and dries it up to a thin varnish-like, and (if suitable gelatine be employed) perfectly transparent coat, through which the pigments are unable to pass out. The alcohol employed should not be diluted, for if this be done the gelatine remains soft and easily comes off.

By this means the author has been enabled to preserve, in an almost unaltered condition, portions of muscle, liver, &c., for over four months; and not only so, but more delicate graduations of colour, such as are seen in an atheromatous aorta, for example, are well maintained.

It is as well to point out that this method is not suitable for such tissues as contain very much blood—e. g. the spleen—nor for cyanotic organs; for in such cases the blood pigment is carried to the free surface, and deposited beneath the gelatine in a layer which may be so dense as to give a darkened and discoloured appearance to the specimen. Nevertheless, for most tissues the method has hitherto yielded highly satisfactory results, and has the additional advantage that the alcohol does not become muddy or discoloured, and hence does not require to be frequently renewed.

Staining-fluid for Amyloid Substance.*—Dr. Curschmann, of Hamburg, claims that methyl green has a peculiar affinity for amyloid substance, colouring it an intense violet. Surrounding tissues that have not undergone degeneration are stained green or bluish green. The contrast is striking; the smallest spot of amyloid disease can be readily discovered. Methyl green also colours hyaline casts ultramarine blue, so in a section of the kidney the healthy tissue would appear green, hyaline casts blue, and amyloid spots violet. A one per cent. aqueous solution is used, a few minutes' immersion being sufficient; a more uniform coloration is produced by using a more dilute solution and immersing the section for a longer time. Alcohol, turpentine, and oil of cloves quickly discharge the colour, hence

* 'Louisville Medical Herald,' ii. (1880) p. 123.

specimens cannot be mounted in balsam, but may be mounted in glycerine.

Carbolic Acid for Mounting.—The process described at p. 693 has been received with considerable favour by English microscopists, and we therefore print the following paper, also from Victoria,* which contains a full account of the process by Mr. J. R. Y. Goldstein, the Hon. Secretary of the Microscopal Society of Victoria.

"The mounting of objects in Canada balsam by means of turpentine has long since been a serious difficulty to students, and a nuisance even to practical hands. Turpentine evaporates so slowly that the hardening or baking and finishing of slides becomes a serious obstacle where time is concerned, while the previous preparation of objects saturated by water is exceedingly troublesome, and a general characteristic of messiness pervades the whole operation.

The members of this society have for some years adopted with advantage a method suggested by the President, Dr. Ralph, in 1874, by which the unpleasantness of mounting in balsam is avoided, and the time occupied considerably shortened. Now that the process has stood the test of years and has proved so decidedly beneficial, it is considered advisable to publish in the Journal of the Society a detailed description of it, in order that microscopists generally may know and use what may properly be called 'Ralph's Carbolic Process.'

When first calling attention to the subject Dr. Ralph suggested the use of glycerine as a means of withdrawing water from objects before using the acid, but experience has shown that this is not necessary, as by the use of heat carbolic acid will readily absorb, and eventually replace the water in any object saturated therewith.

The carbolic acid used should be the purest that can be obtained, and it will be as well to keep the greater portion as stock in a dark-blue glass-stoppered bottle, so as to prevent it being discoloured by exposure to light. From this can be transferred as required a small quantity to a working bottle of about two drachms capacity. If the acid is so pure as to be crystallized, melt what is in the smaller bottle and add a few drops of spirits of wine, which will easily mix with the acid if held for a few minutes over the spirit-lamp. The acid will then be less likely to crystallize and the small quantity of spirit used will not affect the process. Should there be any difficulty in procuring stock of perfectly clear acid, the ordinary coloured acid of the shops, if in crystals, may be used without fear. As will be noticed presently, we drive off all the carbolic acid used, replacing by clear balsam or dammar, therefore the coloured acid can do no harm. Perfectly clear acid soon becomes discoloured by exposure to light, and heat has a similar effect; when we boil objects in acid and allow them to remain for a few days, the acid will then have changed to a rich brown, but as this does not affect the object steeped therein, it need not trouble us further.

* 'Journ. Micr. Soc. Vict.,' i. (1880) p. 50.

The advantages claimed for this process are that objects need never be allowed to dry before mounting in balsam or dammar; that the operation from first to last is simple and cleanly; while compared with the old turpentine process, this is wonderfully rapid. A tiny insect may be caught alive, boiled, cleared, mounted in balsam, the slide finished off and put away in the cabinet, all within half an hour.

Objects saturated with water should be drained as well as possible, without allowing all the water to run off, as in that case air might be admitted, then transferred to a clean test-tube, covered with carbolic acid from the working bottle, and boiled for a few minutes over a spirit-lamp. Corked tightly, a test-tube full of objects in acid may be put aside for any length of time before mounting. When we desire to mount one of these objects we transfer it to a clean slide, put on a thin glass cover, and with the aid of a small pipette allow enough clean carbolic acid to run in to flood the object. Having examined under the Microscope, and arranged it to our liking, we warm the slide over a spirit-lamp, and place sufficient balsam or dammar on the slide close to the cover; liquefied by the heat either medium will at once run in and drive the acid out at the other side. This will be greatly facilitated by inclining the slide and holding a small piece of blotting paper under the thumb close to the lower edge of the thin cover. When all the acid has been drawn off, the slide is then placed on a hot-plate to harden, and afterwards finished in the usual manner by scraping off the superfluous balsam, wiping the slide carefully with a clean rag moistened with spirits of wine, and finished on the turntable by sealing the cover with a ring of Brunswick black or other varnish.

Another aid to the thorough displacement of the acid is to use the balsam in as thick and pasty a condition as possible. At the same time this is not essential to success, as thin balsam works very well. Benzine* should be used in preference to turpentine to liquefy balsam that has become too stiff. Newly purchased balsam is often very thin. In this case it is advisable to bake it in a cool oven for some days until it is hard enough to resist slight pressure, and then add about one-fourth part of benzine, placing the bottle in a hot-water bath, which will ensure perfect mixture. Balsam thus prepared will harden quickly, which it does not do if liquefied by turpentine. Turpentine may therefore be excluded from the Microscopist's laboratory.

When mounting, it is well to be provided with several pieces of blotting paper about an inch square. These should be used as above described to aid the substitution of one liquid for another, particularly when displacing watery carbolic acid by pure acid.

Vegetable tissues such as plant leaves, sections of wood, &c., after washing in water may be drained and transferred at once to the slide, covered by thin glass, flooded in carbolic acid, and then boiled over the spirit-lamp, adding fresh acid from time to time until the object is perfectly clear. Air bubbles may thus be boiled out, and the

* Some prefer chloroform, which will liquefy the balsam without heat, but we think the benzine much superior in subsequent operations.

object decolorized and rendered beautifully clear by the process. When cool add fresh acid and follow with balsam as above.

Insects whole, or their organs, and animal tissues generally may be treated in the same way, which seems to suit such organisms better than the old method. The action of the acid under heat is rapid * and can easily be stopped when required by simply blowing upon the cover.

In preparing Sertularians and Polyzoa, where the empty cells retain the air so pertinaciously, this annoyance may be overcome by boiling in water and allowing to cool, replacing the water by carbolic acid, when alternate boiling and cooling at intervals more or less lengthened will effectually dispose of air in the cells. Those who have opportunities of collecting on the sea-shore will find that just after storms many species will have been washed upon the beach, some possibly alive. Objects thus obtained, or by means of dredging, should at once be placed in small phials in a fluid consisting of spirits of wine and water in equal parts—sea-water will do. When these are taken home, they should be washed several times in fresh water to get rid of the salt, sorted, and transferred to a mixture of spirits of wine and fresh water in equal parts. They can thus be kept in good order for any length of time, or they may be mounted at once by the carbolic process.

Radulas or palates of molluscs should be boiled in strong liquor potassæ for a few minutes, well washed in three or four waters to remove all traces of the potash, and then, treated with the carbolic acid as above described, may be mounted very quickly.

To ensure clear mounts, the balsam should always be immediately preceded by perfectly clean acid, displacing with the aid of blotting paper the acid previously used. If this be neglected, and the acid first used should not be completely removed, a little cloudiness may result from the admixture of the balsam with the water in the acid. In this case the slide must be flooded in fresh acid to soften the balsam, heated, and the cloudy balsam drawn off by blotting paper, substituting fresh balsam."

Wax Cells.†—Mr. F. Barnard gives the following as a preferable process for making these cells:—Take a small piece of wax according to the size and depth of the cell required, place it in the middle of the glass slip, warm it thoroughly over a spirit lamp, then press it upon the slide perfectly flat and even with a smooth surface. This is easily done by means of what he calls a gauge made thus: on each end of a slip of glass, cement with balsam small pieces of paper, card, or glass of the thickness of the required cell, moisten the under side and press upon the warm wax till down as far as the end pieces will allow; by moving this gauge about a little, there will be a tolerably smooth and level cake of wax on the slide the thickness of the gauge.

* As some objects are injured by heat, they may be cleared by soaking in cold carbolic acid for a few days, or until cleared sufficiently.

† 'Journ. Micr. Soc. Vict.,' i. (1880) p. 53.

The centre can be turned out with a penknife or other convenient tool on a turntable. The cell can be cleaned with a rag moistened with benzine, or to avoid the difficulty of this the glass slip may be covered with a solution of gum tragacanth, to which a small quantity of sugar has been added, allowing it to dry before the application of the wax, when the marks of the knife left in turning out the cell can be removed by washing in water only. These cells would not, however, do for mounting in glycerine, water, &c., and the adhesion of the wax to the slide would be destroyed; but if the process is carried a little further and the slide with the cell on is soaked in water, the cell will be freed, and when washed and dried can be applied to another slide. By this use of gum any number of cells can be made and kept ready, like glass and vulcanite cells.

Dry "Mounts" for the Microscope—Wax and Gutta-percha Cells.*—The following is by Professor Hamilton L. Smith (in the new American weekly periodical 'Science,' which is intended to be conducted on a similar plan to 'Nature').

"What shall we use to preserve dry mounts effectually? Many may think that nothing is easier; a cell of Brunswick black; a wax ring, or one of balsam; but the question is not thus easily to be disposed of. The writer has, within the last five years, mounted, or has had mounted under his supervision, some 15,000 slides of various microscopical objects, chiefly, however, foraminifera and diatoms; half of these were dry mounts.

Two things are important—the cell should be quickly and easily made, and the object when mounted in it should remain unchanged. There are very few cells as now made which will fulfil both these conditions, especially the latter. The deterioration of delicate dry mounts, and especially of test objects, sometimes within a few months after their preparation, but more or less certain in nearly every case, is well enough known.

All of the dry mounts of the Eulenstein series of diatoms, e.g., which I have seen, are spoiled; and my cabinet is full of such preparations. Even Möller's do not escape, though they are, upon the whole, the most durable. I have abundance of amateur works that no doubt looked very beautiful just as they issued from the hands of the enthusiastic preparers, which are now, alas! mere wrecks; and, worse than this, many choice and rare specimens, which I cannot replace, hopelessly ruined.

I believe that I was the first one to suggest the use of sheet wax for the bottoms of cells for foraminifera and other opaque objects, and of wax rings for diatoms and other transparent objects. The number of spoiled specimens, especially of diatoms and delicate transparent objects which I can now show, proves that this method of mounting is decidedly bad. I have lived to see the day when I shall be quite glad if the responsibility of suggesting such a nuisance as the wax ring can be transferred to some one else. For large opaque objects, like most of the foraminifera, seeds, pollens, &c., the object

* 'Science,' i. (1880) p. 26.

itself is not so much injured, but the covering glass will, sooner or later, become covered (inside the cell) on the under surface, with a dew-like deposit, which, when illuminated, will glisten almost like so many minute points of quicksilver, and though out of focus when the object is viewed, will show very disagreeably, like a thin gauze between; and with transparent objects these minute globules will not only dot the entire field as so many dark or light points, but the object itself will appear as though it had been wetted.

Not long ago a well-known optician showed to me a spoiled slide of *Podura*. The scales were very good and large—in fact, it was a slide which I had given to him, and it had been selected by myself in Beck's establishment in London as unexceptionably fine. This slide began slowly to show symptoms of 'sweating.' One scale after another appeared, as though moisture had, in some mysterious way, penetrated to the objects; it was not water, however, for when the cover, after much trouble, had been removed, and warmed sufficiently to evaporate anything like water, the scales still exhibited the same appearance, and, in fact, the heat required to get rid of this apparent moisture was so great that the scales were charred. When wax rings are used, this apparent wetting or 'sweating' occurs quickly, and more disagreeable than this, innumerable elongated specks, possibly crystalline, appear all over the under surface of the cover-glass. The same trouble occurs when any of the ordinary asphalt preparations are used, and the only cement which I have thus far found to be tolerably successful is shellac thoroughly incorporated with the finest carbon (diamond black), such as is used in the preparation of the best printing inks; the solvent being alcohol, these rings dry rapidly, and the cover is attached by heating. Even these rings cannot be trusted, unless thoroughly dry, and spontaneous drying is better than baking. I have had preparations spoiled after mounting on asphalt rings, which had been made for over a year, and which had been subjected for several hours to the heat of a steam-bath. With large, somewhat coarse objects, the defect is not so marked; but with delicate ones, and especially test objects, it is simply a nuisance. With care I think the shellac rings may answer pretty well. I have not tried the aniline coloured rings. The moisture (whatever it is), and the crystalline specks, appear to be derived from the vaporizable parts of the wax, or cement, given off under conditions where one would suppose such a thing impossible; it is, however, a fact; I have the proof of it, and I dare say hundreds of others have, too plainly evident.

There is another mode of making cells which promises well for permanence. My attention was first called to this method by Dr. Tulk, of London, who suggested for this purpose the thin gutta-percha tissue used by surgeons in the place of oiled silk. I have had special punches made, which cut neat rings from this tissue, and I have used these rings with the greatest satisfaction. I have no preparation of my own more than about two years old; these, so far, show no signs of change. Dr. Tulk informs me that he has them ten years old, and still good as when new. I have noticed that in some recent papers in the microscopical journals the writers, who with little experience have so lauded wax rings, speak of 'thin rubber' for rings; evidently they have seen somewhere the gutta-percha mount, and supposed it rubber—the latter will not answer, melted rubber will not become hard. One beauty of the gutta-percha ring is the very moderate heat required; it is thus available for many objects which might be injured by the greater heat necessary for the asphalt or shellac rings. As these rings, in the arrangement which I have spoken of, can be rapidly made, and as they can be kept for any length of time (shut away from the dust), they are at any moment ready as well as convenient for use. The preparation is first arranged, dried or burnt on the cover, the slide cleaned, a ring laid on the centre, and on this the cover is placed; the whole is now held together by the forceps, and *slightly* warmed, just sufficient to soften the gutta-percha; the forceps may now be laid aside, or used simply to press the cover home, warming the slide gently, also the cover; the perfect contact of the softened 'tissue' with the cover and slide is easily recognized, and with a little care this can be effected very quickly, and nothing further is necessary. A finishing ring of coloured cement makes a very neat mount, but it is not necessary."

Mr. F. Kitton, writing* on the above paper, says that he is unable to suggest a remedy.

The "damping-off" of dry mounts, particularly of diatoms, used to be (some twenty-five years ago) attributed to the imperfect washing of the diatoms: either the acid used in cleaning was not eliminated, or the water used for that purpose was impure; but preparations which showed no acid reaction, and which had been carefully washed with the purest distilled water obtainable, when dry mounted, still showed the presence of moisture. This was then accounted for (?) by the suggestion that the supposed moisture was really condensation from the asphalt ring supporting the cover; he therefore mounted some covers perfectly cleaned (by boiling in acid, washing in distilled water, and afterwards heating them over a Bunsen burner) on some hard asphalt rings; the slides were heated sufficient to cause the covers to adhere, and when cold the latter were concave, the interior of the cell being nearly exhausted of air. These mounts (about a dozen) were carefully finished, and then left upon the table for several months before examination. Some of them showed minute globules on the inner surface of the cover-glass, others minute radiating acicular crystals, and the remainder were perfectly clear.

This experiment being far from satisfactory, he tried "shellac" as follows: Perforating a hole about $\frac{1}{2}$ inch in diameter, in a piece of "thick" thin glass, he covered the edges with the lac, and cemented two thin covers to it, and with a similar result to the previous experiment. He also tried paper cells saturated with "shellac" dissolved in spirit, or soaked in paraffin wax, but in no case were they invariably successful. He has therefore come to the conclusion that the fault rests with the cover itself, and confirmatory to this opinion is the fact that the covers on balsam (hardened before attaching the cover) some-

* 'Engl. Mech.,' xxxi. (1880) p. 582.

times show like deposits. A similar "sweating" almost invariably occurs on our oculars, which has often been referred to an exudation from the "black" within the tube, but erroneously.

Mr. Kitton has in his possession a small box of thin covers, selected by the late William Smith, author of the 'Synopsis of British Diatomaceæ,' of which at least 30 per cent. exhibit traces of oxidation in the form of minute pits. Query—Would not these covers have shown the so-called "damping-off" if used?

Covering Fluid Mounts.*—In mounting objects in fluid, one of the principal requirements is to fasten the cover of the cell securely, so as neither to permit leakage nor running-in of the cement. There are two methods described in most of the text-books, both of which have, according to Mr. W. M. Bale, disadvantages that impair their utility to a greater or less extent.

The first, which is recommended by Davies, is to paint the cell on its upper surface, and the cover on its under surface near the margin, with thin coats of gold size or other cement, and to press down the cover, forcing out the superfluous fluid in doing so, when the varnished surfaces of the cover and cell, not being affected by the fluid, will adhere together. It is a serious defect in this process that it will not permit of sliding the cover to one side after fixing it, if, as frequently happens, it should be necessary to readjust the position of an object which may appear on examination under the Microscope to require alteration. Moreover, thin pellicles of fluid frequently remain between the cover and the surface of the cell, preventing the perfect adhesion of the cement, and allowing the ingress of air. The other process, which is preferred by Dr. Carpenter, is to simply apply the cover upon a cell a little larger than itself, and when the outside is dry to paint it round the margin with varnish, giving several coats as they successively dry. This has the disadvantage of not holding the cover sufficiently firmly to the cell, and of being peculiarly liable to "running in."

These evils are to a great extent obviated in the following plan, which is especially adapted to cells of any thickness not greater than that of ordinary card or thin glass. An essential point consists in reversing Carpenter's rule, and using a cell *smaller* than the covering glass, so that when the cover is in position it projects beyond the cell for about one-sixteenth or one-twelfth of an inch on every side. The cells may be made of any suitable material—thin tissue paper will serve for minute objects, and common cardboard for those of considerable thickness. The cell may be attached to the slide, or simply placed in the position which it is to occupy, without being cemented. The objects are immersed in the fluid in the centre of the cell and the cover pressed gently down, forcing out the fluid which is in excess of the capacity of the cell, and after it is ascertained, by examination under the Microscope, that the object requires no readjustment, the fluid must be removed from the space between the cover and the slide *outside* the cell-wall. This is easily accomplished by simply allowing

* 'Journ. Micr. Soc. Vict.,' i. (1880) pp. 57–60.

the slide to stand till the superfluous fluid has evaporated, or, where the cell is thick enough, blotting-paper may be inserted under the margin of the cover to absorb it. If this plan be adopted, care must be taken, after the fluid is removed, to allow the slide to stand for a minute or two until the slide and the under surface of the cover margin are quite dry, otherwise the cement will not adhere. Two or three drops of thin balsam or gold size are then to be applied at different points of the edge of the cover, when it will run in by capillary attraction and fill the space outside the cell and beneath the cover. Directly this cavity is filled, any superfluous cement remaining on the slide must be removed, otherwise the running-in process will extend too far, and the cement will enter the cell. The slide may then be put aside to harden. It will often be found after a day or two, especially with cells of considerable thickness, that the cement will be so shrunk from evaporation as no longer to quite fill the space destined for it, when a little more may be applied at the edges till the space is refilled, care of course being taken to scrupulously remove the superfluous cement as soon as the requisite amount has run in. It occasionally happens that some of the fluid is forced out of the cell in process of drying, and occupies part of the space which should be filled only by the cement. This "running out" is no doubt caused by the shrinkage of the cement drawing the cover down more closely, and if the fluid extends only a very slight distance beyond the outer margin of the cell no injury is done, but if enough is expelled to make a passage nearly or quite through the cement wall, there will be a liability of leakage. The best safeguard against this mishap is to be cautious that the cement is not run in till the whole of the fluid has evaporated from outside the cell, or even till the thin film between the covering glass and the upper surface of the cell has commenced to dry. When this occurs, the cover will generally be drawn down as closely as is necessary, and the cement may be applied with reasonable security.

The result of this operation is to secure a double cell, the inner part consisting of the paper or whatever material may be used, and the outer of a solid wall of cement firmly uniting the slide and cover, and as wide as may be required. The author uses a cell about one-eighth of an inch less in diameter than the cover, giving a margin of $\frac{1}{16}$ all round. Care must be taken in finishing slides mounted in this manner, as he has found one commence to run in on the application of varnish, after being mounted some months, the fresh varnish having softened the original cement. This difficulty would probably be obviated by using a rapidly drying varnish, and only applying a thin layer at once, or by making a narrow circle of gum round the margin of the cover and allowing it to dry before using the finishing material; or by using paper covers, and thus dispensing with varnish entirely. There can be no doubt that slides mounted in this way will have almost the permanency of balsam mountings, so far as freedom from external influences can secure it.

A modification of the above process may be used with media which will not evaporate to dryness, such as glycerine and castor oil. In this case it will be advisable to place the object in the centre of the cell, in a quantity of the medium so small that on pressing down the cover the drop will not quite fill the cell, and consequently none will be forced out. The cement may then be run in under the margin, as above described. If the medium be thin and likely to spread over the floor of the cell before the cover can be applied, it will be better to suspend a small drop from the centre of the cover, and bring it down upon the object; and in any case the cover should be moistened with the medium before applying it.

The author adds in a note that he finds Tuckett advises the use of a cover larger than the cell, in order to prevent running in; but as he does not withdraw the fluid from the space round the cell, his method gains no advantage over the ordinary plan in security from leakage.

Thickness of Cover-glasses.—Dr. C. Reddots points out,* in answer to a complaint that cover-glasses are not accurately assorted as to thickness by the dealers, for which it was said "there seems no good reason," that the good reason is to be found in the extra cost that would be entailed by measuring, so that the matter is better left to each microscopist to do. Moreover, in these days of objectives with large working distance—homogeneous-immersion and others—there is no such necessity as there used formerly to be to hunt for very thin cover-glasses.

Finishing Slides.†—A writer in the 'American Monthly Microscopical Journal,' having used dammar dissolved in benzole as a mounting medium for some time past, finds that, when thoroughly dry, the gum becomes brittle, and a slight jar is apt to start the covering glass, and rapid destruction of the slide follows. He has found it necessary, therefore, to run a ring of some tough material around the covering glass to protect it, his efforts being directed to discovering a material that would give the necessary strength, that can be easily handled, so as to make a neat finish. The best results can be obtained by the use of a thick copal furniture-varnish—what is known as rubbing-varnish—using the thickest, finest varnish that can be procured, and putting enough dragon's blood in the bottle to give it colour, without destroying its transparency. It should be so thick that a small drop will not flow from the camel's-hair brush. The older it is the better.

The slide, having been cleaned of superfluous gum or balsam, should have a little shellac varnish run around in the angle formed by the covering glass and the slide to prevent the coloured varnish from running under the cover in the subsequent operations. When this is dry, which will be in a few minutes, the slide is mounted on the turntable, and a sufficiency of the varnish put round the edge of the covering glass, extending over the slide. The turntable is then put in rapid revolution, and with the point of a knife applied to the glass, first outside on the slide and afterwards inside on the covering

* 'Am. Mon. Micr. Journ.,' i. (1880) p. 123. † Ibid., pp. 122–3.

glass, a ring is spun, which may be made as narrow as is desired, and with its rounded top extending above the covering glass.

The slides are laid aside in a dry place for at least a week to harden, when the superfluous varnish can be cleaned off from the glass with a bit of soft linen rag and rottenstone and water, rubbing the whole mount gently with circular strokes. This removes the superfluous varnish from the glass to the edge of the ring, leaving it with a clean circular edge, and at the same time rubs down any inequalities which may exist in the ring itself. After this, wash the slide well in fresh water with a soft brush to remove all traces of the rottenstone, and gently dry it with a soft cambric handkerchief. When it is dry, a few circular strokes with dry cambric on the end of the finger, will give the ring a semi-polish, which leaves it with a very neat finish.

The whole slide is usually cleaned with the rottenstone and water, so that when it is dried and gently wiped, it is ready to receive the label. The whole process is quite expeditious, and the results are so satisfactory, in the permanence and finish of the slides, that the author is confident, if any one gives it a fair trial, it will supersede all other cements for a like purpose.

Novel Form of Lens.*—Dr. Cusco, ophthalmic surgeon in one of the hospitals of Paris, has invented a lens of variable focus, in which the pressure of a column of water or other transparent liquid is made to alter the curvature of the flat faces of a cylindrical cell of brass closed with thin glass disks. The pressure can be regulated by a manometer gauge to any required degree within the limits of working. It is said that the lens gives a sharp, well-defined focus. It was constructed for Dr. Cusco by M. Laurent.

Swift's Radial Traversing Substage Illuminator.—Messrs. Swift have further developed the idea of a "swinging substage" by the apparatus shown in Figs. 82 and 83. The essential feature is the addition of a *second* sector with condenser at right angles to the first.

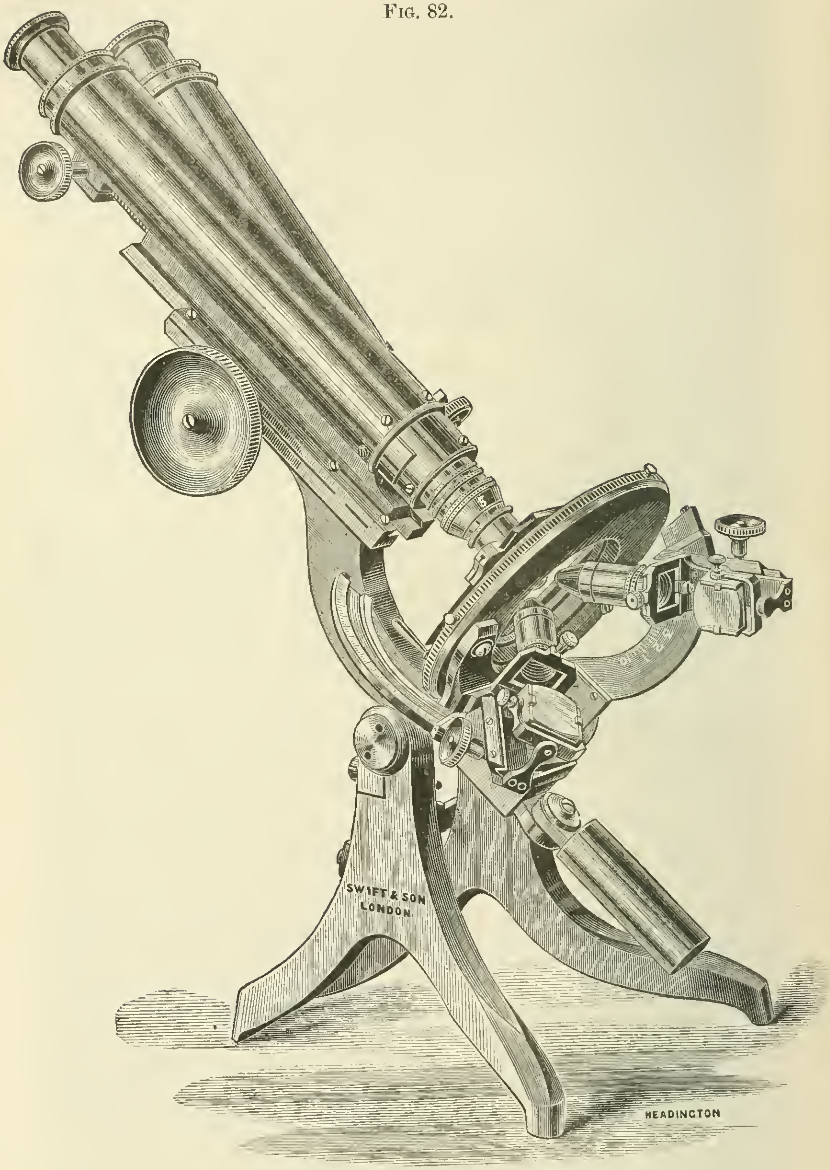
The following is their description of the apparatus (slightly abridged).

"This apparatus has been constructed for the purpose of increasing the resolving property of high-power objectives by causing still more oblique pencils to impinge on the object than can be obtained by any other method. The arrangement consists firstly of an arc-piece fixed below the stage radial to an imaginary line drawn through the axis of the objective, and in the same plane with the object. On this an achromatic condenser of special construction is made to travel, thus keeping the rays of light on the object during its entire traversing, these rays converging in a focus through the front lens in a highly concentrated form. The condenser is illuminated by a rectangular prism.

The next part of the contrivance consists of a second arc-piece placed at right angles to the former one; this also carries a similar achromatic condenser and illuminating prism, and moves radial to

* 'Nature,' xxii. (1880) p. 280.

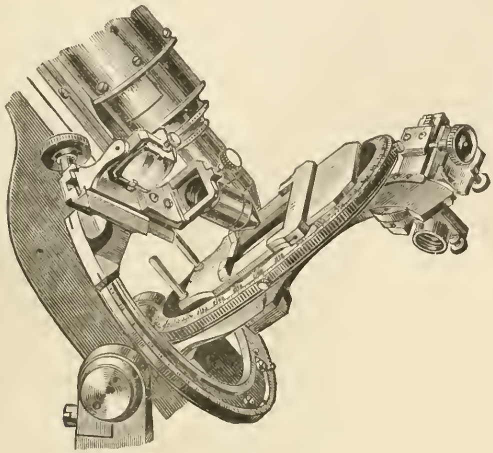
Fig. 82.



the same centre. Both these arc-pieces are so divided that each pencil of light can be projected at a similar angle, and previous results always recorded in the same way. Difficult test objects are readily revealed, especially such diatoms as have rectangular striæ or markings

With diatoms easily resolvable, and only requiring one pencil of light to show the markings, the second arc-piece with its illuminating apparatus can be turned away from the stage as shown in Fig. 83. The figure also shows how opaque objects may be illuminated, viz. by moving the condenser of the first arc-piece above the stage of the

FIG. 83.

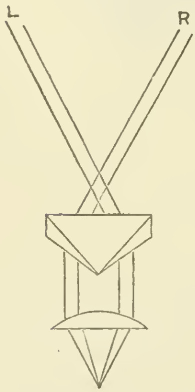


Microscope, when a pencil of light can be projected on to the object more perpendicularly than with the bull's-eye condenser, thus preventing shadows in coarse or deep objects which often produce distortion and false appearances. When the apparatus is used for opaque objects with a lower power than the 1-inch objective, the achromatic combination can be removed and the light directed from the prism, which can be made to give convergent rays sufficient for use with a 4-inch objective.

A great advantage is presented in this arrangement, viz. that a more oblique angle of light can be obtained with it than by other swinging stages, in consequence of the optical combination (with all its fittings included) being less than $\frac{1}{6}$ the diameter of the established size of substage used with the Zentmayer, for instance, thus enabling the apparatus to be moved further up to the under surface of the stage than if its mountings were larger. A still further improvement claimed for it is that the whole of the apparatus and its belongings can be easily detached from the Microscope, and an ordinary substage slid into the same fitting for the purpose of receiving polarizing apparatus, paraboloid, spot lens, &c. As its fitting is not adapted to or connected with the stage, the firmness and stability of this very important portion of the instrument are not thereby impaired."

Holmes's "Isophotal" Binocular Microscope.—The description of this Microscope should be added to the "Curiosities of Literature." The paper was recently presented to this Society, but withdrawn on our objection to print it *au serieux* and without alteration, having apparently met with a similar objection at the hands of the British Association authorities last year. Deviation is described as being "half as great when an isosceles prism is used," it being apparently supposed that an "isosceles" prism has an invariable angle instead of an infinite variety of angles. A prism is commended as giving "flatness of field." Reflecting prisms are described as causing more loss of light and more error than refracting ones, and notwithstanding a 5 per cent. *loss* of light by transmission, a net *gain* of 5 per cent. is vouched for as the result of the interposition between the objective and the eye-piece of the refracting "Isophotal" prism (!). The "distance of the prism from the objective in relation to the eye-piece" is held to have an effect on the angles of incidence and emergence. Wenham's prism is denounced as causing the "left-eye view to be darkened, definition impaired, field cylindrically distorted," and Stephenson's as having prisms with "twelve surfaces" (instead of six or eight), and as "practically useless from the line of sight being at right angles to the objective, and from torsion of the image." An achromatic prism is italicized as having only "*three surfaces*" (instead of four), and finally a right-angled prism is apparently in future to be known as a "Holmes prism."

FIG. 84.



The Isophotal prism as drawn by the inventor is shown in Fig. 84 (fac-simile).

The following is the inventor's description verbatim:*—

"In the course of experiments to produce a Microscope that might be used with both eyes, I have originated *three* constructions. The first of these acted by *total reflection*, the second by free transmission through *divided glasses*, and the third by an *achromatized prism*."

[The first † and second ‡ plans are then described.]

"With regard to my *third* and last plan of binocular Microscope, by means of an achromatic prism. The advantages I claim for it are (1) that it can be used as a monocular or as a binocular without change of body-tube; (2) that it gives two equally lighted fields in two equally inclined body-tubes; (3) that it gives stereoscopic effect with less loss of light or definition than any other construction with undivided glasses; and (4) from its evident adaptability to higher powers."

* 'Engl. Mech.,' xxxi. (1880) p. 464.
† 'Journ. Quek. Micr. Club,' i. (1869) p. 175.
‡ 'Mon. Micr. Journ.,' iii. (1870) p. 273.

[Here follows a description with diagrams of various binocular Microscopes, viz.:—Riddell's (1851), Nachet's (1852), Wenham's first (1853), Holmes's first (1858), Wenham's second (1860), Holmes's second (1869), Stephenson's (1870).]

"Here, then, we have six different systems employing prisms having from *four* to *twelve* surfaces to absorb light and impair definition. Division and angulation of the objective [Holmes's second plan] disposes of all these sources of error, and gives directness and value to an observation; but when that plan is considered inadmissible, the solution of the problem must rather be sought in the direction of a *refracting arrangement of few surfaces*, as less light is lost and less error introduced thus than by any number of reflecting prisms.

These considerations led to my third binocular, Fig. 84, wherein one achromatic prism of *three surfaces** of the form and in the position shown, divides the light from the objective and bends it into itself, until both its halves cross each other and diverge from opposite sides into two eye-pieces. I call this the *Isophotal* prism, and it gives the most correct stereoscopic effects to all objects viewed, without impairing illumination or definition.

The light lost by transmission is about 5 per cent., and the gain by observing with two eyes is about 10 per cent.; therefore, a more brilliant view is obtained in this manner than by a monocular, using the same glass and illuminator.

The two equally inclined bodies of the Microscope swing on a pivot, at their junction, to such extent as to bring one of them vertical, when the instrument becomes a monocular by merely withdrawing the prism. This motion was *first* devised by me for this Microscope.

In applying any refracting prism to a beam of light carrying an image, it is necessary to place the prism in such a position that it shall refract in its least degree—that is, cause the minimum deviation of the beam acted on; in all other positions the image of a circular spot of light will be elongated to an elliptical form.

In adapting a pair of prisms to bend the image pencils from the halves of an objective across each other into opposite eyes (Fig. 84), the violence is greater than if they were to be bent only into adjacent eyes. It therefore becomes important to construct the prisms of such a form as to give the least refraction possible for a given angle of glass; otherwise, the resulting images being elongated in one direction, a distorted view would be produced.

This error is entirely eliminated by attention to two considerations. Firstly, the prism must receive its beam at an angular and not at a perpendicular incidence; secondly, the distance of the prism from the objective in relation to the eye-piece must be such as to make the angles of incidence and emergence equal to each other—no other form or position being admissible without distortion. I claim to be the first to have recorded this action in connection with this subject, and to have based the construction of an instrument on the deduction.

* This should of course be *four* surfaces, which is equivalent to *eight* in all, the same as the Stephenson binocular when the reflecting plate is used.

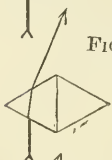
The achromatized prism for stereoscopic effects can take but three forms. For simplicity's sake, I will only deal with one half of the prism, the other half being symmetrical.

If a right-angled prism (Fig. 85) receive the rays at a perpendicular incidence, the whole of the refraction takes place at the inclined second surface, and the distortion is the greatest possible.

If an isosceles prism (Fig. 86) be used, the deviation is half as great, but still so considerable as to preclude its use.

Fig. 85.

Fig. 86.



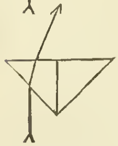


Fig. 87.

But if my form of prism (Figs. 84 and 87) receive the incident beam on its inclined surface, the angles are more nearly equal than in any other form in any other position, and perfect equality may be obtained by modifying the relative distances between objective, prism, and eye-piece.

These conditions at once indicate the dimensions of the prism. When in position it must be large enough to admit all the rays from the objective at the distance seen to give no distortion of a known object; and here we have distinctness and flatness of field also.

Such is the Isophotal prism, giving its name to the Microscope. In the course of experiments, I have made the prisms of the lightest and densest glass, of the longest and shortest diverging power, as large as a shilling, and again so small as to slide into a $\frac{1}{4}$-inch objective; and have arrived at what I believe to be the best form for practical use."

It need hardly be said that the quality of "Isophotal" is not (as the inventor would seem to imply by the title of the paper) by any means peculiar to this instrument, those of Riddell, Nachet, Stephenson, and Ahrens, being equally "isophotal."

We are fortunate in having been for some years the possessor of one of these instruments, which we preserved, not so much on account of the "Isophotal" prism, as for the mechanical curiosity of the arrangement by which "the two equally inclined bodies of the Microscope swing on a pivot at their junction to such an extent as to bring one of them vertical, when the instrument becomes a monocular by merely withdrawing the prism." This motion, Mr. Holmes says, "was *first* devised by me for this Microscope."

Mr. Wenham subsequently pointed out* the incompleteness of the article in regard to the binocular Microscopes previously made (Nachet's existing form and others being omitted), and also that the "Isophotal prism" is the same as that devised by himself in 1860.†

Mr. Holmes, in reply to Mr. Wenham's first note, wrote: ‡—

"Matters of date have nothing to do with the subject, there being

* 'Engl. Mech.,' xxxi. (1880) pp. 500 and 569.

† See 'Mon. Micr. Journ.,' 1874, p. 129.

‡ 'Engl. Mech.,' xxxi. (1880) p. 516.

no question of priority in dissimilar inventions. My prism does not claim to be either a copy of, or an improvement on, Mr. Wenham's prism of 1860, as he appears to suppose, but is substantially an independent invention, made ten years later (1870) in total ignorance of Mr. Wenham's prism. . . . And I have only to say, in conclusion, that my prism is as different from Mr. Wenham's prism as a Huyghenian eye-piece is different from a Ramsden eye-piece."

Nachet's Microscope with Rotating Foot.—A Microscope was devised some time ago by M. Nachet to embody a rotatory motion in azimuth around the mirror. This was effected as follows:—

The base of the stand was a solid disk of metal, in the centre of the face of which the mirror was attached with Nachet's usual articulations, permitting free motion in all directions. Near the edge of the base a circular groove was made, into which the foot of the Microscope proper—a ring of metal carrying the pillar support, as in the Bockett lamp—was fitted, and made to rotate easily. The centre of this circular foot was made coincident with the optic axis of the Microscope. It is obvious that so long as the object remained in the axis of rotation (which was secured by the Microscope being used in a vertical position), the azimuthal rotation around the mirror was practically perfect, except just where the pillar of the stand intercepted the light on the mirror; and the varying effects of light due to this motion, when the mirror was placed excentrically, could be observed with facility.

The stand was intended to provide in the simplest form the equivalent of a perfectly concentric rotating stage, such as is adapted to M. Nachet's more elaborate stands. We have never understood why this inexpensive form of Student's stand has been withheld from popular appreciation.

Edmunds's Parabolized Gas Slide and Nachet's Gas Chamber.—Dr. Edmunds claims that everything which can be accomplished by means of the latter apparatus * may also be accomplished by the parabolized gas slide.†

For the study of such coarser microscopical objects as do not need the black-ground effects of the immersion paraboloid, it is necessary only that a ring of tin-foil, wax, or shellac be interposed between the margin of the thin cover and the top of the slide, oil or grease being still used to seal up the interspace. Thus the thin cover and the film of material under observation is lifted away from immersion contact with the top of the central paraboloid, and gaseous reagents act instantaneously upon the object. If also a slender ring of cotton or silk be packed into the bottom of the annular channel, it serves to hold water and keep up the humidity of the object when, from any cause, it is less convenient to pass gaseous reagents over a piece of wet cotton-wool before entering the annulus of the slide.

Dr. Edmunds also considers that the gas chamber introduces a practical difficulty, inasmuch as on changing the reagent it takes a long time to sweep the chamber clear of its previous contents, and

* See this Journal, *ante*, p. 707. † Ibid., p. 585.

therefore it becomes difficult to determine the point at which the effects of the various reagents begin and end. On the other hand, in the gas slide the annular channel is a mere continuation of the tube, and is instantly swept clear, so that the effects of various reagents mark themselves off sharply.

Advantages of the Binocular Microscope.—Very varied opinions exist as to whether the binocular Microscope is or is not of practical value in histological investigations. Such authorities as Professors Huxley * and Lankester in England, Professor Ranvier in France, † and the German biologists almost without exception have pronounced against it. Nevertheless there is undoubtedly a large class of cases in which the binocular Microscope is of the greatest use in the ready recognition of the true structure of an object, and this is especially so in transparent objects in which the precise position of one part above or below another can be recognized by means of a binocular with exceptional facility, and as is said by the writer of the paper next referred to, "there is no difficulty in deciding whether a fine nerve-termination passes over or under or *into* a connective-tissue corpuscle." Several cases occurred during the last scientific session in which it was clear that the observers had failed to appreciate the true relation of the parts of the object in consequence of the use of a monocular instrument.

Whilst, however, we object to the view that the binocular is not of value in biological investigations, we have to call attention to the necessity of avoiding an error of an opposite kind, viz. of laying too much stress on the perfection of the stereoscopic effect when objectives of *high angle* are used. An instance of this is to be found in a recently published paper,‡ the writer of which refers to the "bold relief" obtained with a Wenham prism used with an objective of high angle. Cells are described as being seen, "not as flat plates, but as spheroidal bodies." Now Dr. Carpenter long ago pointed out § that with large angles the effect of projection is so greatly exaggerated, that in the case of perfectly spherical objects the side next the eye instead of resembling a hemisphere looks like the small end of an egg. "Hence," he says, "it may be confidently affirmed—alike on theoretical and on practical grounds—that when an objective of wider angle than 40° is used with the stereoscopic binocular the object viewed by it is represented in exaggerated relief, so that its apparent form must be more or less distorted."

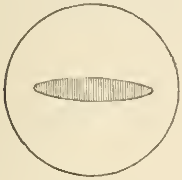
In addition, it may be noted that high-angled objectives having little "penetration" produce a false sense of stereoscopic effect by reason of the parts of the object which are within and without the focus being larger than those which are in focus.

Reduction of Angle of Aperture with the Binocular.—Microscopists should bear in mind that it is only in *one direction* that the binocular reduces the angle of aperture of objectives. If for instance

* 'Journ. Quek. Micr. Club,' v. (1879) p. 146.
† See this Journal, i. (1878) p. 149.
‡ 'Quar. Journ. Micr. Sci.,' xx. (1880) p. 318.
§ 'The Microscope and its Revelations,' 5th ed. (1875) p. 69.

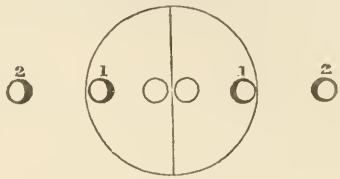
an object have parallel lines upon it, and these lie in a direction from the back to the front of the stage, the diffraction spectra will be arranged in a row at right angles to the lines, and half of the spectra which would otherwise have been admitted will be cut off by the

Fig. 88.



Object.

Fig. 89.



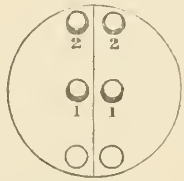
Spectra.

prism (Figs. 88 and 89). If, however, the object is turned round so that the lines run from left to right, the row of spectra will be admitted (Figs. 90 and 91), and there will consequently be no diminution of aperture.

Fig. 90.

Object.

Fig. 91.



Spectra.

If the number of lines in the object were doubled, the distance between the spectra would also be doubled, and the spectrum No. 1 in Fig. 89 would occupy the place of No. 2, and would thus fall outside the field, and there would be no resolution. On turning the object round, however (see Figs. 90 and 91), the spectrum No. 1, though more widely separated from the central illuminating beam by reason of the greater fineness of the lines would still fall within the field (occupying the place of No. 2) and the object would be resolved.

It is therefore of practical importance to see that the object is properly placed when a binocular is used.

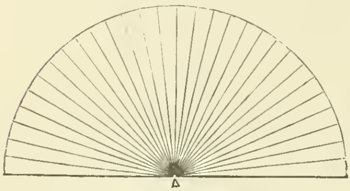
Apertures exceeding 180° in Air. — Many microscopists still experience a difficulty in grasping the idea of an object-glass having an aperture "exceeding 180° in air," but a little consideration should dispel any difficulty.

Fig. 92 represents the theoretical maximum of 180° in *oil* or other homogeneous fluid. It is a semicircle, enclosing 30 spaces, radiant from the point A (of 6° each), spread out as a fan, through which the diffraction spectra emanating from A may be supposed to pass.

If we now substitute for the oil a fluid, such as *water*, having a lower refractive index, the radiant spaces will become wider, and can therefore no longer be contained in the semicircle, as is shown in Fig. 93. The fan will have opened out, and instead of the original 30 spaces there will be only $26\frac{2}{3}$, the other $3\frac{1}{3}$, outside the semicircle, being excluded.

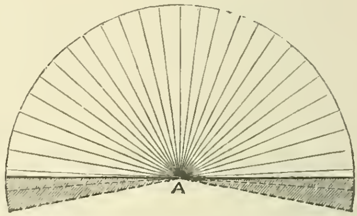
If we now substitute *air*, we shall have a further widening of the radiant spaces; the fan will have been yet further expanded (as

Fig. 92.



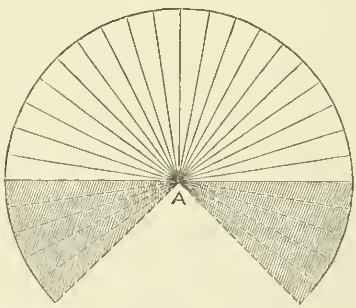
Oil.

Fig. 93.



Water.

Fig. 94.



Air.

shown in Fig. 94), arising from the still lower refractive index of air, and the semicircle will contain no more than 20 spaces, 10 of them being now beyond the 180°.

It will therefore be seen that while an aperture of 180° in air includes (in the illustration given) only 20 radiant spaces, 180° in water and oil include respectively $26\frac{2}{3}$ and 30, these numbers representing the respective apertures in air, water, and oil, the *smallest* number (20) representing, as before stated, 180° in air.

The whole confusion has arisen from not getting beyond the simple and obvious fact, about which there can be no dispute, that a *dry* lens cannot have an aperture of more than 180°. That which is not appreciated is the fact that by substituting for the air of the dry lens either water or some other more refractive medium than air, the conditions are entirely changed, and that "aperture" is not a question of "*angles*," simply as angles, at all.

Diameter of Microscope-tubes.—In a paper read two or three years ago to the San Francisco Microscopical Society (now first published *), Dr. J. H. Wythe says that the diameter of the Microscope-tube has an important relation to the distinctness and luminosity of the image. Few tubes are wide enough to utilize more than a small proportion of the rays proceeding from an objective. The field-glass of the eye-piece should be of the greatest diameter possible for its focal length, and the tube wide enough to receive it, in order to concentrate the greatest number of rays from the objective. The short tubes of French and German Microscopes are supplied with narrow eye-pieces, which cut the cone of rays nearer the objective, and give a more brilliant image than would be possible in a longer tube. If the tube be longer, it must also be wider, and the eye-piece of corresponding diameter.

Wythe's Amplifiers.—Dr. Wythe in the same paper proceeds to explain his views as to the construction of amplifiers, some of which he exhibited to the Society, which were considered to be a great improvement upon any previously seen.

"In considering the construction of the Microscope with a view to greater amplification by the eye-piece, it occurred to me that the concave lens or meniscus used to diverge the rays of the objective should form a part of the eye-piece, and be of as large diameter as the tube will allow. If it be of small diameter, it must be placed nearer the objective. This is the form and position of the amplifiers of Tolles, Zentmayer, and others.

One of the amplifiers, exhibited by me to the Society on a previous occasion, consists of a conical meniscus, whose position in the tube and effects correspond with the amplifiers above named. With this simple addition placed in the lower end of the draw-tube the magnifying power of an objective can be nearly doubled with little loss of light or of definition.

The other form of amplifier now exhibited is still better. A double concave lens, or meniscus, of as great diameter as the tube will allow and of considerable diverging power, is placed at a distance of from 2 to 4 inches in front of the eye-piece. In the improved form in which I now present it, a concave meniscus of 6 inches equivalent focus and 1½ inch diameter (which formerly served as part of the object-glass of a small telescope), is placed in a draw-tube at the end next the eye-piece and about 3 inches from the latter. To counteract the aberration of the amplifier, I have sometimes substituted for the plano-convex field-glass of the Huyghenian eye-piece a convex meniscus of short focus, which gives also a very wide and flat field of view. Ordinary eye-pieces and the periscopic eye-pieces of Gundlach may also be used with the amplifier. The amplifying eye-piece, thus constructed, has given me great satisfaction. If the concave meniscus were made achromatic, it would doubtless be

* 'Am. Journ. Micr.,' v. (1880) p. 81.

a still further improvement, yet the performance of the eye-piece leaves little to be desired. The wavy, basket-like, longitudinal striæ on *Surirella gemma* and the hexagons on *P. angulatum* are well seen with a $\frac{1}{4}$ objective, and the *Frustulia Saxonica* and *A. pellucida* (dry) have been resolved by it with a non-adjusting $\frac{1}{8}$ of Gundlach's.

In place of the concave meniscus referred to, I have also used, with nearly as good effects, a double concave lens of 2 or 3 inches equivalent focus, such as can be obtained at an optician's for about 50 cents. So that by a very small cost of time and money, the possessor of an ordinary objective may increase the power of his instrument to a very great degree.

I reiterate the conviction before expressed, that further improvement of the Microscope may be looked for in the construction of eye-pieces—regulating their magnifying power and increasing their diameters so as to concentrate rays from the objective, which are now absorbed by the sides of the tube."

Foreign Mechanical Stages.—We described and illustrated at pp. 712–13 (Figs. 60–1) a mechanical stage (by Schmidt and Haensch), which was claimed to be a great improvement upon other stages, and the action of which, as regards the movement of the object in two rectangular directions, and the proof that thereby every part of the object must certainly come into the field of view, were given with extreme minuteness, as if the idea of a mechanical stage with rectangular movements had only now dawned upon microscopists.

The matter has now been carried a step further, and we are brought somewhat nearer to the present day by the two stages described below, and which are represented to be better than the English stages in several important particulars. As the description * would suffer by any abstract, we have given a full translation. The writer (Dr. E. Kaiser, of Berlin) first refers to the above Microscope of Schmidt and Haensch,† and its arrangement for exact centering of the tube whilst focussing, and then proceeds as follows:—

"We Germans have hitherto fitted up our Microscopes in a most meagre way as regards mechanical accessory apparatus. If we compare our instruments in this respect with those made on the other side of the Channel, we must certainly confess that ours are far excelled by the English ones. We have always consoled ourselves for this with the idea that the numerous mechanical appliances of the English instruments are really only playthings which are never in any case *necessary*. But nothing is so erroneous as this idea. The so-called 'substage' of the English, their provisions for the fine adjustment and mechanical motion of the object, do not constitute a mere plaything in any sense, but are *absolutely* necessary and indispensable for scientific investigations. The conviction of this has gained ground with time more and more in our *scientific* circles, and to Zeiss's manufactory,

* 'Bot. Centralbl.,' i. (1880) p. 728. † See this Journal, *ante*, p. 713.

under the excellent theoretical guidance of Professor Abbe, is due the credit of being the first to take into account this new tendency.

A year ago, the firm of Schmidt and Haensch following in the footsteps of Zeiss, made improvements in the Microscope, and in particular brought out their new movable stage.

The first and oldest movable stage on Schmidt and Haensch's model was placed on the ordinary stage, and very much distinguished itself over those of English construction [i. e. the stage on p. 713 !] in being more simple, and entailing, therefore, *a higher degree of certainty and exactness* * in the work. The motion from back to front was produced by a screw, whilst the lateral motion (from right to left) was effected by a simple lever-movement. This construction did not provide, it is true, for the diagonal motion of the object, which is possible with English Microscopes, but, on the other hand, it afforded what is entirely wanting in English stages, an *absolute* guarantee that no portion however small of the preparation can escape the attention of the observer. The eminent importance of this in many scientific investigations need not be insisted upon by us.

One defect, however, of this stage of Schmidt and Haensch could not be disguised, and that was that it appeared only suitable for use with low powers. All other objections which have been brought against it, especially those of Professor Johne of Dresden,† must be met with the rejoinder that they are either empty phrases or, as the writer will prove in another place, erroneous conclusions drawn from wrong calculations and false premises.

Messrs. Schmidt and Haensch's manufactory has now produced at the instigation of the writer and by the application of an idea of Professor H. Goltzsch, two new movable stages, which are free from the reproach we have admitted above, and which ought to satisfy *all* requirements.

There is the most absolute certainty, even when the highest powers are used, that not even the minutest part of the preparation will be passed over; whilst at the same time, like the Maltwood finder, it serves to find again readily any particular point of the preparation.

An essential advantage of the new stages over English ones consists in the fact that, besides the *simplicity* and *certainty* of their construction, the larger one can also be used as a screw micrometer, and both allow of *a much greater use being made of the optical capacity of the Microscope*, on account of their being considerably thinner than the English movable stages, whereby a better adjustment of the diaphragms (e. g. raising the diaphragms to the under surface of the slide without using the condensers) is rendered possible.

The two stages are designed on a common principle, but differ from each other by one being intended for *rapid work* with low and medium powers (up to 600), whilst the other is for *exact scientific investigations and measurements*, in which the highest powers may be used.

* All italics as in original text.

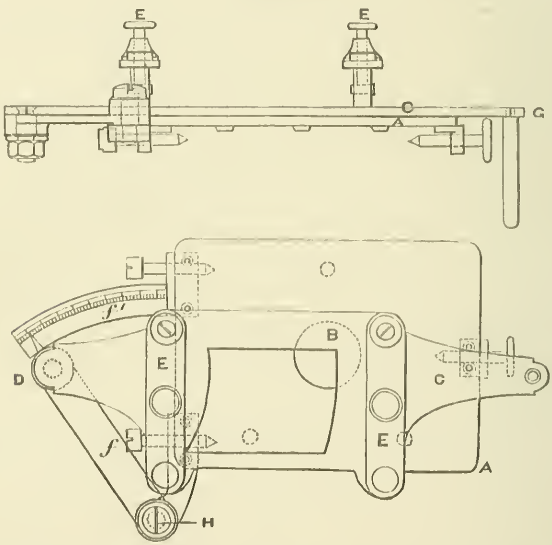
† See this Journal, *ante*, p. 713.

Both stages are applied to the ordinary stage, and are held in position by springs.

The first stage (Fig. 95), which is the simpler of the two, consists, 1st, of a fixed plate A, with a central opening B for the usual diaphragms, and, 2nd, of the movable plate C, which turns about D, and has a larger rectangular opening.

On the plate C are two clamps E E, which serve to fix the slide. A sector *f f'* is attached to the fixed plate A, and is graduated at *f'*. The pointer *f* turns on H, and is connected at D with the movable plate C by a screw, and the plate can therefore be moved about the point D. As appears from a simple inspection of the figure, the pointer *f* (and with it of course the plate C) can be turned about H

Fig. 95.



so as to fall upon any particular division of the scale *f'*. The preparation on the slide which is fixed by the clamps E E, can therefore be moved its whole width under the objective by means of the lever movement at D, whilst the examination of the object longitudinally is effected by gradually pushing the pointer *f* along the scale *f'*.

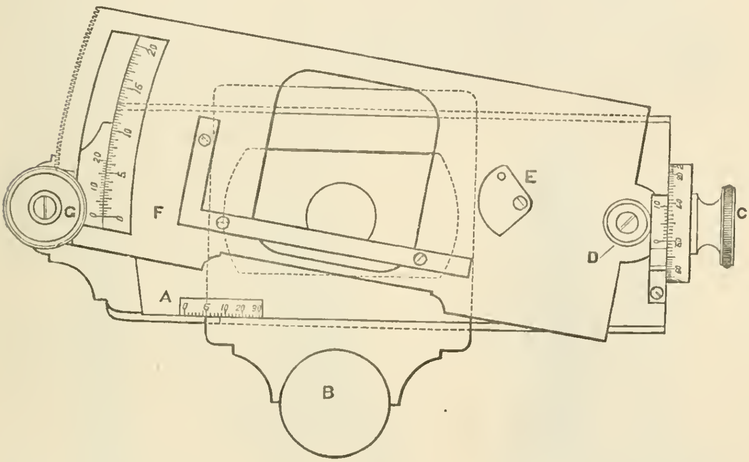
If the motion of the pointer *f* on the scale *f'* is so regulated that it moves each time over the space of the field of view, and if after every such movement the preparation is examined through its whole width by turning the plate C about D, it follows that every point of the object must appear in the field; the applicability of this stage as a Maltwood finder is also thus evident.

To use the stage, for instance, for finding a given point (e. g. a diatom-frustule), it is only necessary to note the position of the pointer f on the scale of f'. Suppose a *Pleurosigma attenuatum* of a certain preparation to lie in the field when the pointer f was on the division 18 of the scale f', and it is required to find this frustule again. Solution: Put f on the division 18 of f', place the preparation firmly between the clamps E E, and turn the plate C about D, the *Pleurosigma* sought for must inevitably appear in the field.

A great advantage of this stage consists in its enabling the observer, by simply taking out the screw H, to move the preparation about in any direction under the objective, just as in the case of free-hand movement of the object with the ordinary stage.

The second stage (Fig. 96), which is the more complicated, and is intended for scientific investigations and for measuring, is similar in construction to the stage above described.

FIG. 96.



The plate A is dovetailed into the microscope-stage B, and by means of the divided screw C can be moved longitudinally. It has a scale at A, the divisions on which correspond to a revolution of the screw C (0·25 mm.). The drum of the screw C is divided into one hundred parts, each division having thus the value 0·0025 mm. There is also a nonius which marks the tenth part of this value.

On the plate A there is a second movable plate (on which is an excentric disk E, and the piece F for fixing the slide), movable about the screw D by the pinion at G, so that one minute may be read off directly by means of the scale and nonius.

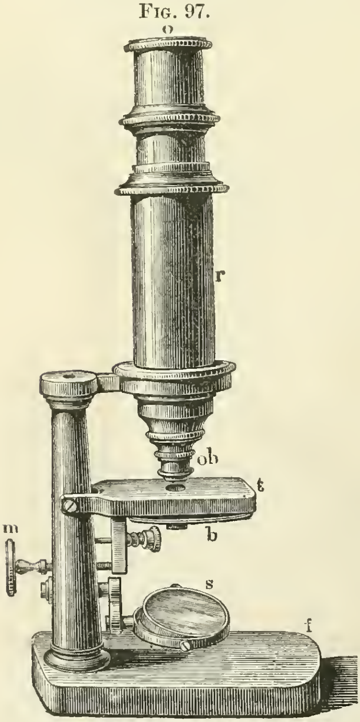
It is not necessary to prove that the same principle is involved in the construction of both stages, and consequently that with the second stage an equally systematic, and indeed much more perfect reading off of the position of the object is possible, as with the first stage. It can also be used in just the same way as a Maltwood finder, but giving, of course, much greater precision. The divisions at A and C, as also the scale at G, give most exact and close readings for fixing the position of a given point of the object, and the stage has the advantage that the position of the point is referred not to a curved line merely, but to a particular portion of the segment of a circle which lies within the dimensions of one field.

When this stage is used as an object-micrometer, it must of course (as with every screw micrometer), be used in the direction in which the screw C works. It is well only to commence measuring after the screw has been turned a little in the direction in which the measurement is being made, as only by this means can the dead-way be obviated, which is unavoidable when a screw turns backwards and forwards.

The measurements are read off directly from the divisions at A and C. At A we have a value of $0 \cdot 25$ mm., at C of $2 \cdot 5\ \mu$, and at the nonius at C (to read which a lens is required), a value of $0 \cdot 25\ \mu$.

Lastly, it should be mentioned that an objection which may rightly be urged against the first stage, and which precludes its use for exact scientific investigations, is got rid off entirely in the second form. It is this: the turning of the upper movable plate about the point D in the first stage produces somewhat excentric circles; in the second this is not the case, as the circles formed about the point D are exactly concentric."

Fig. 97.



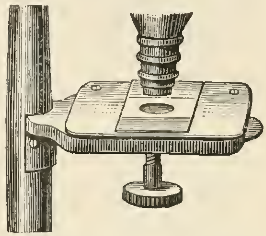
What are the mechanical stages of English construction which have found their way to Germany, and to which the above two stages are so greatly superior?

"Fine" Adjustments.—The crimes that are said to have been committed in the name of liberty are, we think, pretty well matched by those committed in the name of cheapness, at any rate when perpetrated in the case of such an instrument as the Microscope. Fig. 97 shows a method actually adopted in practice in a German instrument for making the fine adjustment. When the screw *m* is withdrawn, the spring seen above the mirror presses the arm attached to the stage against the pillar of the Microscope, and the stage then takes an oblique position. When the screw *m* is turned, it forces the arm outwards, and thus elevates the stage above the horizontal position as much as it was formerly inclined below it.

We should have supposed that whatever advantage might be gained by being able to use a high power with this instrument would be lost by the defective adjustment.

A still cheaper and still more barbarous method is shown in Fig. 98, in which the screw beneath the stage elevates the upper of two plates of which the stage is composed; the upper plate is, however, only separable from the lower plate at one side, so that in this case also the object would not lie horizontally, but obliquely; indeed, by reason of its thinness the upper plate in our instrument is more or less curved when separated.

Fig. 98.



It is perhaps fair to note that, when literally translated, these adjustments are described by the relative term of "*finer*," and that they are very cheap.

Fig. 99.

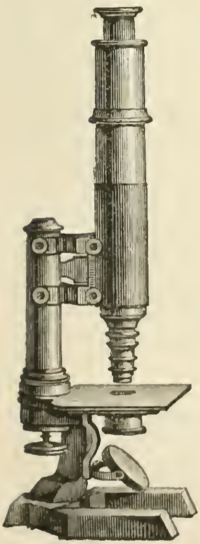


Fig. 100.

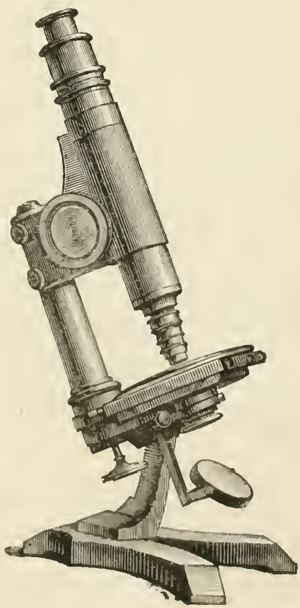
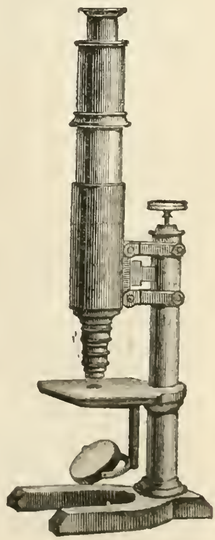


Fig. 101.



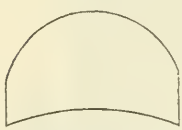
Seibert and Krafft's Fine Adjustment.—It is claimed for this contrivance that it acts without friction. Three different forms are shown in Figs. 99, 100, 101.

The tube is suspended from two parallel arms, whose terminal points are movably connected with both the pillar of the microscope and the tube itself. These arms with medium adjustment are exactly horizontal; but if the tube is raised or lowered by means of the micrometer-screw, which acts upon a projecting piece between the arms, the latter assume a slightly oblique position. The movement effected by means of the screw corresponds therefore to the displacement of a parallelogram of which one side remains fixed in a vertical position while the opposite side is slightly raised or lowered, still preserving the parallelism. Since the displacement takes place between the points of eight screws, any shifting of the image is entirely avoided, and friction is reduced to a minimum. In consequence of this the micrometer-screw turns very easily, and dead-way is avoided with equal resistance on both ends.*

Construction of Immersion Objectives.†—The following note is by Mr. Wenham, and we therefore give it verbatim (with the woodcut), though we are not sure that we altogether understand what is meant to be conveyed, especially in regard to dispensing with the use of oil. No alteration of the front of an objective can, as it seems to us, ever make a water-immersion objective equal in aperture an oil- (homogeneous) immersion :—

"From the above ‡ it may be inferred, that if the front of an object-glass, in cases when the aperture is supposed to be limited by water from rays reflected back and increased by an intermedium of oil of cedar or cloves, if the first surface is also made concave, it would be the means of dispensing with the objectionable use of oil. I have tried some experiments this way. Fig. 102 is the front lens of an immersion $\frac{1}{10}$-inch object-glass. At first the concave surface of the front was made much shallower than is shown, without any appreciable difference in effect from that of a flat plane. The concave was then deepened till it reached to near three times that of the hemispherical back radius, with a slightly improved result in the way of increase of light and flatness of field. The experiment was not carried further. The radius of the back convex is ·045, that of the concave ·13. Of course if oil of the same optical properties as the glass were to be used, the effect of the concave surface would be simply nil. It would then act like a flat front."

Fig. 102.



Mounting of the Front Lens of Immersion Objectives.—Messrs. Powell and Lealand claim to have made a water-immersion $\frac{1}{4}$, with a numerical aperture of 1·30 or 155° (the theoretical maximum being 1·33 or 180°).

To obtain this aperture the plan described by Professor Abbe § is

* Nägeli and Schwendener, 'Das Mikroskop,' 2nd ed.
† 'Am. Mon. Micr. Journ.,' i. (1880) p. 101.
‡ A description of the construction of the immersion-paraboloid.
§ See this Journal, ii. (1879) p. 821.

adopted. The front lens is greater than a hemisphere, and the surface is active in the production of the image up to several degrees beyond the equator, so that the lens is mounted on a thin glass plate, and the slightly prominent edge of the latter fixed to the brasswork of the objective.

"F. R. M. S.," writing on this subject, says: *—"This plan of mounting front lenses on a thin plate of glass so that the setting need not encroach on the active spherical surface, seems to have been known to and practised by the late Andrew Ross in connection with dry lenses. Some ten years ago Tolles, of Boston, experimented with this plan of mounting, for water-immersion lenses. But I believe it is not on record that either Ross or Tolles ever attempted to utilize a front lens beyond the hemisphere.

The first notice I have met with, relating to the possible use of a front lens greater than a hemisphere, is in a paper 'On the Question of a Theoretical Limit to the Apertures of Microscopic Objectives,' † by Professor G. G. Stokes, of Cambridge. Professor Stokes there discussed the question from a theoretical point of view, and gave a demonstration, based on the assumption that such a front lens could be utilized, proving the possibility of apertures approximating to 180°, measured in the body of the lens.

The first practical development of this idea—whether suggested by Professor Stokes's paper or not, I am unable to say—was projected by Professor E. Abbe, of Jena University, and successfully applied by Zeiss, the optician, of Jena, under Professor Abbe's direction, to extend the apertures of homogeneous-immersion objectives to the highest point hitherto attained, 1·4 numerical ap. (= 134°, nearly, measured in crown glass of mean index 1·525).

In June 1879, Professor Abbe brought over to England one of these high-angled $\frac{1}{8}$ objectives. He explained at the R. M. S. that he had found it necessary to prepare a special immersion fluid (an aqueous solution of chloride of zinc) for use with the new lens, because he had not found it possible to obtain satisfactory correction of the aberrations with any of the refractive fluids previously in use. Even with the zinc solution he found it important to improve the corrections by a novel chromatic refracting device of his own contrivance, to be placed immediately below the eye-piece. While this immersion medium remained in the desired condition, the definition obtained with the lens was remarkably good; but, unfortunately, the solution quickly became turbid and useless, so that Professor Abbe did not venture to exhibit the lens at work in public. He stated that the difficulties of construction would probably preclude Mr. Zeiss from making such lenses for sale. I had the good fortune to see the lens tested under the most favourable conditions, and can affirm that it produced excellent results.

In certain demonstrations conducted by Professor Abbe he pointed out the fact that the new lens could be utilized for proving the refractive indices of various immersion fluids; for example, using

* 'Engl. Mech.,' xxxi. (1880) p. 517.
† See this Journal, i. (1878) p. 139.

water, he obtained the precise numerical aperture 1·33 (= double the "critical angle," 62° 58′, from crown glass to water), &c. With air as the external medium at the plane-front of the lens, the num. ap. 1·0 was exactly shown (as, indeed, it is with all immersion objectives having num. ap. greater than 1·0, i. e. greater than corresponds to the maximum air-angle, 180°).

In applying this kind of front lens to the water-immersion system, Messrs. Powell and Lealand have distinctly had in view to extend the aperture to the maximum *with water as the immersion medium.* The new $\frac{1}{4}$ has an aperture so near the limit (123° out of a possible 126°),* that it may be taken to exhaust the problem of aperture—so far as it can be exhausted with the condition that the aberrations must be corrected *with water as the inter-medium,* and with that *initial power* of magnification. It is to be hoped that a similar aperture will be obtained with a much higher initial power of magnification—say, $\frac{1}{8}$, $\frac{1}{12}$, $\frac{1}{16}$, and $\frac{1}{25}$, which will practically close the water-immersion question until new refracting media are experimented with.

There can be no doubt that the development of the homogeneous-immersion system is the problem of the future as regards attaining the limit of visibility with the Microscope. In view of the success that has attended the construction of the new $\frac{1}{4}$ water-immersion, with a front lens greater than a hemisphere, Messrs. Powell and Lealand have not hesitated to engage themselves to construct a $\frac{1}{12}$ on a similar formula, but for homogeneous immersion." The objective has since been completed, and has an aperture of 142° (measured in a crown glass semi-cylinder of mean index 1·5 nearly), with a focal distance of ·007 inch.

Penetration.†—Dr. Blackham protests against objectives with penetration, the amount of which he contends increases with the amount of spherical aberration in the objective which has been left uncorrected, and decreases in proportion as the corrections for spherical aberration approach perfection. Penetration, he maintains, produces a melting together or con-fusion of the images and a necessary loss of definition; and he appears to consider Dr. Carpenter's recommendation of focal depth in objectives as inconsistent with his statement that the "defining power of an objective mainly depends upon the completeness of its corrections, . . . an attribute essential to the satisfactory performance of any objective, whatever be its other qualities." He also combats the suggestion that as the human eye has considerable penetrating power, that quality must also be good for objectives. He points out (1) that the eye is in fact possessed of penetrating power to a much less degree than is generally supposed, this being confounded with the power of *accommodation*, by means of which the eye can be successively focussed with great rapidity upon objects at different distances; and (2) that the optical conditions in regard to the relative distances of the object and image being reversed, it does

* Or 118° and 122° if the index is taken as 1·52.
† 'Am. Journ. Micr.,' v. (1880) p. 145.

not follow that, admitting a certain amount of penetration to be useful in the eye, the same is true with the objective.

As to the view that objectives with penetrating power enable us to see the parts of objects in their true and natural relations, and that the greatest part of histological work is being done with them to-day, he replies, "the more is the pity, because most of it will have to be done over again with better lenses." The fallacy that such objectives enable us to see different planes of objects in their true relations arises from confounding depth of focus with stereoscopic effect, the latter not being dependent upon the former. Diagrams are given of two pieces of wire netting, in squares of different patterns, which are supposed to be laid over one another. "With a corrected objective you see the upper one first, and following nature's plan with the eye, you focus down through it and see the other. If both are seen at once, as a penetrating objective would do, we get a compound figure totally unlike either—an illusion of sight."

Tolles's Improved Traverse-lens, Illuminating and Aperture-measuring Apparatus.—Mr. Tolles has improved upon the traverse-lens which he described in 1879,* and his new apparatus is shown in Fig. 103. The following description is supplied by him :—

The apparatus being intended for measurement and use of the largest apertures, a nearly semicircular sector-plate became a necessity.

For more convenient use, a small stage *c* is supplied, but this stage and its accompanying traverse-lens *b* are readily removable. The traverse-lens *b* is less than a hemisphere by the thickness of an object-slide—assumed ·05 inch.

For convenience of mounting in its cell, the top surface of *b* has a curvature moderately convex, but with a medium of the index of glass connecting the lens and slide, the curvature is neutralized.

When the object to be viewed is in position, it is of course in the centre of motion of the illumination apparatus, as guided by the groove in the plate A. The semicircular rim of the plate is graduated to degrees, and numbered each way from the zero point (midway from the ends) to nearly 90°.

When the truncated cone of glass *k*, having immersion contact with the traverse-lens *b*, is moved from zero to the degree of obliquity where the light fails to give view of the object through the objective, at the eye-piece of the Microscope, then the half angle of interior aperture can be noted by means of an index at the edge of the plate *h*. If desirable, the half angle on the other side of the axis can be ascertained in the same manner, the cone *k* being first transferred to the fitting on which the prism *n* is shown in the figure.

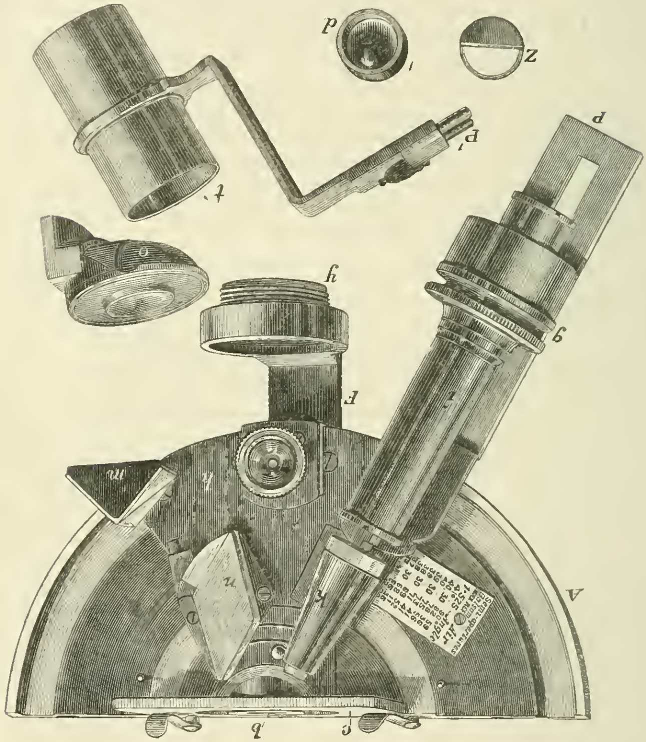
The outer end of the cone *k* can be cut off by means of a cup *z*, with a semicircular opening so as to limit the light to an axial direction *in the cone*. For greater accuracy the apparatus includes an extra arm *p* and *p'*, for carrying a small candle in the tube *t* as a radiant, and which attaches to the plate *h* in place of the prism *m*. This arm

* See this Journal, ii. (1879) p. 388.

also carries an adapter *g* for the reception of objective, having the standard screw, so that any suitable objective can be used as a condenser.

But in taking angles with the candle-radiant in use, a tube *i*, of

Fig. 103.



A, grooved semicircular plate. *b*, traverse-lens fitted to stage *c*. *c*, stage on which the object is clamped. *d*, condensing lens fitting on *k*. F, elbow-arm for attachment of the whole apparatus to the substage of the Microscope. This attachment is effected by means of an adapter *y*, or can be fitted with rack movement. *g*, an adapter for auxiliary tube, or to carry an objective as a condenser. *h*, a plate on which is mounted various apparatus for directing and condensing light upon the object. *i*, auxiliary tube for measuring apertures. *k*, a solid glass cone, concave at the smaller end (for immersion contact with the traverse-lens *b*) and plane at the other, upon which a condensing lens *d* fits, or the semicircular diaphragm *z*. *m*, a rectangular prism, to give direction to the light axially upon *k* or *n*. *n*, a reflecting prism (acting with two internal reflections), to give very great obliquity of the illuminating ray with moderate movement of the plate *h* out of the axial position, or the *zero* position. *o*, a *hemispherical* traverse-lens, for use in measuring the widest possible interior angles, with intervening medium of index 1·525; it fits in the position occupied by *b* and *c* in the figure. *p*, a radial arm extending from the plate *h*. *p′*, arm for candle fitting in tube *t*. *b*, *c*, *k*, *m*, *n*, and *p*, are removable.

some two inches in length, is mounted in this adapter between the radiant and the cone *k*. This tube has only a narrow central slit opening at each end, which slits being brought coincident in direction with the candle-flame, permit only a thin sheet of light to pass to the object. This restriction of the incident light, though not practically important in taking interior angles, *shuts out any question of accuracy.*

The extra traverse-lens *o* is made a *hemisphere*, so as to dispense with the object-slide; traverse-lens *b* and stage *c* being removed, and lens *b* replaced with traverse-lens *o*.

The object is mounted on the plane surface of this hemispherical lens under a cover-glass, and all cemented with balsam of 1·525 index of refraction. The cone *k* has immersion contact as before, and the cone and all the illumination apparatus can be brought round to 90° of axial obliquity without coming in contact with *slide* or stage.

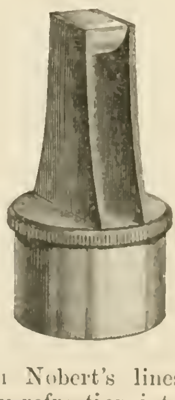
This last-described arrangement of radial-arm and radiant is especially useful in taking air apertures with dry mounted objects under view.

My method is this:—Selecting a cover-glass of ¾ inch or larger diameter, I place at any marginal part of the cover a little diatomaceous material, add a drop of alcohol to distribute the same, and by burning off the alcohol the objects adhere sufficiently to the surface.

This cover-glass is then to be cemented to a slide, not at the centre, but projecting over the end more than half its breadth, the diatomaceous *mount* being most distant from the slide-end. At about the centre of the slide, another cover of similar thickness should be cemented, so as to bring the slide to parallelism with the face of the back-stage (part of *c* in figure) when placed with the cover-glasses downward upon it. The slide is then moved to bring the mounted objects into the optical axis, and the objective focussed upon them, with correction in some way for cover thickness.

Under these circumstances, with *nothing* intervening between radiant and object, when we restrict the light that illuminates the object to what can pass through the narrow slits at the ends of the tubes mounted on the radial arm *p*, there can remain no question of the *obliquity* of the illuminating rays that give us view of the object; *for rays of no other obliquity are admitted.*

Fig. 104.



Semi-cylinder Illuminator.—Mr. J. Mayall, jun., sends us the accompanying figure, showing a convenient way of mounting a semi-cylinder, or prism, &c., to be used for oblique illumination in the substage of those stands that are not provided with swinging motion. The mounting permits the semi-cylinder to be tilted and placed excentrically; in this manner, without immersion contact, by suitable adjustment, the dry object can be viewed with any colour of monochromatic light. Placed in immersion contact with the slide, the utmost obliquity of incident light can be obtained on Nobert's lines (ruled on the under surface of cover-glass in air) by refraction into the stratum of air, using a pencil incident at the upper internal surface just within the critical angle of emergence—the prismatic rays of different refrangibility being then available. Objects in fluid may be placed on the plane surface of the semi-cylinder and illuminated with ordinary transmitted light, or rendered "self-luminous" in a dark field, as with the hemispherical illuminator, prism, or Wenham's immersion paraboloid. A concave mirror with double arm is sufficient to direct the illumination. The semi-cylinder figured was made in 1875 by Mr. Tolles, of Boston, for measuring apertures. The mounting was exhibited at the Society in 1878.

The Iris Diaphragm an Old Invention.*—It is generally supposed that the iris diaphragm, as applied to Microscopes and telescopes, is a very recent invention, but the following passage, taken from an early volume of 'Nicholson's Journal' (1804), shows that it is three-quarters of a century old:—

"Every attentive observer must have taken notice, that light is of as much consequence to artificial vision as magnifying power. It may therefore afford matter of surprise that the most variable of all adjustments of the eye, viz. that of aperture, should never be introduced into our artificial combinations. Distant woods, and other land objects, are invisible to a high magnifying power, for want of light, when the same objects may be distinctly seen with a lower. By means of an artificial iris, which an ingenious artist will find little difficulty in contriving, this disadvantage in telescopes might be obviated. Suppose a brass ring to surround the object end of the telescope, and upon this let eight or more triangular slips of brass be fixed so as to revolve on equidistant pins passing through each triangle near one of its corners. If the triangles be slidden in upon each other, it may readily be apprehended that they will close the aperture; and if they be all made to revolve or slide backwards alike, it is clear that their edge will leave an octagonal aperture greater or less, according to circumstances. The equable motion of all the triangles may be produced either by pinions and one toothed wheel, or by what is called snail-work."

Microscopical Goniometer.†—Mr. Rutley, referring to the Schmidt goniometer (a positive eye-piece in which a cobweb is placed with a graduated brass circle and vernier), says that when the angles of crystals occurring in sections of rock which are not very translucent have to be measured by this instrument, difficulty is often experienced in seeing the cobweb distinctly, and this is one of the most serious drawbacks to the use of this kind of goniometer for petrological purposes. Its utility would, he considers, be increased if one-half of the field were obscured by the insertion of a blackened semicircle of metal within the focus of the eye-piece instead of the cobweb.

Pleurosigma angulatum as a Test Object.—We continually find suggestions made in English and foreign journals that *P. angulatum*

* 'Am. Journ. Micr.,' v. (1880) p. 136.
† 'Study of Rocks' (8vo, London, 1879) p. 53.

is not now a proper test object for "high-power" objectives, and this view appears to be founded on the fact that whereas at least a $\frac{1}{8}$ objective was formerly required to resolve this diatom, it can now be accomplished by a $\frac{1}{4}$ or $\frac{1}{2}$ inch.

In the first place, there is an error in the assumption that resolution is essentially dependent upon the *power* of the objective instead of upon its *aperture*. A $\frac{1}{8}$ objective, if of only 1·1 numerical aperture, will not resolve so many lines to the inch as a $\frac{1}{4}$ of 1·15 of equal quality.

In addition to this, it is of course a mistake to consider that the test depends upon the mere fact of the resolution of the markings upon the object. For such a purpose, it is agreed that no one would now think of using it. The real test, however, is *the manner in which the image is shown*, and by the *quality* of the image of a known object the performance of objectives can be most readily determined by practised observers.

Fasoldt's Test Plate.*—Mr. Fasoldt has, it is said, made a test plate of forty-one bands with a new machine constructed by him for the execution of fine ruling, and capable of dividing an inch into 10,000,000 parts. The first band is ruled with lines at the rate of 5000 to the inch, and the last at the rate of 1,000,000 to the inch. After the million band, there are three "test bands" ruled in 50,000 lines to the inch, but the lines cut of the same breadth and depth as those of the quarter million, half million, and one million bands respectively.

We have not yet seen any description of the plate, our information being taken from an article, "An Evening with Fasoldt's 1,000,000 Test Plate," in which the writer is rapturous over the "genius who dared not only to project, but to execute, a test so many years in advance of microscopical science."

Günther's Photographs of Pleurosigma angulatum.†—After the researches of Professor Abbe on the Theory of Microscopic Vision had placed it beyond doubt (writes Dr. Kaiser) that "the image of fine structures is not produced dioptrically, but by the interference of diffracted rays," there could no longer be any question that "the interference images arising from the action of diffraction do not necessarily represent the nature of the corresponding object," and therefore all attempts to determine the structure of the more difficult objects (as e. g. diatom valves) by simple inspection of their microscopical images, must be considered *à priori* as utterly futile. Rows of depressions will produce precisely the same images as actual striæ, whilst on the other hand, by striæ of different densities, may be produced the same interference-images as with an actual grating.

In order, therefore, to properly ascertain the structure of finely-organized objects, and especially to determine the structure of the diatom valves used as test objects, recourse has repeatedly been had to microphotography, which has proved an excellent auxiliary in this department of micrographic research, and in addition has to some

* 'Am. Journ. Micr.,' v. (1880) p. 160.

† 'Bot. Centralbl.,' i. (1880) p. 683.

extent furnished empirical proof of the correctness of the deductions of our theorists.

Photographs of *Pleurosigma angulatum*, in which the polygons observed on the valves show as annular depressions, have been already published by Stein in his 'Das Licht im Dienste wissenschaftlicher Forschung' (Leipzig, 1877), plate x. These photographs were not, however, taken directly from the object, but were only enlargements of a smaller microphotograph (reproduced from plate ix.) made by photographic apparatus which enlarged it with a rather objectionable effect, the original microphotograph exhibiting the well-known hexagonal markings.

To Mr. Carl Günther, a photographer of Berlin, the credit is due of having produced (exhibited at the recent International Fishery Exhibition) two photographs of *Pleurosigma angulatum* taken direct from the object, which as regards excellence of execution are at least equal to the best productions of microphotography, and which at all events are calculated to refute most thoroughly any objections which may be urged against Stein's enlargements.

Both photographs were taken by a dry process of J. D. Möller, with direct sunlight and central illumination by Abbe's illuminating apparatus, a concave lens being interposed. An old Gundlach's immersion-system No. 7 was used, and with it one of the photographs was produced with an amplification of 2000 times at the distance of 1 metre, and the other with an amplification of 5900 times at a distance of 3 metres.

In those places in which the photograph has come out perfectly sharp (and consequently in the centre especially), both photographs show, like Stein's enlargements, circular openings, with dark contour and bright centre, a circumstance which characterizes them as being without doubt "*openings*."

Where the photographs are less sharp (near the margin, therefore) the figures, which still produce the impression of openings, are more angular, whereby on a superficial examination is produced the appearance of the well-known "hatchings," running in three directions. The larger photograph shows, of course, these marked peculiarities more clearly and strikingly than the smaller one.

These photographs, it is certain, not only furnish a fresh proof of the correctness of Abbe's theory of microscopic vision; but they also plainly demonstrate the great importance of photography for the study of the more difficult microscopical structures.

New Microscopical Journal.—Herr Duncker, of Berlin, has commenced a 'Journal for Microscopical Examination of Flesh and Popular Microscopy' (4to), which appears twice a month. The thirteenth number, which is before us, contains articles on "Schools for the Examination of Flesh," "Micrococci and Bacteria," "The Collection and Preparing of Diatoms," &c.

therefore takes place as in *Euglena*, at what may be termed the period of encystment, i. e. during the phase of immobility, when the body is entirely destitute of cilia.

In the next stage, each of the new cells increases in size, separates gradually from its sister-cells, becomes clothed with a delicate cell-wall, and finally entirely covered with vibratile cilia inserted independently side by side, and uniformly clothing the whole of the surface. It next begins to move about, and at the same time secretes abundance of a gelatinous substance. The cilia then gradually fall off in proportion as the body grows in acquiring its ultimate dimensions. Only the single polar tuft of hairs now remains. Beneath this bare surface, at two diametrically opposite points of the equator, a band of bright homogenous protoplasm now makes its appearance, which develops on each side into a fringe of hairs towards the pole. Thus we arrive at the original point of departure.

At no period of development can the presence of cellulose be determined in the membrane, nor of starch in the protoplasm, otherwise the process of gelatinization proceeds as in the Nostochineæ and Bacteriaceæ.

Whether this organism ought properly to be considered as belonging to the animal or to the vegetable kingdom is, M. Van Tieghem considers, doubtful, and he adds " in the present state of science this question, to which formerly so much importance was attached, seems to me devoid of interest."

The name *Dimystax* (*Perrieri*) is proposed, to indicate the secondary tufts of cilia developed after the first tuft has almost completely disappeared.

MICROSCOPY, &c.

Permanent Microscopical Preparations of Amphibian Blood.*— Mr. S. H. Gage says that the very excellent method of drying the corpuscles of mammalian blood on the slide is not applicable to the much more bulky corpuscles of Amphibia. The corpuscles of the latter are sure to be distorted and seamed in drying, hence various methods of preserving the corpuscles moist have been tried with varying success. The following very great modification of the method proposed by Ranvier in his treatise on histology † has been in use for some time in the Anatomical Laboratory of Cornell University, and has given uniformly excellent results. Preparations made three years ago are quite as good as at first.

Three or four drops of fresh blood are allowed to fall into 10 cc. of normal salt solution (common salt 750 milligrams, water 100 cc.), preferably contained in a high narrow vessel like a graduated glass or beaker. The mixture of blood and salt solution should be well agitated, and then 100 cc. of a saturated aqueous solution of picric

* 'Am. Nat.,' xiv. (1880) pp. 752-3.

† 'Traité technique d'Histologie,' i. (1875-78) p. 195.

acid added with constant stirring. After the corpuscles have settled, as much of the supernatant liquid as possible is poured off, and in its place is put about an equal volume of normal salt solution. The corpuscles are allowed to settle, the liquid poured off, and another volume of salt solution added. This is continued until the salt solution acquires only a faint yellow tinge. The use of the salt solution is, first, to dilute the blood in order to avoid distortion of the corpuscles, and second, to wash away the picric acid, so that the subsequent staining will be more satisfactory.

After pouring off the last salt solution, there is put in its place 10 cc. of a mixture of five parts of Frey's carmine and ninety-five parts of picrocarmine. The corpuscles will stain in from one to fifteen hours. A drop of the agitated mixture should be examined occasionally, to ascertain when the staining is sufficient. The nucleus should be deep red, and the body of the corpuscle yellow or pinkish.

When the staining is completed as much stainer as possible should be poured off, and in its place 10 or 15 cc. of acid glycerine (glycerine 100 cc., acetic or formic acid 1 cc.). This mixture of corpuscles and glycerine may be placed in a bottle and used at any time, it being simply necessary to agitate the mixture slightly or to take up some of the sediment with a pipette and mount it precisely as any other glycerine preparation.

The process consists, therefore, of these five steps:—

1. The fresh blood is first diluted with about fifty times its volume of normal salt solution. 2. To this diluted blood is added ten times as great a volume of a saturated aqueous solution of picric acid. 3. The picric acid is washed away with normal salt solution. 4. The corpuscles are stained with picrocarmine, or a mixture of this and Frey's carmine. 5. They are preserved in acid glycerine, and may be mounted for the Microscope at any time.

Preparing and Mounting Wings of Micro-Lepidoptera.*—Mr. C. H. Fernald describes a method by which the wings of the micro-lepidoptera can be prepared so that the venation can be studied under the compound Microscope, in a manner that will leave no doubt of the presence or absence of the faintest vein in the whole wing-structure.

The removal of the scales by mechanical means he considers unsatisfactory, as also are the methods recommended for bleaching the wings, described by Chambers and Dimmock. When mounted dry by the latter method, the scales, although bleached, were not sufficiently transparent to show clearly the more obscure parts of the structure, and when mounted in Canada balsam, the entire wing was rendered so transparent that only the larger veins were visible, and it was found to be extremely difficult to get rid of the air-bubbles, which so readily gather under the concave portions of certain minute wings.

The author's method consists in mounting in cold glycerine; after having been bleached by Dimmock's method (which, for bleaching, is

* 'Am. Mon. Micr. Jour.,' i. (1880) p. 172. (Paper read before the Subsection of Microscopy of the Am. Assoc. Adv. Sci.)

to be recommended), the wings are transferred to the slide direct from the water in which they are washed, then allowed to dry (sometimes hastened by holding the slide over the flame of a lamp); and, when quite dry, a drop of glycerine is to be added, and the cover at once put on. When the glycerine has penetrated around the edges so as to completely saturate portions of the wing, the scales at once become transparent, and the structure is clearly apparent.

By holding the slide over the lamp till ebullition takes place, the glycerine will be found to replace the air under the concave portions of the wings, without any injury to the structure; and even in those refractory cases when the glycerine has been allowed to boil for a considerable length of time, no injury was found to be done to the wing-membrane.

Microscopical Investigation of Wood.—The Vienna Academy propose as the subject for the Baumgärtner prize of 1000 florins, "The microscopical investigation of the wood of living and fossil plants." By such investigation, and the comparison of all known recent and fossil woods, it is desired to ascertain characters whereby it will be possible to determine the genus and species with certainty from microscopical sections. Papers must be sent in before December 31st, 1882, and the prize will be awarded at the anniversary meeting in 1883.

Permanent Preparations of Plasmodium.*—Two methods are already known for making permanent preparations of the motile or naked protoplasmic stage of the Myxomycetes; the older one being to dry the extended plasmodium, and the newer, to harden it with osmic acid. Both these methods are defective, for osmic acid changes the colour of the protoplasm, and drying causes it to shrink as well as to change colour.

Mr. S. H. Gage gives the following as a simple and efficient method of extension and preservation: Small pieces of the rotten wood, on which the plasmodium is found, should be placed on moistened microscope-slides, with some of the plasmodium touching the slides. These should be on a piece of window or plate glass, and over the whole should be placed a bell-jar, or other cover, to prevent evaporation. After an hour or more, the glass on which the slides rest should be lifted up to see whether the plasmodium has crawled out upon any of the slides. If any of the slides are satisfactory, lift off the bell-jar, and remove the pieces of wood from the slide, the plasmodium remaining. The slide should then be put very gently into a mixture of equal parts of a saturated aqueous solution of picric acid and 95 per cent. alcohol; it should be removed in fifteen or twenty minutes, and placed, for about the same length of time, in 95 per cent. alcohol; it may then be mounted in Canada balsam in the usual way, but without previous clearing. The picric acid stiffens the protoplasm almost instantly, but does not shrink it; the alcohol removes the water, and allows of Canada balsam mounting.

* 'Am. Mon. Micr. Journ.,' i. (1880) pp. 173-4. (Paper read before the Sub-section of Microscopy of the Am. Assoc. Adv. Sci.)

The method is especially good for the yellow plasmodium, as the colour is precisely that of the picric acid solution. If white plasmodium is to be mounted, it should be soaked in 25 per cent. alcohol, to remove the yellow colour of the picric acid, before anhydrating it with strong alcohol. Experiments have not been tried with plasmodium of purple and other colours to determine successful methods of preservation, but some slight modification of the above is confidently expected to succeed.

Preparation of Green Algæ.*—Last summer Prof. O. Nordstedt collected at Jönköping the rare, and in many respects interesting, alga, *Sphæroplœa annulina*. This alga has the chlorophyll in the sterile cellules arranged in transversal bands or rings. As he tried to dry them, he found that the rings were destroyed by getting dry. He repeatedly tried to obtain good microscopical preparations by using "liquor Hantzschiæ," as well as acetate of potassium; but when unsuccessful, he applied warmth. He put a small bottle, containing the alga in water, on a black object, and exposed it to strong sunlight for a couple of hours. When the alga afterwards was dried, the rings proved to be pretty well preserved; when afterwards heated by a spirit lamp, the thermometer indicated that the rings when boiled

½ minute at 35°–40° Cels.	Did not keep, or were very badly preserved.
When boiled 5–10 minutes at 45° Cels., ½ minute at 50°–98° Cels.	The rings kept very well.
10 minutes at 60° Cels., 2 minutes at 98° Cels.	The rings were separated from the membrane and placed in the centre alongside the cellule.

It appears to be most convenient for the purpose to use 40°–50° Cels. during about two minutes.

In the *Spirogyra* the chlorophyll-bands, when the plant was boiled, also kept tolerably well; he, therefore, has often applied heat in preparing them. The different species seem to require different degrees of heat.

Slides from the Naples Zoological Station. — A provisional priced catalogue of the microscopical preparations issued by the Zoological Station at Naples † has now been published.‡ It includes 4 different preparations of Protozoa, 33 of Cœlenterata, 49 of Echinodermata, 33 of Vermes, 57 of Arthropoda, 54 of Mollusca, and 193 of Vertebrata.

The list is prefaced by an explanatory note by Dr. A. Dohrn, the Director of the Station, in which he points out that the microscopical preparations which have hitherto been sold "have only in rare cases a true scientific value. For this they must not only be prepared by hands well skilled in the technical processes, but there must also be the understanding of scientific problems and points of view," so that the preparations may exhibit just those points which are of importance

* 'Grevillea,' ix. (1880) pp. 37–8 (from 'Bot. Notiser').
† See this Journal, *ante*, p. 700.
‡ 'MT. Zool. Stat. Neapel,' ii. (1880) pp. 238–53.

scientifically. The slides are prepared under the superintendence of Mr. F. Meyer of Leipzig, who at Dr. Dohrn's request undertook this department. They are of the ordinary English size, and their price varies from 1 to 10 francs.

Aeroscopes.*—In his studies on the microscopic organisms contained in the atmosphere, M. P. Miquel describes two forms of aeroscopes in use at the Montsouris Observatory for collecting such organisms.

M. Miquel objects to Dr. Maddox's "aeroconiscope," † that the quality of air passing during each experiment cannot be calculated, so that the statement of the number of germs collected has no definite signification. In his opinion, it is preferable to make use of apparatus capable of acting in all weathers, during rain and squalls as well as in fine weather.

Fig. 105 represents his "aeroscope à aspiration," which is composed essentially of two parts—the bell A, which is solidly fixed at 2 metres from the ground, and the cone B, which is screwed to A. The former has an aspiring tube placed in communication with a trumpet, and the

Fig. 105.

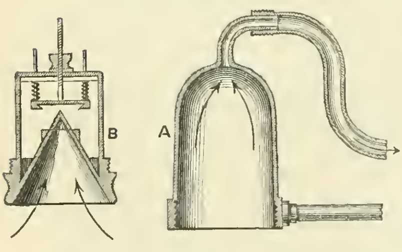
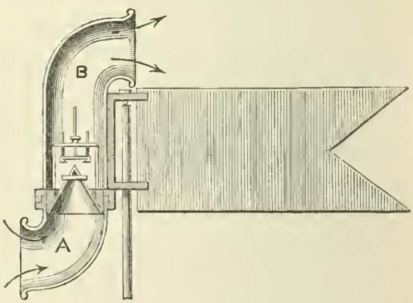


Fig. 106.



latter has at its upper part a very fine aperture, by which the air is directed to the centre of a thin glass plate smeared with a mixture of glycerine and glucose. This plate, which is kept in a horizontal position, may be brought nearer to the summit of the cone, or *vice versâ*. The air aspired by the trumpet, after having passed through the apparatus, is received in a meter, which measures its volume exactly.

A second instrument ("aeroscope à girouette") is shown in Fig. 106. It operates by the action of currents of air, and is used only to analyze the air qualitatively when the other form cannot be employed. Like the apparatus of Drs. Maddox and Cunningham, it is light and portable, but in the same time gives 100 times as many germs. It is in the form of an *S*, and consists of the chambers B (united to a vane, so that the upper bell-shaped aperture is kept constantly opposite to the wind), and A carrying a thin glass plate and a conical

* 'Brebissonia,' ii. (1880) p. 147.
† 'Mon. Micr. Journ.,' June, 1870.

diaphragm, and having its lower aperture turned in the direction of the currents. The apparatus set upon a vertical axis is acted upon by the feeblest currents. A Robinson anemometer serves to measure the velocity of the air during the experiment, and to estimate approximately the volume which has passed through the apparatus.

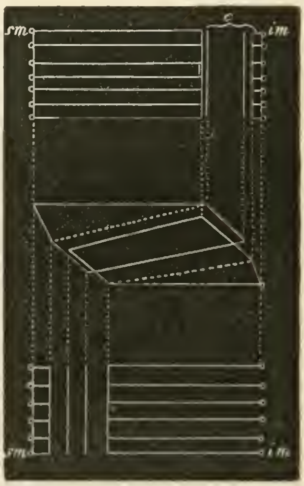
Both forms were originally constructed of glass, but are now made of copper nickelled.

Microscopical Appearance of the Valves of Diatoms.*—This paper by Mr. Julien Deby is written with the view of enabling microscopists more readily to *interpret* the appearances presented by diatoms as seen under the Microscope, which is often very difficult with transmitted light. By an attentive examination, however, of the details, "even the most incomprehensible problems will be resolved as if by enchantment."

Taking *Nitschia* as the first type, the author divides the different forms into two principal divisions—those in which the two sections of a valve meet at an acute angle, and those which meet at an obtuse angle, each of which divisions may have the valve-sections plane or curved. These four divisions may each be subdivided into three others, according as the midrib is central, normally excentric, or submarginal (that is, with one of the valve-sections nearly obsolete).

The author then gives diagrams of the appearances of various forms, of which we can only subjoin one—Fig. 107 (*sm.*, *im.*, upper and lower midrib; *c*, connective). This shows a *Nitschia* with valves whose two sections form an acute angle, and with an excentric midrib. Taking the line which represents the surface of either of the larger sections as a horizontal, and drawing the perpendiculars, we shall have the true microscopical projection of the diatom when viewed from the upper or under side respectively.

Fig. 107.



The author considers that it is necessary to pay more attention to details than has hitherto been the case in this difficult genus, and in defining every species (1) to describe the general form of the frustule, and the relations of the length of the two sections of the valves to the breadth; (2) to indicate the position of the midrib by reference to the imaginary central line of the valve, that is to indicate the relative size of the two sections; (3) to determine the number of striæ by reference to the nodules of the midrib; (4) to count the siliceous grains of the midrib, the striæ of the valve sections, and the number of points per stria per micro-millimetre; (5) to indicate if the valve is acute or obtuse, and its sections plane or curved.

* Sep. repr. 'Ann. Soc. Belg. Micr.,' v. (1880), Mém., 16 pp. and 20 figs.

Cleaning Diatoms with Soap.*—Dr. H. Stolterfoth having tried to clean some of the Welsh deposits by the common acid process, which gave very poor results, even alkalies destroying the valves of the larger *Surirellæ* before they were free from the dirt, boiled them in soap and water for about an hour, with excellent results. The process is also applicable to all kinds of fresh- and salt-water deposits.

The method is this: Place in a test-tube (6 inches by 1 inch) a portion of the earth, about $\frac{1}{4}$ inch in depth, and pour in water till the tube is one-fourth full; into this drop a piece of common yellow soap, about the size of a small pea, and boil gently over a lamp. The solution should be examined under the Microscope from time to time, by taking out a drop with a dipping-tube, and putting it on a slide; as soon as it is seen that the valves are clean, fill up the test-tube with cold water, and let it stand, then wash in the usual way, until all trace of soap is removed.

In pouring on the cold water after the boiling, the solution is quite fluid as long as the water is warm. During this time the diatoms fall to the bottom, but, on getting cold, the solution assumes a somewhat jelly-like consistency, and holds the fine particles and mud in suspension, and is a very useful means of getting rid of what is often a great trouble.

In deposits in which there is much organic matter, recourse must still be had to acids or fire to destroy this, but the result will be improved by afterwards boiling in soap and water. The author has also boiled fresh gatherings in soap and water, and then burnt on platinum foil with good success, much of the flocculent matter being removed.

Dr. E. Kaiser, of Berlin, referring to this paper, says † that the process was communicated to him several years ago from England, but that " it has very many defects and inconveniences."

Separation of Heavy Microsopic Minerals.‡—In order to separate minute particles of heavy minerals, of different specific gravities, from each other, M. René Bréon proposes to employ a mixture of the fused chlorides of lead and zinc, the respective specific gravities of these two liquids being 5 and 2·4, so that by properly proportioning the mixture, any two minerals of different specific gravities, but lying within the above limits, can be separated. The fine powder to be experimented on is thrown into the fused chlorides contained in a conical glass tube, when the particles speedily come to rest, some floating, and the others sunk at the bottom of the tube; the mass is then allowed to cool, and when set, the tube is plunged into cold water, thus cracking the glass. The upper and lower portions of the mass of chlorides containing the minerals can then be removed, and the chlorides dissolved out with water acidulated with hydrochloric acid.

Pearson-Teesdale Microtome.—At the October Meeting Mr. Washington Teesdale exhibited a small and convenient form of micro-

* 'Journ. Quek. Micr. Club,' v. (1880) pp. 95–6.
† 'Bot. Centralbl.,' i. (1880) p. 1213.
‡ 'Bull. Soc. Min. France,' iii. See 'Mineralog. Mag. and Journ. Mineralog. Soc.,' iv. (1880) p. 129.

tome, for amateur use, made by Mr. A. A. Pearson, of Leeds. The instrument is shown in Figs. 108 and 109, and was thus described by Mr. Teesdale:—

"In general form it is based upon the Continental model of Dr. Schiefferdecker, of Strassburg,* but it is more compact, and small objects are more readily held or packed, as the holding or grasping

Fig. 108.

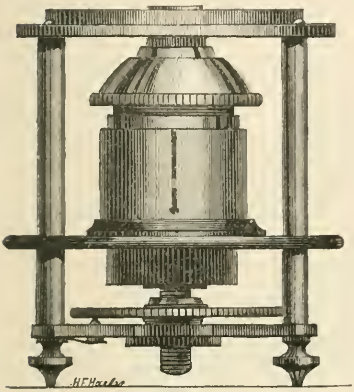


Fig. 109.

is effected by jaws closing centrally like those of an American chuck. The object so held is raised by a double-threaded screw of 50 per in., metrically equal to (but possessing some advantage over) one of 25 threads per in. Its elevation is regulated and recorded by a circular plate and spring stop catching in 20 equal divisions, each one of which indicates an advance of $\frac{1}{500}$ in. In practice I have generally found about $\frac{1}{250}$, in two divisions of this graduation, the most convenient average thickness for vegetable sections.

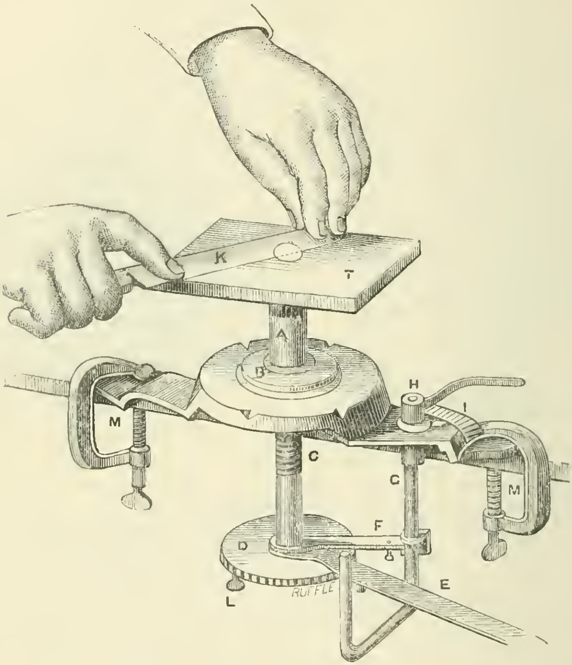
I have used most of the forms of ordinary section-cutters for nearly twenty years. Some are ingeniously contrived and good in theory, or suitable for some special purpose, but have some practical fault or inconvenience for the general all-round work of an amateur. The Strassburg model which furnished the basis of the design of this, was, it appeared to me, an excellent one, and the principle of its construction sound, inasmuch as the object was not irregularly forced up by pressure from beneath, but held firm, and had the cutting table or guide-plate lowered by screw and graduated index. Such intelligent mechanical aid to accuracy and facility ought, and would, assuredly have obtained favourable recognition and general adoption, but, unfortunately, in copies of it made and distributed in England the screw was cut taper in the lathe (instead of being cut perfectly parallel with stocks and dies), consequently the instrument was somewhat shaky."

* 'Quart. Journ. Micr. Sci.' (1877) p. 35.

Hailes' Poly-microtome.*—This instrument, shown in Figs. 110 and 111, is the design of Dr. W. Hailes, Professor of Histology, &c., at Albany Medical College (U.S.A.), who thus describes it:—

This instrument is designed especially for use in the working

Fig. 110.



Poly-microtome (without freezing apparatus). A, small well, fitting on pyramidal bed-plate. B, pyramidal bed-plate, containing different sizes. C, micrometer screw. D, ratchet-wheel attached to screw. E, lever actuating the micrometer screw by means of a pawl engaging in teeth of ratchet-wheel. F, arm, carrying a dog, which prevents back motion of screw. G, regulator for limiting the throw of lever, and consequently governing the micrometer screw. H, lever-nut for fixing regulator. I, index, with pointer and graduated scale, from $\frac{1}{2400}$ inch to $\frac{1}{200}$ inch. K, knife for cutting sections. L, knob to turn micrometer screw direct when pawls are attached. M, table-clamp. T, table of microtome, with glass top to facilitate cutting.

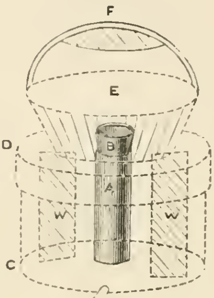
laboratories of medical schools and colleges, where large numbers of sections are required for microscopical examination. It may be employed as a simple instrument or as a freezing microtome, arranged for ice and salt—ether spray, phigoline, &c.

The employment of ice and salt (coarse) is preferred, because it costs but little and freezes the mass solidly and quickly, and, if desired, 500 or 1000 sections can be obtained in a few moments.

* 'Science,' i. (1880) p. 187. (2 figs.)

Time of freezing is about seven minutes, except in very warm weather, when it requires a few moments longer. The instrument does not work so satisfactorily in warm weather, owing to the rapid melting of the surface of the preparation. It is absolutely necessary that the mass should be frozen solid, or the sections cannot be cut smoothly. An extra freezer may be employed, and while one specimen is being cut the other may be frozen, and by exchanging cylinders (they being interchangeable) no delay is necessary to its continuous operation.

Fig. 111.



A, B, tube containing specimen, which is surrounded by freezing mixture in the receiver C, D. E, F, revolving hopper, with wings W, W, for stirring the ice. G, outlet for melted ice.

The art of cutting is readily acquired, and when the preparation is frozen it is the work of a few moments to obtain several hundred sections. Two hundred sections or more, if desired, can be made each minute and of a uniform thickness of about $\frac{1}{200}$ of an inch (thinner or thicker, from about $\frac{1}{2400}$ inch to about $\frac{1}{200}$ inch, according as the pointer is set). The delivery, ease, and rapidity with which they can be cut, must be seen in order to be appreciated. It is not necessary to remove the sections from the knife every time, but twenty or thirty may be permitted to collect upon the blade; they lie curled or folded up upon the knife, and when placed in water straighten themselves out perfectly in the course of a few hours. The knife is an ordinary long knife from an amputating case.

Perfectly fresh tissues may be cut without any previous preparation, using ordinary mucilage (acaciæ) to freeze in, but most specimens require special preparation. If preserved in Müller's fluid, alcohol, &c., they require to be washed several hours in running water; then according to the suggestion of Dr. D. J. Hamilton,* the specimen is placed in a strong syrup (sugar, two ounces; water, one ounce), for twenty-four hours, and is removed to ordinary mucilage acaciæ for forty-eight hours, and is then cut in the freezing microtome.

The sections may be kept indefinitely in a preservative fluid: ℞ glycerinæ, ℥iv; aquæ destil. ℥iv; acidi carbolici, gtt. iij; boil and filter. The addition of alcohol ℥ij is advisable.

Salicylic Acid as a Preservative.†—Mr. A. Mickle has had very good success with salicylic acid in mounting vegetable preparations of all kinds. One difficulty, however, is that it dissolves very sparingly in water, and alcohol produces changes which are frequently undesirable. It is well known that salicylic acid dissolves freely in a solution of borax, and it is also familiar to most persons that borax

* See "A New Method of Preparing Large Sections of Nervous Centres for Microscopical Investigation."—'Journ. Anat. and Phys.,' vol. xii.

† 'Am. Journ. Micr.,' v. (1880) p. 185-6.

itself is quite efficient as a preservative. It therefore occurred to him to combine them, two parts of salicylic acid and one part of borax dissolving completely in half an ounce of glycerine—this solution, when mixed with three parts of water, forming an excellent preservative fluid for coarse organisms. More delicate preparations should be mounted in the above solution diluted with five parts of water.

Preparations so mounted are very durable, and there is no danger of the salts crystallizing out and spoiling the object, and, in addition, it is very easily kept in a cell of almost any kind.

Dry "Mounts" for the Microscope.*—Prof. Hamilton L. Smith, referring to his former paper,† in which he described the methods which he had found tolerably successful, viz. the rings made of shellac and lampblack, and those punched out of gutta-percha tissue, further says that the former appear to answer quite well, and the changes if any are very slight, yet he has in a very few cases observed a deterioration after the lapse of a year or so, probably from imperfect manipulation. Although he has not observed any great change in the gutta-percha mounts, he is not certain they will stand prolonged use with immersion objectives without injury. Messrs. Spencer are decidedly of opinion that the shellac ring is the better for durability; and Mr. Gundlach says that the gutta-percha ring will not stand cedar oil. Dr. Phin has suggested that in time the gutta-percha tissue will disintegrate, but the author has not yet noticed this, and does not think it will happen under the cover of a "mount," especially if protected by a ring of cement subsequently applied. If it does, it will of course be a great objection to its use. The "tissue" becomes so charged with electricity by handling, and also by punching, that it interferes seriously with the latter operation, and thus makes it necessary to place strips of the "tissue" on thin moistened strips of paper, and to punch out both at the same time. The preparation of the shellac rings by the turntable obliges one to keep on hand a large stock all the time, to ensure perfect drying and to have them always ready. The author is obliged to have some 1000 or 1500 on hand in advance, and this necessitates a considerable outlay in stock which will not always be convenient for amateurs.

For the above reasons, a new process is now proposed which appears to meet all the desired wants, and which combines the advantages of the shellac cement and the gutta-percha rings. The author says that "the very simplicity of this process causes him to wonder why it was not thought of before."

Take a sheet of thin writing paper, white or coloured, and dip it into thick shellac varnish (shellac dissolved in alcohol), and hang it up to dry. When thoroughly dry, it should have a good glaze of the varnish on it (different thicknesses of paper can be used according to depth of cell required). Out of this shellac paper cut the rings, and these can be made in any quantity, and kept for any time. The process of mounting is simple. The slide is cleaned and the flat paper ring placed in the centre; on this the cover is placed, having

* 'Science,' i. (1880) p. 74. † See this Journal, *ante*, p. 861.

the object dried on it, and the two are held together by the forceps and gently warmed; this serves to attach the ring to the slide and cover at several points, so that the forceps may now be laid aside. The next step is to take a glass slip (another slide), and laying this on the cover, to grasp the two slides at each end by the finger and thumb of the two hands, and pressing them tightly together, to warm the slide gently; by looking at the ring obliquely on the under side one can tell at once when all the air is pressed out, and the adhesion is complete between the cover and the ring, and also the ring and the slide, and they must be held together a moment or two to cool. If the lac is sufficiently thick on the paper, the adhesion takes place quickly, and with moderate heat, and there will be no danger of breaking the cover, unless it has been warped in the process of warming, which will sometimes occur when very thin glass has been heated too much for the purpose of burning off the organic matter, or when the support is too small in diameter, or when it is not flat.

The author, in conclusion, says, "I cannot conceive of anything more satisfactory than these rings. Many large objects which would be crushed if one used only the shellac rings made on the slide by the use of the turntable, by the giving way of these by softening, and under the necessary pressure for attaching the cover, are perfectly protected by the paper rings. I am satisfied that the balsam mounts will be much less frequently used as soon as we can find some *sure* dry process. The diatoms as a rule show much better when mounted dry, and with whole frustules, exhibiting both the side and the front view, also the mode of attachment, &c. The dry mounts are certainly to be preferred when they are desired for anything except pretty objects, and even for this latter purpose there is often a very great difference in favour of the dry mount. Although I have not used these shellac paper rings for any very great length of time, yet I can see no reason why they should not be equal to the simple shellac ring for durability, and very much superior to it in other respects."

We should note, in regard to this suggestion of Prof. Hamilton Smith, that the rings above referred to were the subject of a paper read to this Society by Mr. James Smith * in 1865.

Dr. Phin has found, he says,† "that pure shellac in all its forms is very apt to separate from the glass after a time.

Wax Cells.‡—Dr. Phin does not appear to be disposed to abandon these cells, as suggested by their originator (Prof. Hamilton L. Smith). He has carefully examined a number of slides of the mounting material of which wax forms a part. Some were found to be spoilt, others were good. It is evident that the dew may arise either from

* 'Trans. Micr. Soc. Lond.,' xiv. (1866) p. 29. The following is an extract from Mr. James Smith's paper:—"Both surfaces of the cardboard [are to be] covered with a cement formed of shellac or marine glue dissolved in naphtha; one to three coatings of this cement being usually sufficient, care being taken that one is perfectly dry before the next is applied. The cells being thus prepared, they can be cut off, and by the application of heat and slight pressure are easily attached to a glass slide."

† 'Am. Journ. Micr.,' v. (1880) p. 203. ‡ Ibid.

the object itself or from the mounting material. In the case of such objects as Polycistina and diatoms which have been exposed to low red heat, it is unlikely that any vapours would ever be given off, and slides of these objects have been found both with dew and free from it. A good deal probably depends upon the quality of the wax and the processes used in bleaching it. Where bleached by exposure to sunlight and water, and afterwards carefully melted, it is believed no vapour will be given off. Where the wax has been bleached by the action of acids and chlorine it is difficult to tell what changes may occur.

Amongst the directions for mounting in wax cells, one which has been generally given and very usually followed, is to soften the wax with turpentine at the point where the object is to be placed. When this has been done, and the cell closed immediately, the turpentine is sure to evaporate and settle on the cover. It there becomes oxidized or ozonized, so that it is no longer volatile, and it was undoubtedly this ozonized turpentine which resisted the high temperature alluded to by Prof. Smith. Instead of turpentine, a copper wire should be used. highly heated, and held near but not in contact with the wax.

To the same tenor are the remarks of Mr. C. F. Cox and Mr. J. F. Stidham.* The former points out that while if the ground for condemnation—"dew" on the cover-glass—were found exclusively in the case of wax cells, it might be fair to infer that the cause was the wax, yet as it is found more or less in cells of all kinds, and is not worse in wax cells than in most others, the denunciation by Prof. H. L. Smith of his own invention is not justified. The misty condensation may possibly be caused in some cases by emanations from the sheet wax, but Mr. Cox's experience goes to prove that it is mainly due to the too free use of cements containing resinous or oily solvents, like turpentine or benzole, though sometimes it may arise from the want of dryness in the object itself, or a recrystallization of chemical constituents of the cements, as the Professor suggests. If a cement is used, composed of shellac dissolved in alcohol, plenty of time allowed for the completion of each step, no more cement used than is necessary, and the specimen itself thoroughly dry, the cell will be free from vapour and condensations, and he is therefore of opinion that the wax cell is "the best cell for dry objects that has ever been used."

Mr. Stidham's testimony is to the same effect. He "has found no trouble since covering the whole cell with a thin film of shellac, and using shellac to fix the cover, provided the *day was a dry one*, and the cover is held for a moment over the lamp flame." He thinks Mr. C. C. Merriman's suggestion of leaving a small opening so that moisture may get out would be of practical advantage if it can be done.

Improvement in Making Wax Cells.†—For making wax cells, when they are wanted smoother and handsomer than they can be made with a punch alone, Mr. J. D. White recommends the following

* 'Am. Journ. Micr.,' v. (1880) p. 207.
† 'Am. Mon. Micr. Journ.,' i. (1880) p. 150-1.

process as simpler and easier than that of Dr. Hamlin, described on page 507.

With home-made punches of ordinary brass tubing (cartridge cases answer very well), cut out rings and disks a little larger than the finished cells are to be, and fasten them to the sides by pressure and gentle warmth, after centering as accurately as possible. Then, with a tool made by bending a small chisel at a right angle about half an inch from the edge, turn or scrape the cell on a turntable until it is of the right size. If the tool is sharp, a beautifully polished surface will always result. The chisels which accompany sets of bradawls are just right; but any flat piece of steel, if not too heavy or clumsy, will do. The cutting edge should be about one-fourth of an inch wide. Punches, and all tools used for cutting wax, should always be dipped or moistened in starch, prepared precisely as for laundry use; this operates much better than water, or indeed anything else.

Atwood's Rubber Cell.*—Mr. H. F. Atwood calls attention to a cell for opaque objects made of hard rubber highly polished.

Fig. 112 is a sectional view of the cell, the dotted line indicating the position of the thin glass cover. The base is solid, giving a black background of rubber, and round the top is a ledge fitted to receive a ½-inch cover-glass, which may be secured by a little shellac or similar cement.

Fig. 112.

The cell is claimed to be specially advantageous in two ways:—1st. It solves the problem which often perplexes the collector who is crowded for cabinet room. Many objects for future reference may be mounted, numbered, and put away without a slide, a cabinet drawer holding 200, while but 40 slides could be accommodated in the same space. 2nd. In exchanges the cells may be sent through the post without glass slips, so that there is a saving in postage and no risk of breakage.

Mr. Atwood suggests that the cell "may be attached to a glass slip by any cement before or after preparation." Our own experience is that rubber is by no means easy to attach securely, and that some other means of examining the cells under the Microscope will be necessary. In this view, Messrs. Beck have devised a circular cell-holder, in ebonite, holding 12 cells, which lies upon the stage, and can be rotated so as to bring each cell successively under the objective.†

Parkes's Frog-plate.—Instead of the ordinary method of examining the circulation of the blood in the frog's foot, which is attended with some degree of inconvenience, at any rate, to the animal, the following plan is recommended:—

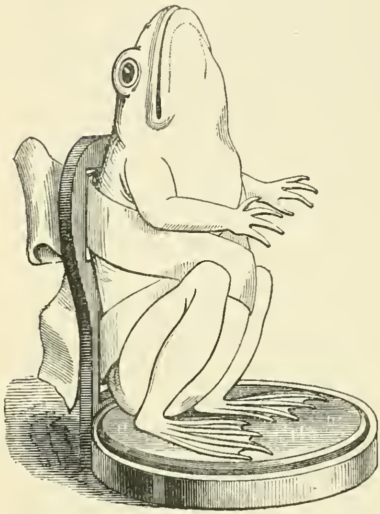
Put the frog into an empty wide-mouthed bottle (such as a pickle-jar), cover the cork with a piece of linen rag, on which pour a little sulphuric ether, and then insert the cork immediately, and lay the bottle on its side. In a few minutes the animal will be sufficiently

* 'Science,' i. (1880) p. 209.

† A description of this holder, with a figure, will be given in the next number.

etherized * without affecting the circulation, and may then be placed on the frog-plate, shown in Fig. 113, in an erect position, with its feet on the circular glass, a little soft tape being placed—not too tightly—round the body to keep it erect. The web of the foot may now be moistened with a little cold water, and the plate laid on the stage for examination.

Fig. 113.



If sufficiently etherized, the frog will remain perfectly quiet for half an hour, and both feet may be examined alternately. The toes must of course be spread out so as to stretch the web, which should be moistened occasionally with a camel-hair pencil dipped in cold water. The process may be repeated many times on the same frog if carefully managed, but after each examination it should be put into a vessel with a little cold water, till it recovers consciousness.

Sternberg's Culture-cell.†—There are many experiments in which a culture-cell is required which will preserve the blood in a fluid condition, free from atmospheric contamination, and yet surrounded by a sufficient amount of air to furnish the necessary oxygen to organisms that may develop from any germs that may be present in the blood. In addition to this it is necessary that a very thin stratum of blood should be within reach for examination by the highest-power immersion objectives.

The Boldeman cell fulfils the first requirement. A central eminence is surrounded by a circular channel, ground in the glass, which serves the purpose of an air-chamber. The summit of the central eminence is slightly concave, and the drop of fluid to be observed is placed upon this and protected with a thin glass cover, which is attached to the slide by a circle of cement, or simply by a little oil.

The main objection to this cell was found by Mr. G. M. Sternberg, Surgeon U.S. Army, to be that the stratum of blood held in the shallow cup of the central eminence was too thick for satisfactory examination with high powers; that portion of the fluid next the cover, which could be brought into focus, being shut off from the

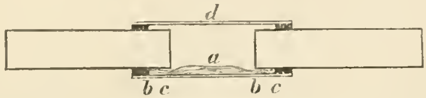
* It may always be known when the frog is fully under the influence of the ether, by placing it on its back, before taking it out of the bottle, as it will not remain quietly in this position except when etherized.

† 'Am. Mon. Micr. Journ.,' i. (1880) pp. 141-3. 1 fig.

light by floating corpuscles in the background. And this difficulty led him to invent the following culture-slide.

A circular hole, about $\frac{1}{4}$ inch in diameter, is drilled through the centre of a glass slide. A very thin circle of cement, $\frac{1}{2}$ inch in diameter, is then turned about this central hole on one side of the slide, and a thin glass cover is attached to it by gentle pressure. When the cement is thoroughly dry, the cell is ready to receive the drop of blood, or other fluid which is to be observed. This is placed in the bottom of the cell (*a*, Fig. 114), and flows by capillary attraction into the space below, between the thin cover and the slide, until it extends to the circle of cement by which the cover is attached.

Fig. 114.



We have thus a thin stratum of the fluid between the points *b* and *c*, which may readily be examined by inverting the slide and bringing an immersion lens down upon any point between the central air-chamber and the circle of cement by which the cover is attached. Finally, the cell is closed by turning a still larger circle of cement upon the upper surface of the slide, and attaching a larger thin glass circle (*d*).

Mr. Sternberg does not see why it should not also serve a good purpose as a cell in which to mount objects either dry or in fluid. If the manufacturers would furnish glass slips of different thicknesses, having central perforations of $\frac{1}{4}$ to $\frac{1}{2}$ inch in diameter, a thin glass cover can easily be attached to make the bottom to the cell; and these might, for many purposes, replace the various cells in common use.

Apertures exceeding 180° in Air.—Mr. Shadbolt's note on this subject will be found in the Proceedings of the November Meeting, *infrà*, p. 1089.

Visibility of Minute Objects — New Medium for Mounting (*Monobromide of Naphthaline*).—Professor Abbe has recently been experimenting upon substances adapted for mounting diatoms (having regard to the suggestions made in Mr. Stephenson's recent paper *), and has discovered that monobromide of naphthaline is very suitable for the purpose, and does not present the inconveniences of some of the other substances.

The liquid is colourless and oleaginous, with the odour of naphthaline. It is soluble in alcohol and ether, and has a density of 1·555, with a refractive index of 1·658, giving therefore as the "index of visibility" 22 as against 11 for Canada balsam. It is not volatile.

Dr. H. van Heurck refers to this substance, some of which was sent him by Mr. Zeiss. His experiments with it have given the best

* See this Journal, *ante*, p. 564.

results, the diatoms mounted in it showing with "excessive beauty." The striæ of *Amphipleura pellucida*, amongst others, were clearer than he ever before saw them. Objectives, with which he had never been able to see the striæ by simple lamp-light, showed them at once in the new medium. He considers, therefore, that its employment will be found very useful wherever the delicate details of diatoms are not sufficiently visible in ordinary preparations.

Dr. L. Dippel, also writing * on Mr. Stephenson's paper, commends oil of aniseed and oil of cassia for mounting, the last of which has especially proved to be well adapted for making the fine structure of the siliceous valves clearly visible. He has recommended both oils for some years to one and another of the German mounters. Oil of aniseed was employed by Professor Weiss in studying diatoms.†

Of the fluids which Mr. Stephenson further proposes, the solution of phosphorus in bisulphide of carbon is, Dr. Dippel considers, precluded on account of its combustibility, and mounting in bisulphide of carbon as well as in the solution of sulphur is attended with so many inconveniences that neither could well be taken into common use as fluids for mounting. On the other hand, monobromide of naphthaline is most excellently adapted for it. It does not affect wax as far as experience has gone as yet, and hence objects may be conveniently prepared with it. The cover-glass should be run round with a ring of wax, then with a cement of isinglass dissolved in spirit (called Heller's porcelain cement), or Canada balsam, rather thick, dissolved in chloroform; finally closing with a solution of shellac. Amongst other diatoms thus mounted, is a small and very finely striated *Amphipleura pellucida*, the structure of which, with immersion objectives—homogeneous-immersion specially—appears wonderfully clearly and sharply defined.

Absolute Invisibility of Atoms and Molecules.‡—Professor A. E. Dolbear writes:—

Maxwell gives the diameter of an atom of hydrogen to be such that two millions of them in a row would measure a millimetre; but under ordinary physical conditions most atoms are combined with other atoms to form molecules, and such combinations are of all degrees of complexity. Thus, a molecule of water contains three atoms, a molecule of alum about one hundred, while a molecule of albumen contains nine hundred atoms, and there is no reason to suppose albumen to be the most complex of all molecular compounds. When atoms are thus combined, it is fair to assume that they are

* 'Bot. Centralbl.,' i. (1880) p. 1148.

† Dr. Dippel, if we understand him correctly, also points out that "this method of preparation is not in all respects new. He himself came upon it in his investigations on the cell-wall ['Das Mikroskop,' i. pp. 67 and 83], and since 1867 has mounted not only histological objects, but also various diatom preparations in oil of aniseed and oil of cassia." We need hardly, however, mention that the point of Mr. Stephenson's paper is not to describe *as a novelty* the use for mounting of phosphorus, bisulphide of carbon, &c.; for, as he says in the paper, preparations were so mounted in 1873, when his previous paper was read.

‡ 'Science,' i. (1880) p. 150.

arranged in the three dimensions of space, and that the diameter of the molecule will be approximately as the cube root of the number of atoms it contains, so that a molecule of alum will be equal to

$$(\sqrt[3]{100} = 4 \cdot 64)\ \frac{4 \cdot 64}{2000000} = \frac{1}{431000} \text{ mm.},$$

and a molecule containing a thousand atoms will have a diameter of $\frac{10}{2000000} = \frac{1}{200000}$ mm.

A good Microscope will enable a skilled observer to identify an object so small as the $\frac{1}{4000}$ mm. Beale, in his works on the Microscope, pictures some fungi as minute as that; and Nobert's test bands, and the markings upon the *Amphipleura pellucida*, which are about the same degree of fineness, are easily resolved by good lenses. If thus the efficiency of the Microscope could be increased fifty times ($\frac{200000}{400} = 50$), it would be sufficient to enable one to see a molecule of albumen; or if its power could be increased one hundred and seven times, it would enable one to see a molecule of alum.

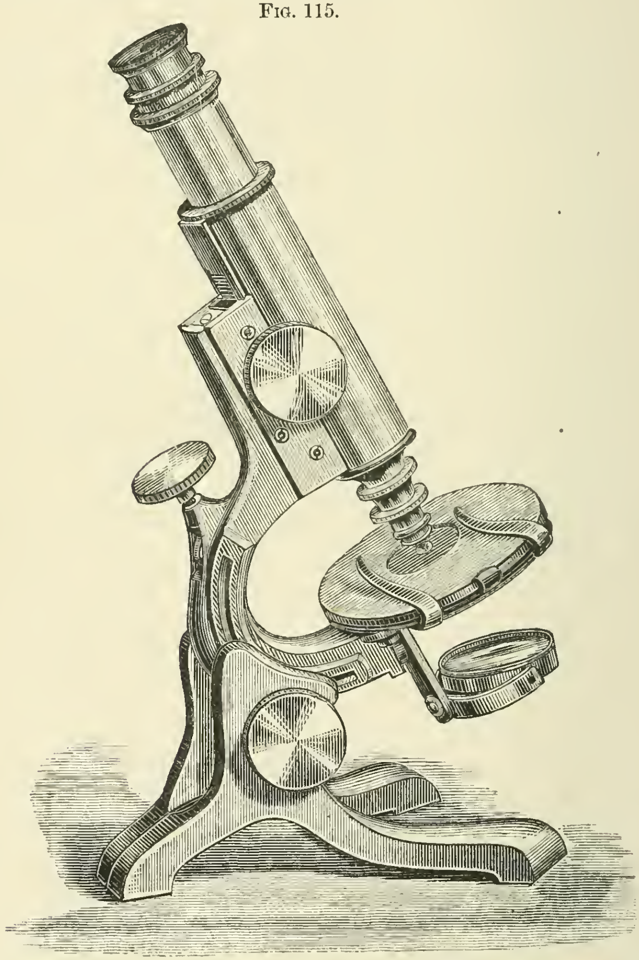
Now, Helmholtz has pointed out the probability that interference will limit the visibility of small objects; but suppose that there should be no difficulty from that source, there are two other conditions which will absolutely prevent us from ever seeing the molecule.

1st. Their motions. A free gaseous molecule of hydrogen at the temperature of 0° C., and a pressure of 760 mm. mercury, has a free path about $\frac{1}{10000}$ mm. in length, its velocity in this free path being 1860 m. per second, or more than a mile, while its direction of movement is changed millions of times per second. Inasmuch as only a glimpse of an object moving no faster than one millimetre per second can be had, for the movements are magnified as well as the object itself, it will be at once seen that a free gaseous molecule can never be seen, not even glimpsed. But suppose such a molecule could be caught and held in the field so it should have no free path. It still has a vibratory motion, which constitutes its temperature. The vibratory movement is measured by the number of undulations it sets up in the ether per second, and will average five thousand millions of millions—a motion which would make the space occupied by the molecule visibly transparent, that is, it could not be seen. This is true for liquids and solids. Mr. D. N. Hodges finds the path of a molecule of water at its surface to be ·0000024 mm., and though it is much less in a solid, it must still be much too great for observation.

2nd. They are transparent. The rays of the sun stream through the atmosphere, and the latter is not perceptibly heated by them, as it would be if absorption took place in it. The air is heated by conduction contact with the earth, which has absorbed and transformed the energy of the rays. When selective absorption takes place, the number of rays absorbed is small, when compared with the whole number presented, so that practically the separate molecules would be too transparent to be seen, though their magnitude and motions were not absolute hindrances.

Wale's "Working Microscope."—The new feature of this instrument by Mr. G. Wale (Fig. 115) consists in the method of suspending the main limb carrying the optical body, so that it may be inclined at any angle. It is suggested that the ordinary method changes the position of the centre of gravity of the instrument so considerably as to render it more or less unsteady, while the new method avoids the difficulty, and at the same time furnishes a secure and convenient means of clamping the body at any position.

Fig. 115.



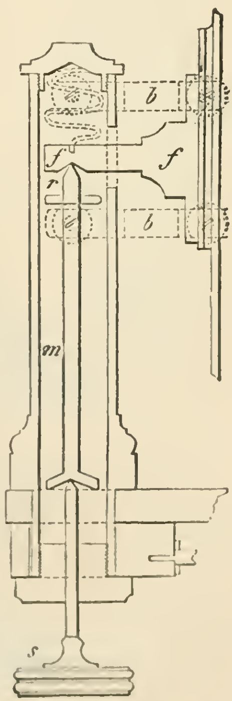
The stage and optical body are supported on the curved limb, which is nearly a semicircle, as shown in the figure. This limb has sectoral grooves about 90° in arc on either side, and slides between corresponding curved jaws, on the inner side of the upright pieces of the foot. The foot itself is made in two symmetrical pieces fitting together, and grasping the limb by means of a screw, of which the milled head is seen at the right-hand side of the instrument. By loosening this screw somewhat the curved limb is released; the sectoral grooves then permit it to slide between the jaws of the foot until the tube reaches the desired position (vertical, horizontal, or an intermediate position), when it may be clamped by tightening the screw.

The fine adjustment moves the entire body by a lever in contact with the screw (milled head) shown on the back of the limb, the distance between the eye-piece and the objective not therefore changing.

The rotating stage-clips can be applied to hold the object on either side of the stage, as described and figured in vol. ii. (1879), p. 623, where this Microscope was briefly alluded to.*

Seibert and Krafft's Fine Adjustment.—We referred on p. 883 to this fine adjustment (Figs. 99 to 101), citing an explanatory passage from Nägeli and Schwendener's 'Das Mikroskop.' The accompanying figure (Fig. 116) from the same authors will enable the reader to understand the mechanism, and the description will correct a slight inaccuracy (in the original) relative to the non-displacement of the optic axis.

FIG. 116.



The focussing-screw *s* acts upon the funnel-shaped head of the pivot *m*, the upper end of which acts in a similar manner upon *f f*, the solid bar attached to the optical body. The ring *r*, which serves as a guide-piece, lies loose in the hollow column, and as a rule does not touch the pivot; its function is merely to prevent the point of the pivot from slipping out of the notch in *f f*. The cross-bars *b b* (two on each side) are attached by screws to the hollow column, and the optical body is held between the points of four screws near the front ends of the bars. The focussing motion is communicated to the solid bar *f f* by the screw *s* acting against the pressure of the spiral spring shown above by dotted line, the friction being confined to the eight screw-points of the four cross-bars. The movement is similar to that of an ordinary parallel ruler with connecting bars, the hollow column being the stationary side.

It is obvious from an inspection of the figure that the optical axis must suffer a slight displacement. Any movement of the focussing screw *s* upwards or downwards from the normal position as shown, will cause the cross-bars *b b* to assume a diagonal position; the pivot *m* will consequently incline from its base backwards, and the solid

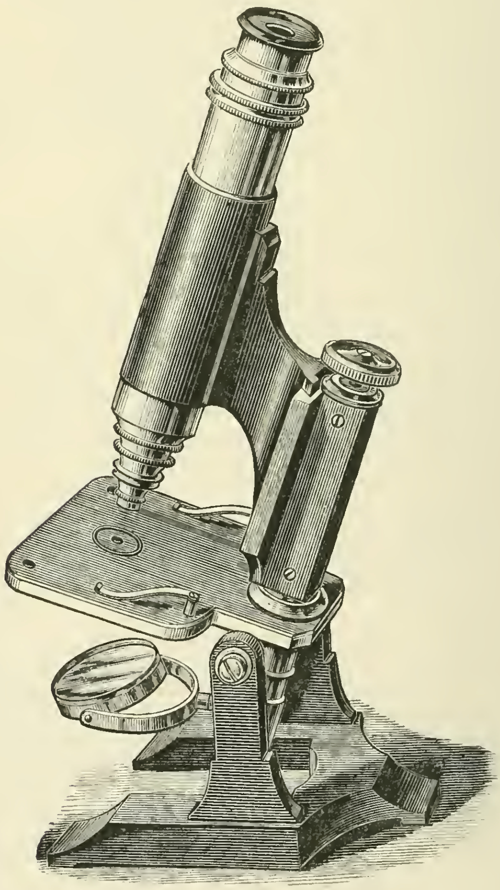
* See also Dr. Carpenter's observations on this Microscope, *infrà*, p. 1086.

bar *ff* will be drawn in the same direction, and with it, of course, the optic axis.

This method of fine adjustment presents difficulties in combination with a rotatory stage, and for comparative micrometrical measurements. The position of the milled-head at the *lower end* of the column is, however, very convenient, as the hand rests on the table while focussing.

"Sliding" Objectives. — The Microscope shown in Fig. 117 (Parkes's "English Medical Microscope") is provided with a "patent

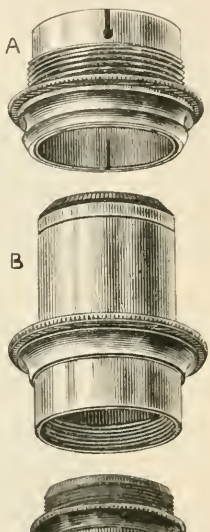
Fig. 117.



sliding adapter," for enabling the powers to be applied and changed very rapidly, without the loss of time occasioned by screwing. It is claimed that this plan will be found to save much time in cursory examinations, such as medical men have frequently to make.

In Fig. 118 A is the adapter, shown natural size (having the Society screw, it fits any Microscope); this adapter contains a "sprung" tube into which the tube B slides, carrying the optical part C (a 2-inch in the figure) at its lower end. All the objectives are composed of the sliding-tube B and the optical part C, which together form one piece about the usual size of an objective. In use, the adapter A is kept screwed to the body of the instrument, and the removal of B C from A is effected by simple withdrawal, as in the case of an eye-piece, and another power can thus be readily substituted.

Fig. 118.



For the convenience of those who have objectives with the Society screw, the lower end of the compound body of the Microscope is screwed to the standard size, so that by simply unscrewing the adapter which receives the objectives belonging to the instrument, any standard glass may be used. On the other hand, by sliding any of the former objectives into the adapter when thus unscrewed, they may be used on any other standard instrument. The Society screw has not been adopted for the optical part (joining C to B), which, however, it would be advantageous to adopt if it can be done without increasing the weight to such an extent that the latter would slip down out of the adapter. With the Society gauge, any objectives might of course be applied. At present, the use of the sliding arrangement is confined to the maker's own objectives.

Instead of the "sprung" tube, the plan adopted by Mr. Browning for astronomical eye-pieces might, we think, be made use of with advantage, viz. to make the sliding tube B not cylindrical, but tapering, the "taper" being for a short distance below the middle less rapid than at the middle part, the portion next the collar being exactly cylindrical.

Homogeneous - immersion Objectives for the Binocular.—Fig. 119 shows in natural size a $\frac{1}{12}$ homogeneous-immersion objective of Powell and Lealand made as described by Mr. H. Gibbes at p. 373, for use with the ordinary Wenham binocular, and showing both fields fully illuminated.

The lenses of the objective are contained within the lower part of B, the upper portion of *B* being a very short adapter into which the former can be screwed from behind. The back lens is thus brought to within about a quarter of an inch of the binocular prism. As the objective is so much shortened it is necessary with most Microscopes to have either a super-stage or a special arrangement for allowing the tube to be racked down that the objective may focus upon the object on the ordinary stage.

When not required for use with the Binocular prism the lenses are screwed to the long adapter A.

Mr. Wenham many years ago suggested the use of a very small binocular prism with high-power objectives. The prism was mounted in a special tube and was slipped down the body of the objective almost to touch the back lens. Fig. 120 shows (natural size) an $\frac{1}{8}$ objective (with correction-adjustment) constructed by Messrs. Powell and Lealand on Mr. Wenham's plan, D being the objective complete, and C the tube with the binocular prism. The objective, as will be seen, is shorter than usual.

FIG. 119.

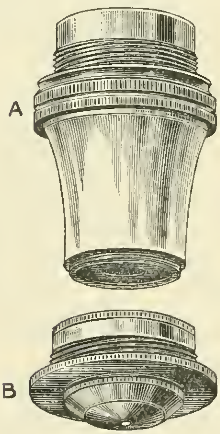
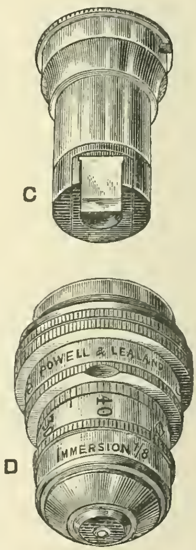


FIG. 120.



The plan first described can be used more effectively with homogeneous-immersion objectives, as they do not necessarily require correction-adjustment. The body can therefore be much shorter and the back lens almost in contact with the binocular prism.

Extra Front Lenses to Homogeneous-immersion Objectives.—It is suggested * that if such an objective as Powell and Lealand's new formula homogeneous-immersion $\frac{1}{12}$ † (aperture = 142° in crown glass of index 1·5 nearly, by means of a front lens greater than a hemisphere), were provided with two extra front lenses, one giving an aperture in glass of, say, 115° and one giving 90°, we should be enabled to view objects through a considerable range of thickness of covering-glass, approaching in each case to the maximum aperture that could be used, and hence, probably, we should find much less need of $\frac{1}{8}$ or $\frac{1}{16}$ objectives.

By the homogeneous-immersion formula adopted by Powell and Lealand the focal distance is practically a constant quantity; it

* 'Eng. Mech.,' xxxii. (1880) p. 84. † See this Journal, *ante*, p. 886.

follows then that a reduction of the aperture by making the front lens *thinner* immediately provides greater working distance without affecting the aberrations, for as the *first* refraction takes place at the posterior (curved) surface of the front lens the removal of any portion of thickness at the anterior (plane) surface simply cuts off zones of peripheral rays without altering the distance—the distance being at once filled up by the homogeneous-immersion fluid or by an extra thickness of covering-glass. An extra front lens may then be applied to the back combinations of such a $\frac{1}{12}$ to enable the observer to view an object through a covering-glass that would be practically a maximum thickness for an $\frac{1}{8}$ (aperture = 90°) constructed on the usual formula where the setting encroaches on the active spherical refracting surface; a second front might give a high average aperture for a $\frac{1}{12}$ (115°), whilst the thickest front (representing the maximum aperture of the whole construction, 142°) enables the observer to view an object with a *greater* aperture than has hitherto been obtained with any $\frac{1}{16}$, owing to the difficulties of construction, and through a thicker covering-glass than a $\frac{1}{16}$ of this aperture (even if it could be successfully made) would permit of; hence the three different fronts would give a great range of aperture with a corresponding range of working distance, which is practically what is sought by having objectives constructed of the three different foci, $\frac{1}{8}$, $\frac{1}{12}$, and $\frac{1}{16}$.

We understand from Messrs. Powell and Lealand that for an aperture of 115° in glass, there would be no necessity to mount the front lens on a plate, that aperture having already been successfully obtained and exceeded by mounting the front in the usual way. The purpose of the plate (which is only ·003 in. thick) is, as before mentioned,* to allow of a portion of the posterior curved refracting surface of the front lens *beyond* the hemisphere to be utilized.

Fluid for Homogeneous-immersion Objectives.—Mr. A. A. Bragdon writes to us in regard to his note inserted at page 701. After referring to the fact that sulpho-carbolate of zinc was first suggested by Professor Abbe,† he says that cedarwood oil, in his opinion, can never become generally useful. It varies so much in different samples that even an index of 1·512 as first named for it cannot be relied upon. Then it is so fluid that it runs all over slide and stand, so that the objective cannot be immersed without placing the Microscope erect every time. Experimenting with it, however, in combination with other oils, some good results were obtained, e. g. with oil of anise, although not equal to the zinc and glycerine, which can be as easily cleaned from the slide and lens as glycerine by using water.

By taking equal parts by weight of C. P. glycerine (Price's) and sulpho-carbolate of zinc crystals, mingling the two, and applying heat sufficient to boil the glycerine, a solution of proper index can be obtained for use with a Zeiss objective of 1·50 index, or a Tolles of 1·525 index (i. e. for all practical purposes). If, however, one desires to be exact for the latter, the solution will have to be evaporated

* See this Journal, *ante*, pp. 884-5. † Ibid., ii. (1879) pp. 346 and 823.

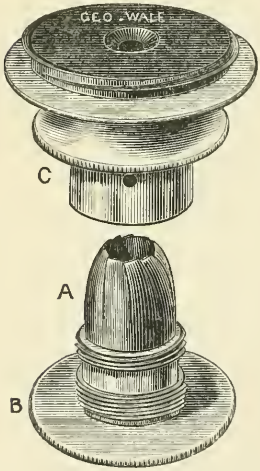
somewhat, or more carbolate added. The solution can be made in about one hour.

No fear need be had about boiling too long, as the longer this is done the less liability will there be for the solution to deposit crystals on the bottom of the bottle when cooled, which it will do if the temperature is only kept up long enough to first dissolve the crystals. Some made in October 1879 is still free from any deposit. Filter while hot, and the microscopist will have a solution practically of *fluid crown glass* as clear and transparent as glycerine itself, having only one objection, viz. when of 1·50 to 1·525 index, the consistency is such that if used on a histological preparation *just* mounted and the objective racked back to remove the slide, the cover, unless great care is used, will be lifted enough to endanger a choice preparation.

Mr. Bragdon is still experimenting with the view of finding a medium a trifle more fluid so as to make the homogeneous-immersion objectives "as nearly perfect as possible for every-day use."

Iris Diaphragms.—To the "Working Microscope" of G. Wale * an inexpensive and very simple and ingenious form of "iris" is adapted, shown (separated) in Fig. 121. It consists of a piece of very thin cylindrical tube A, about $\frac{3}{4}$ inch in length and $\frac{5}{8}$ in. diameter, the whole circumference of which is cut through with shears to nearly its whole length at intervals of about $\frac{1}{4}$ inch; by means of a screw-collar B, attached below, this cut tube is forced into a parabolic metal shell (contained within C) whose apex is truncated to an aperture of about $\frac{3}{8}$ inch; the pressure of the screw causes the thin metal tongues to turn and to overlap in a spiral which gradually diminishes the aperture to the size of a pin-hole. On unscrewing the collar B, the spiral overlapping of the tongues is released somewhat, and their elasticity causes the aperture gradually to expand.

Fig. 121.



As adapted to the stage of the "Working Microscope," the iris, when unscrewed until its aperture is smallest, is then almost in contact with the base of the slide; when at its largest expansion it is about $\frac{1}{16}$ inch lower. The whole device is fitted into the opening of the stage from beneath (so as to be flush with the upper surface) with one turn of a very coarse screw on the edge of C—a far more convenient plan than the "bayonet joint."

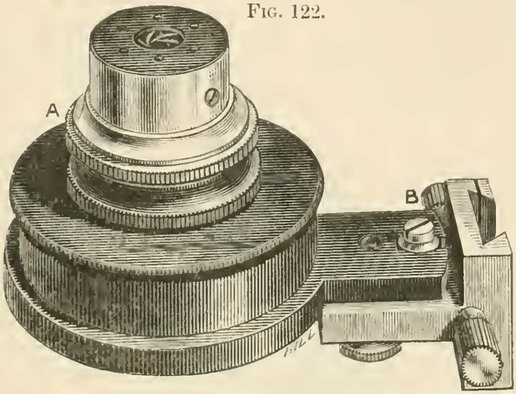
Another form of "iris" (Fig. 122) has been manufactured in America by Messrs. Sidle and Poalk (fitting to their "Acme" stand).† It is similar in construction to the earlier forms known

* See *ante*, p. 1045.

† See this Journal, *ante*, p. 522.

in England, but instead of the movement of the plates being controlled by a lever arm, there is an outer cylinder-cap A, that can be turned like the adjusting collar of an objective. The range of aperture is from about $\frac{3}{8}$ inch to a pin-hole, and it remains

Fig. 122.



in the same plane during the motion. This diaphragm is mounted on a substage B provided with centering motions (a short bar working with a loosely fitting slot, that can be clamped beneath), which is a somewhat primitive contrivance. Centering motions must be capable of exact adjustment or they are practically useless.

Swift's Calotte Diaphragms.—Messrs. Swift have recently devised two forms of "calotte" diaphragms for use *above* the achromatic condenser, and on a level with the plane of the object stage.

Fig. 123.

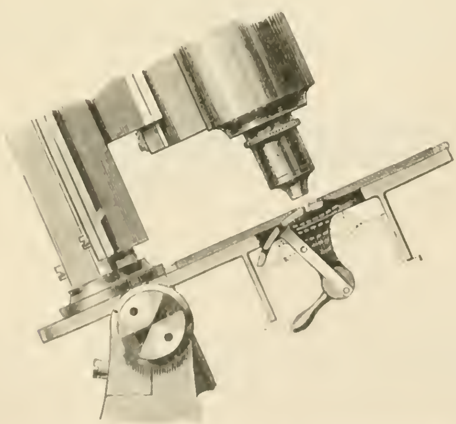
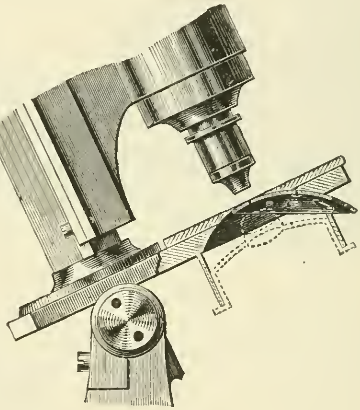


Fig. 123 shows the first method. A small rectangular segment of a spherical shell has three different sized diaphragms cut, and the mounting is so contrived that by movement of the lever-arm (shown with shaped handle attached), the diaphragms can be successively moved over the achromatic condenser, the optical part of which is shown by dotted lines. The stage is suitably hollowed out beneath to facilitate the adjustment.

Fig. 124 shows an improved form, which Messrs. Swift regard as superseding that shown in Fig. 123. The diaphragms are here cut in

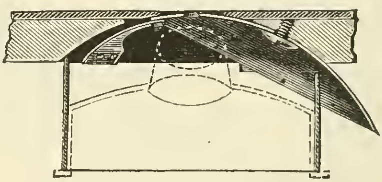
FIG. 124.



a metal "calotte" mounted eccentrically, so that by rotation the apertures pass successively over the top of the achromatic condenser; the rotation is effected by the projecting edge of the calotte—somewhat as with the diaphragms in Gillett's condenser.

It should be observed that Mr. Zeiss has for some time applied calotte diaphragms to his "Travelling Microscope"; * but they do not

FIG. 125.



act quite in the plane of the stage, nor are they constructed to be used in conjunction with the achromatic condenser. It is evident, however, that the effect obtained is similar to Mr. Bulloch's application of the Gillett diaphragm *above* the condenser.† In Messrs. Swift's

* See this Journal, ii. (1879) p. 955. † *Post*, p. 1078.

arrangement (as shown on a larger scale in Fig. 125) the calotte is attached to the under surface of the stage,—in Mr. Bulloch's plan, the diaphragm plate forms part of the condenser and can thus be removed at pleasure.

Swinging Substages.—As there seems to be a tendency to provide Microscopes which have a substage with the so-called "swinging" form, we now extend the history of such instruments by giving descriptions in the succeeding notes of some which we have not yet described.

Taken in chronological order, the instruments hitherto made with such substages are as follows:—

GRUBB	1853-8 ..	See vol. ii. p. 320, and below.
THURY-NACHET	1855 ..	" *post*, p. 1059.
ROYSTON-PIGOTT	1862-4 ..	" *post*, p. 1060.
TOLLES	1871 ..	" *post*, p. 1061.
BULLOCH	1873 ..	" *post*, p. 1067.
ZENTMAYER AND ROSS-ZENTMAYER ..	1876-80 ..	" vol. i. p. 197, vol. ii. p. 320, and *ante*, p. 704, and *post*, p. 1067.
TOLLES-BLACKHAM ..	1877 ..	" vol. i. p. 392, and *ante*, p. 520.
BULLOCH	1877 ..	" *post*, p. 1073.
SIDLE AND POALK ..	1880 ..	" *ante*, p. 522.
BECK	1880 ..	" *ante*, p. 329.
SWIFT	1880 ..	" *ante*, p. 867.

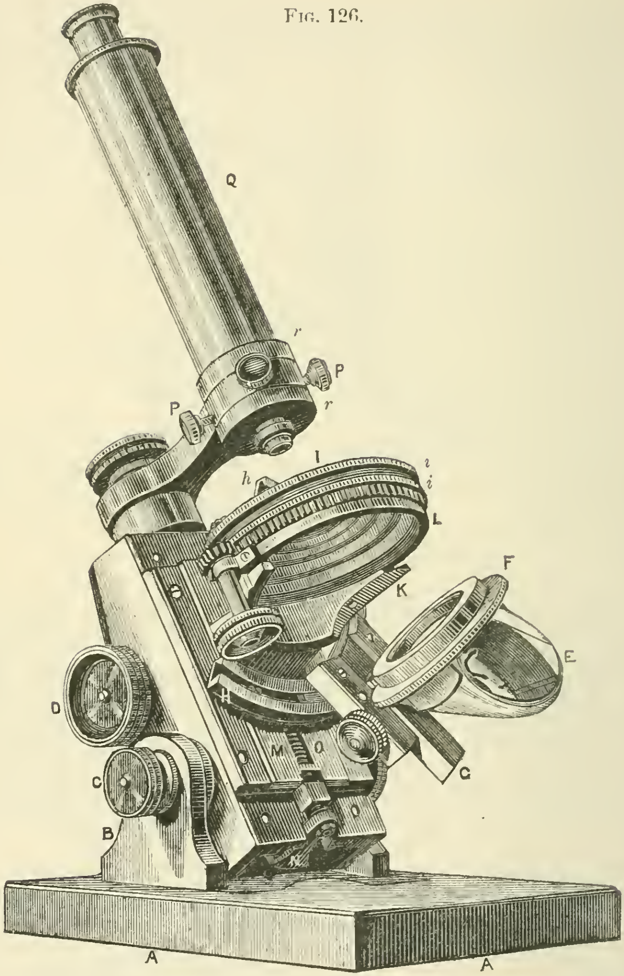
Grubb's Sector Microscope.—This is admittedly the earliest instrument of the kind referred to in the preceding note. The following description is contained in a paper read on the 26th March, 1858, to the Royal Dublin Society,* and is entitled "On a New Table Microscope, by Thomas Grubb, Engineer to the Bank of Ireland":—

"The instrument to which I have the honour of drawing your attention this evening will be recognized by some present as having the same general and peculiar form of that which I had devised and constructed some years since, and previous to our (Dublin) Microscopic Society having merged into the 'Natural History' Society.

"The instrument, in its original state, included, indeed, the advantages of extreme steadiness, an improved fine adjustment for focussing, and improved safety-tube for the object-glass, with the means of viewing objects (placed on a horizontal stage) at the most comfortable angle for vision. But it is the peculiarity of the instrument, in its present state, that it removes all necessity for that subsidiary and costly apparatus for illumination which those microscopists who pursue delicate microscopic research find it necessary to provide, in addition to the Microscope *proper*; and not only this, but the present instrument enables the observer to apply, with a facility otherwise unattainable, without removing the eye from the instrument, without any changing of parts, and by simply moving its one illuminator on its sector, every kind of illumination, *seriatim*, to an object placed

* 'Journ. R. Dublin Soc.,' 1858; reproduced in 'Engl. Mech.,' xxxi. (1880) p. 229.

Fig. 126.



A A. The base (of mahogany).

B. One of the two brackets of support.

C. One of the two milled heads for clamping the instrument at the desired inclination for use.

D. One of the milled heads for coarse adjustment of focus, acting upon a strong triangular bar (not seen in the engraving).

E. Illuminating prism.

F. Milled ring for adjusting by hand the *azimuth* of the prism.

G. Slide, with rack and pinion, for adjusting the distance of the prism from the object.

H. Sector (seen also at *h*) on which the prism is moved by hand through any required arc concentric with the object on the stage.

I. The stage; *i i*, upper and lower milled rings, which produce, on being turned by hand, the slow motions, in two directions, of the object-plate of the stage.

K. Bracket-piece supporting the stage, and also the plate for carrying the polarizer when required.

L. Toothed wheel with pinion and milled nut for revolving the stage in azimuth.

M. Dovetailed slide carrying both stage and sector, with the illuminating prism. A screw and its bent lever (the latter passing to the back of the instrument) are partially seen at N; and at O is a spiral spring which keeps the slide M in close contact with the screw N. The lever N is equally available to either hand at the back of the instrument; P P are opposing screws which serve to bring the optic axis of the body or tube Q to coincide with the centre of revolution of the stage, Q being purposely not screwed (as usually) into the projecting arm, but held (with a sufficient amount of lateral movement) between the collars *r r*.

upon the stage of the instrument. It does more than this; for it enables the observer, when he has produced any appearance or effect by the illumination which he desires to reproduce at pleasure, to register the same, so that he can either resort with certainty to it at a future time, or communicate the particulars to a friend, who, if possessed of a similar instrument, can do likewise.

"The subsidiary apparatus for illumination of a well-furnished Microscope usually includes a set of achromatic condensers, the prism of Amici, the parabola of Shadbolt, and Bergin's addition to the latter for oblique illumination. It is unnecessary to go into any detail of the trouble experienced, and the time frequently consumed in obtaining, with the assistance of one or more of these appliances, a satisfactory illumination. These drawbacks are well known to microscopists. For the information of others, I may state that frequently five minutes of very eye-teasing work, and sometimes three times that, are devoted to obtaining a satisfactory result, which, after all, is liable to be undone by an incautious touch of the mounting, and which is only to be restored by the same tentative process of the previous adjustment.

"It was such experiences as these which led to the improvements combined in the present instrument. A little consideration was sufficient to show that, assuming we are in possession of an illuminating pencil of unexceptional quality for every kind of illumination required, then every kind of such, including the illumination of opaque objects, will be comprehended under two heads, viz. first, the means of applying such illuminating pencil at all angles with respect to the plane of the object (or the stage of the Microscope); secondly, the means of applying the pencil at all azimuths of same.

"This generalization, so to speak, of the illumination indicated the means of carrying it out effectually. I had previously ascertained, from direct use, that an achromatized prism was capable of giving every kind of illumination required, in a manner not surpassed by other means extant. Rejecting the difficult matter of causing the illuminating pencil to move in azimuth round the object, I devised the present stage, which, while it is made to revolve, has those objections to revolving which appertain to other stages removed; and, by making a little variation in the manner of attaching the body (or tube) of the instrument to its arm, means are provided for readily bringing the optic axis of this tube to pass through the centre of revolution of the stage, and thus all objection to revolving the object, instead of the light, is got rid of.

"For the other movement of the prism (or that vertical to the plane of the stage), I have, as may be seen, adopted a sector, on which slides the carriage containing the prism and including the ordinary adjustment for focussing and a small azimuthal movement for modifying the illumination. This sector is attached to the same piece which carries the stage, and so that its centre, if produced, would cut the optic axis of the tube where an object mounted upon a glass slide of the ordinary thickness and laid upon the stage of the instrument would be. A prism or other object being simply moved round on a sector so placed, will evidently remain unchanged in its distance from that central point.

"In constructing the illuminating prism, it was to be recollected that there was but one direction in which the light could be placed, viz. in the plane of the object, or say one-tenth of an inch above the plane of the stage, and vertically to the sector's plane; and, secondly, that the distance of the light from the stage must be assumed. The prism, therefore, necessarily reflects the rays at a greater angle than 90°, and its reflecting surface usually requires silvering. This has been assumed to be an objection; but the light is still more than ample, as well as beyond that given by most other illuminators, the prism having (although a triple combination) only two uncemented surfaces. I have, from my own experience, adopted a distance for the source of light of about 15 inches, as most useful for general work; but should a distance of 2 feet or upwards be selected, then the prism may be one of total reflection and its reflecting surface consequently remain unsilvered.

"The manner of using the instrument is, shortly, as follows:—The microscopist will, of course, place it as he would any other Microscope, conveniently on a table, and incline it to the desired angle for work. The lamp, or other source of light, is to be placed directly opposite, and in front of, the instrument, and at the proper distance of height, the distance being always the same, and the height that which brings the light into the plane of the upper plate of the stage. The adjustment may be verified and corrected as follows:—Place a slider with a grayed surface on the stage (grayed surface upwards); move the prism to the lowest point of the sector (or to zero), and turn it directly outwards, or towards the light; adjust the distance of the prism from the grayed surface, so that an image of the light is formed upon the latter; and looking through the tube of the instrument (the lenses being removed), observe if the image formed on the grayed glass be central with the tube; if not, make it so by a slight alteration in the inclination or azimuth of the instrument, without varying its distance from the light. It is by no means necessary to make these adjustments accurately; but the more accurate they are, the more perfectly will the image on the grayed surface *only revolve*, and without changing place, on moving the prism on the sector. It is, perhaps, unnecessary to observe that the Microscope, without making any of these adjustments, may be used in the same manner as, and with all the convenience of, an ordinary instrument, while, by making the adjustments as described, we obtain the peculiar advantages sought for in the construction.

"These advantages may be shortly summed up as follows:—An object being placed upon the stage, and the focus adjusted, the observer can examine it under every azimuth of illumination by revolving the stage, and under every possible kind of illumination in each azimuth, viz. direct transmitted light, oblique transmitted, dark-ground illumination, and, finally, the illumination for opaque objects, by simply moving the prism on the sector; and he can do all this without once removing his eye from the eye-piece; while the quality of the illumination, in all its varieties, is such as is not surpassed by other more or less special contrivances. Indeed, the general impression of those who have used the instrument is that its illumination is more effective, particularly in showing the delicate details of difficult objects, than any other extant.

"Lastly, and not least, the power of reading off on the sector the angle of illumination used, whereby the effects of different angles of illumination can be registered, resorted to again at pleasure with certainty, or communicated to other observers, enabling them to do the same, if provided with a similar instrument.

"Perhaps I may be permitted to conclude this imperfect description by mentioning what one who is well qualified to judge of the merits of the instrument has communicated respecting it. He quaintly says, 'I find but one fault with your Microscope, and that is, that it puts me out of conceit with the using of any other.'"

Although the above paper is dated 1858, it should be noted* that the main features of novelty had been previously described by Mr. Grubb, viz. in 1853, in the 'Proceedings' of the Royal Irish Academy,† and in his patent of 1854, ‡ in both of which the graduated sectoral arc is referred to. In the paper of 1853 Mr. Grubb said he had mounted "a suitable illuminator on a vertical circular sector (nearly a complete circumference), concentric with the focus; this part of the arrangement enables me to throw the beam on the object at all angles of incidence, whether from beneath, as in the case of translucent, or from above, in the case of opaque objects, and as the sector is graduated, I have the power of observing or restoring any position at pleasure."

Thury-Nachet Traverse Substage.—This appears to be the next in order of date, having been made by M. Nachet, on the suggestion of M. Thury, in April 1855.

The substage is shown in Fig. 127, separated from the Microscope. It consists of two sector-bars C C equidistant from the object, mounted parallel and attached to the main limb of the stand by screws behind the square end G. These bars carry the condenser B above, and the mirror A below, on a moving framework on which is a graduated scale F for observing the degree of inclination. By means of a rack and pinion (milled head D shown on the further side of figure) the framework, carrying condenser and mirror, can be moved concentrically with the object, producing oblique illumination. The traversing movement causes the toothed pinion H to turn in the rack J, and an endless screw at the lower end of the same pinion (behind the milled head E) works on the toothed wheel I attached to the mirror; this automatic motion keeps the reflected beam from the surface of the mirror exactly in the axis of the condenser whilst the latter is being inclined obliquely to the object. The mirror itself can be adjusted by the milled head E, the pinion through I being held in position by

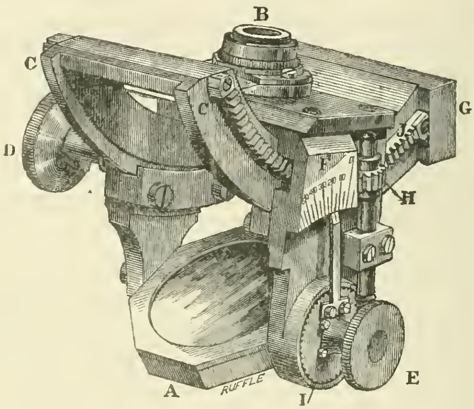
* 'Engl. Mech.,' xxxi. (1880). † Vol. v.

‡ See this Journal, ii. (1879) p. 320.

friction. An indicator arm on I marks the degree of inclination on the scale at F.

If we suppose the apparatus, as figured, to be in adjustment for central light, then, by turning the milled head D, obliquity of

Fig. 127.



incident light is obtained as far as the rack on the sector-bar or the thickness of the stage will permit, the surface of the mirror inclining regularly so that the reflected light is directed constantly in the axis of the condenser throughout the traversing movement.

The original apparatus from which Fig. 127 was drawn was at once forwarded to us by M. Nachet upon our applying for information on the subject, and at the same time he wrote: "The apparatus was specially designed to keep the focus of the illumination upon the object with varying degrees of oblique incidence. The movement was, however, only from back to front—not lateral. In Grubb's and more modern stands, lateral movement of the substage (unless the lamp be attached to the moving arm) necessitates a continual readjustment of the mirror or reflector; whereas in this device the mirror moves automatically with an exactly calculated differential motion, and the light is constantly directed in the axis of the condenser, consequently in the field of view, whatever may be the inclination. The observer can thus watch the minutest changes developed by the obliquity, which appears to me a considerable advantage."

Royston-Pigott's Oblique Condenser Apparatus.—Dr. Royston-Pigott is the inventor of an apparatus for giving oscillating oblique action to the condenser. It was thus described * by him:—

"In former times the precise position of the mirror for throwing the rays of reflected light at one particular angle (often hit only with much waste of time and labour) was attained with more or less success so as to give the most brilliant definition of

* 'Mon. Micr. Journ.,' xvi. (1876) p. 178.

difficult objects. In 1862 I adapted a semicircular arc carrying a condenser, and afterwards I constructed gimbals to carry an achromatic condenser at any angle of obliquity, attached to a double-motion stage placed exactly beneath the upper stage movements: by this contrivance particular angles of illumination could be readily attained without the excessive aberration of the usual wide-angled achromatic condenser. The instrument is exhibited in the South Kensington Museum Collection, No. 3551—described as follows:—'3551. Microscope with complex adjustments, searcher, and oblique condenser apparatus. This Microscope is fitted with a peculiar hypocycloidal movement and traversing screws for very delicate observations. The condenser possesses wide rectangular movements combined with a unique oscillatory oblique action for directing the minute image of a flame or of the sun either directly or obliquely upon any desired point in the field of view, giving fine views of many difficult objects. . . . .'"

Tolles' "Radial Arm" and "Circular Track" Microscopes.—Our information in regard to these Microscopes is derived from certain sworn depositions which have been forwarded to us, and which we print verbatim.

"*Invention of Swinging Substage.*

WASHINGTON CITY, DISTRICT OF COLUMBIA, SS.

I, J. J. WOODWARD, a Surgeon in the United States Army, and a resident of the city and district aforesaid, do hereby solemnly swear that Mr. R. B. Tolles, of Boston, visited me at the Army Medical Museum, Washington, District of Columbia, June 30, 1871; that he had with him several objectives and a small Microscope-stand fitted with a radial arm beneath the stage, carrying a condensing lens of about one inch focal length, and so arranged that by deflecting the arm, any degree of obliquity in the illumination could be obtained; and that I was so pleased with the contrivance that, November 8, 1872, having occasion to inquire of Mr. Tolles the price at which he would make a large stand for the Museum, I made it a condition in a letter written on that day, that the stand should have a 'radial arm to carry an inch condensing lens for oblique light.'

J. J. WOODWARD,
Surgeon U.S. Army.

Sworn to and subscribed before me this eighteenth day of September, A.D. 1880.

LOUIS SCHADE,
Notary Public.

I, EDWARD W. MORLEY, of Hudson, in the State of Ohio, Professor of Chemistry and Toxicology in Cleveland College, and Professor of Chemistry in Western Reserve College, on oath depose and say that on the seventh or eighth day of August, 1872, I was in Boston, in the

State of Massachusetts, and there selected a Microscope objective at the office of Charles Stodder, agent for Robert B. Tolles, of said Boston. Afterward on the same day I met said Tolles, the maker of said objective in his manufactory on Hanover Street in said Boston, and conversed with him about the manipulation of said objective. In said conversation said Tolles described a device for facilitating the application of light of any desired obliquity, which device he thought would be possibly the best for my purpose. It was to attach to the stand of the Microscope an arm which would rotate on an axis at the level of the upper surface of the object-slide. To this arm an achromatic condenser (or objective as a condenser) could be screwed so that if adjusted to bring light to a focus on the object at any one obliquity it would still be in focus at any other obliquity. Said Tolles exhibited to me a device used by him on his own stand to accomplish this result. It consisted of an arm under the stage carrying the achromatic condenser, which arm was adapted to carry the condenser through a considerable arc, keeping it in a radial position with the centre of motion at the focus of the objective in use in the body. We discussed several plans for securing the motion around the plane of the upper surface of the object. I understood that the plan used in said Tolles' stand was an adaptation of a stage not originally designed for the purpose and therefore of necessity the radial motion with centre in the plane of the object was obtained by some combinations whose nature does not occur to me. My recollections about the radial arm for oblique light from a condenser as seen by me at this time are very distinct because I had then some intentions of imitating the arrangement and actually afterwards made some preliminary trials in that direction. In reference to my own Microscope-stand, said Tolles, in said conversations suggested the making of a semicircular track to be borne on the substage fitting, which should answer the same purpose of carrying the condenser concentrically with the object on the stage.

Edward W. Morley.

State of Ohio, Summit County, ss.

Sworn to by the said Edward W. Morley, before me, a Notary Public, within, and for said County and State, and by him subscribed in my presence this 23d day of May, A.D. 1878.

Witness my hand and official seal at Hudson County and State aforesaid this 23d day of May, 1878.

H. B. Foster,
Notary Public.

I, Orlando Ames, of Somerville, in the Commonwealth of Massachusetts, on oath depose and say, that in the years 1870, '71, and '72, in the shop of the Boston Optical Works, of which Mr. R. B. Tolles was Superintendent, I had charge of the work of construction of Microscope-stands. That in the years 1870 and 1871 the first Microscope-stand of his class A was made. That after it was otherwise completed, I by Mr. Tolles' direction adapted to the stand a swinging arm to carry a condenser at various obliquities to the optical axis of the

Microscope.* This arm was hinged to have its axis of rotation as nearly in a line passing through the object place on the stage as was conveniently practicable. The stage having mechanical movements was of considerable thickness and the axis of the arm was therefore fixed at a point about three-fourths of an inch below the place of the object. The arm swung over an arc of a circle graduated to read angles of obliquity of the arm, and the condenser had an independent motion of its own so that its axis could always be brought to coincide with a line passing through the object on the stage. That at this time and for an indefinite period before, I had known of such an arrangement of swinging arm on a Microscope used by Mr. Tolles particularly for trial and testing of objectives. In this case the whole arrangement could be attached to the main arm of the Microscope and detached readily. The axis of motion of the arm was under the stage, but the whole apparatus had adjustment laterally (or sidewise) so that the swinging arm could be brought into line with any radius of the object as a centre through a considerable range of obliquities. That in the summer of 1875, I, by Mr. Tolles' direction constructed and adapted to a Microscope-stand of his class B, numbered [ ] and now belonging to Dr. J. Bacon of this city a *circular track* as a substitute for a *radial arm*. That this circular track having its centre coincident with the object place on the stage involved no change in the model or construction of the B stand, whereas the incorporation of a radial arm required considerable change; and I desire to distinctly state that the circular track was adopted for that instrument instead of the swinging radial arm to avoid such change and reconstruction.

I have also to state that during the period named, from 1871 to 1875, the plan as an invention of Mr. Tolles of a swinging radial arm for condenser, and other accessories of a Microscope having its axis of motion in the object or object-place on the stage was familiarly known and talked of in the shop where his Microscopes were made. ORLANDO AMES.

Witness, F. L. HAYES.

SUFFOLK, ss. Boston, March 19, 1878.

There personally appeared the above named ORLANDO AMES and made oath that the foregoing statement, by him subscribed, is true.

Before me, FRANCIS L. HAYES,

Justice of the Peace."

In July 1875, Mr. Tolles made and sold the instrument described in the following specification for a patent (the application for which was filed in July 1877 †):—

---

* NOTE.

"TOLLES' LARGEST MICROSCOPE.

A.

* * * * * * * Can be furnished with radial arm to carry accessory apparatus at any angle for $50."

—C. Stodder's Price List for 1872, page 5.

† According to the U.S. Patent Law, an inventor has two years *after* the first instrument is sold in which to apply for a patent.

United States Patent Office.

Robert B. Tolles, of Boston, Massachusetts.

Improvement in Microscopes.

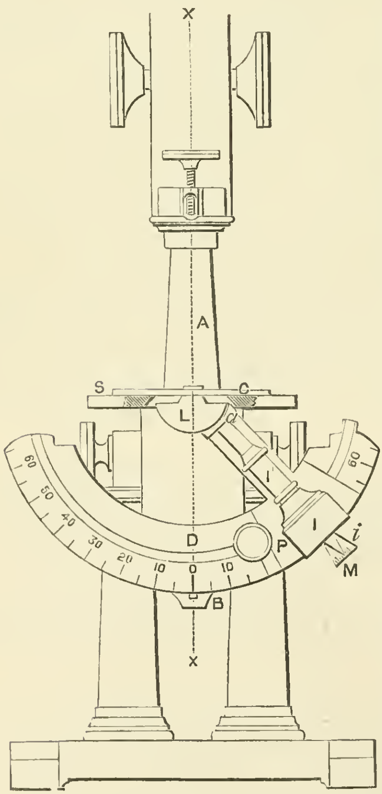
Specification forming part of Letters Patent No. 198,782, dated January 1, 1878; application filed July 27, 1877.

To all whom it may concern:

Be it known that I, Robert B. Tolles, of Boston, in the County of Suffolk and State of Massachusetts, have invented certain new and useful improvements in Microscopes, of which the following is a specification, reference being had to the accompanying drawings, making a part of the same, in which—

Figure 128 represents a front elevation of a portion of a Microscope-stand with my improvements applied thereto. Fig. 129 represents a side elevation of the same. Fig. 130 represents in section a portion of the sub-stage detached. Fig. 131 represents in side elevation a portion of the substage illumination apparatus detached and drawn upon an enlarged scale, and modified by connecting with it a graduated arc; and Fig. 132 represents in end elevation the parts shown in Fig. 131.

Fig. 128.



My invention relates to the combination of a circular track in a plane parallel with the optical axis of the instrument and concentric with the object to be examined, with a substage carriage, upon which said track is mounted and carried on guides.

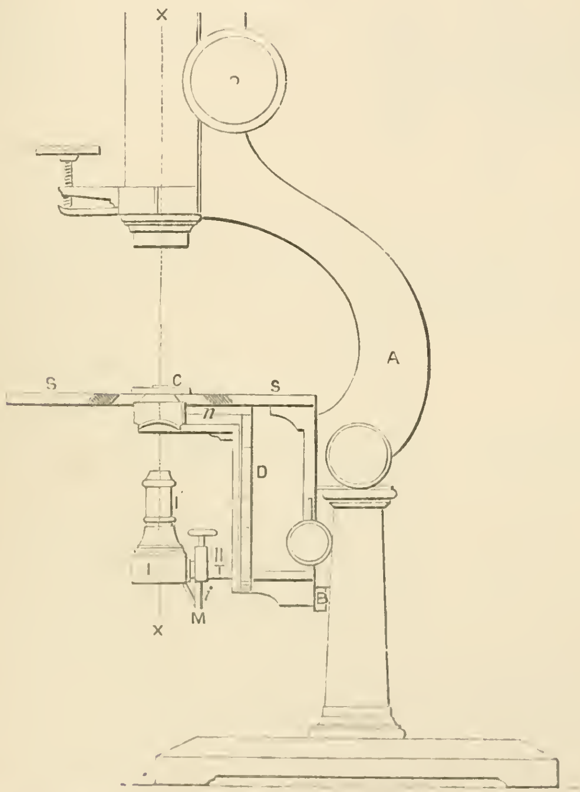
It also relates to the said circular track, provided with graduations, in combination with a carriage running thereon, and carrying a condensing-lens and other accessories, either singly or combined.

It also relates to a holder to carry an achromatic illuminator or other accessory, in combination with a graduated arc and clamping device, to fix the holder at any angle to the radius that may be desired, or in the radius of the circular track.

It also relates to a convex lens, either plano-spherical or plano-cylindrical, in combination with a plano-concave lens, that can be caused to traverse the surface of the plano-convex lens, and an illumination-tube to direct a beam of light through the plano-concave lens.

It also relates to the convex lens and its support in the radius of the circular track, in combination with an illuminating device.

Fig. 129.



It also relates to a graduated circular track to support an illumination-tube and accessories, with the stage, to support the object-slide, as will be more fully described hereinafter.

In the drawings, the base or stand has jointed to it a curved arm A, upon which the body of the instrument is mounted. It also carries the stage S, upon which is placed the object-slide C. D represents a circular track mounted upon a substage carriage B, connected to the arm A. This circular track is mounted and carried on or within guides in a plane parallel to the optical axis X X of the instrument and concentric with the object to be examined, mounted in the slide C, so that whether the slide be above or below the stage, the object it holds shall always be in the axis of said circular track D. This track has graduation-marks placed upon it, by which the position of the carriage P, that it carries, can be set and recorded. It may also be

Fig. 130.

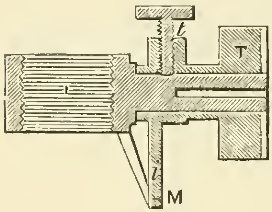
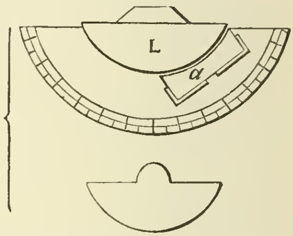


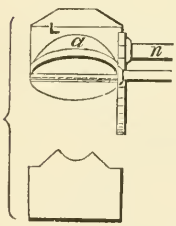
Fig. 131.



used without graduations. Upon this carriage is mounted the substage T, carrying the holder I, to which is screwed the illumination-tube I′, or other accessories.

The spindle of the holder I can turn in its socket, and be clamped to it by the screw *t* in any position in which it may be placed, to carry an achromatic illuminator or other accessory, either in the radius of the track D, or at any degree of obliquity thereto; and to facilitate this adjustment, it is provided with an index M, resting against a graduated arc *i*, attached to the substage.

Fig. 132.



The apparatus is provided with a convex lens L, either plano-spherical or plano-cylindrical (the plane surface of either being modified to concave or convex, if either of these forms should for special purposes be deemed preferable to a plane), and a plano-concave lens *a*, the curvature of whose concave surface is the counterpart of the convex surface of the lens L, the lens *a* being caused to traverse the surface of the lens L by the movements of its carriage—in this instance an arm of the carriage P, which latter also carries an illumination-tube I′, or a condenser arranged to direct a beam or pencil of light upon the plane face of the lens *a*. The convex lens L is mounted upon the axial end of an arm *n*, which arm is in the radius of the circular track D, and is also carried by the substage.

Having now fully described my invention, I claim—

1. The combination of a circular track D in a plane parallel to the optical axis X X of the instrument and coincident with the object to be examined, with a substage carriage B, upon which said track is mounted in a plane parallel to the optical axis, substantially as shown and described.

2. The combination of a graduated circular track D, with a

carriage P running therein, and carrying a condensing-lens and other accessories, either singly or combined, substantially as shown and described.

3. A turning-holder I, carrying an index M, in combination with a graduated arc *i*, and a clamping device, to secure the holder either in the radius of the track D or at any degree of obliquity in which it may be placed, to carry an achromatic illuminator or other accessory, substantially as shown and described.

4. The combination of a convex lens L, of plano-spherical or suitable form, with a plano-concave lens *a*, of counterpart curvature, and a carriage P carrying said concave lens, and also an illumination-tube, substantially as shown and described.

5. The combination of a convex lens L, and an arm *n*, on the axial end of which said lens is mounted, with a circular track D, and carriage P, carrying a suitable illumination device, substantially as shown and described.

6. The combination of a graduated circular track D, and carriage P, for guiding and supporting an illumination device and other accessories, with a stage S for supporting the object-slide, substantially as shown and described.

In witness whereof I have hereunto subscribed my name.

ROBERT B. TOLLES.

In presence of—

P. S. YENDELL,
ARTHUR MCNALLY.

Bulloch's Sector Microscope.—The next in order of date is the Microscope shown in Fig. 133, which was designed by Mr. W. H. Bulloch, of Chicago, U.S.A., and exhibited in 1873.

The figure shows the general design of the Microscope. The substage was described by Mr. Bulloch as follows: "Compound substage, with the most complete movements for centering or for oblique light, with achromatic condenser, has one-fourth inch movement each way, rack and pinion vertical movement, *rack and pinion movement in arc of circle for oblique light. . . .*"

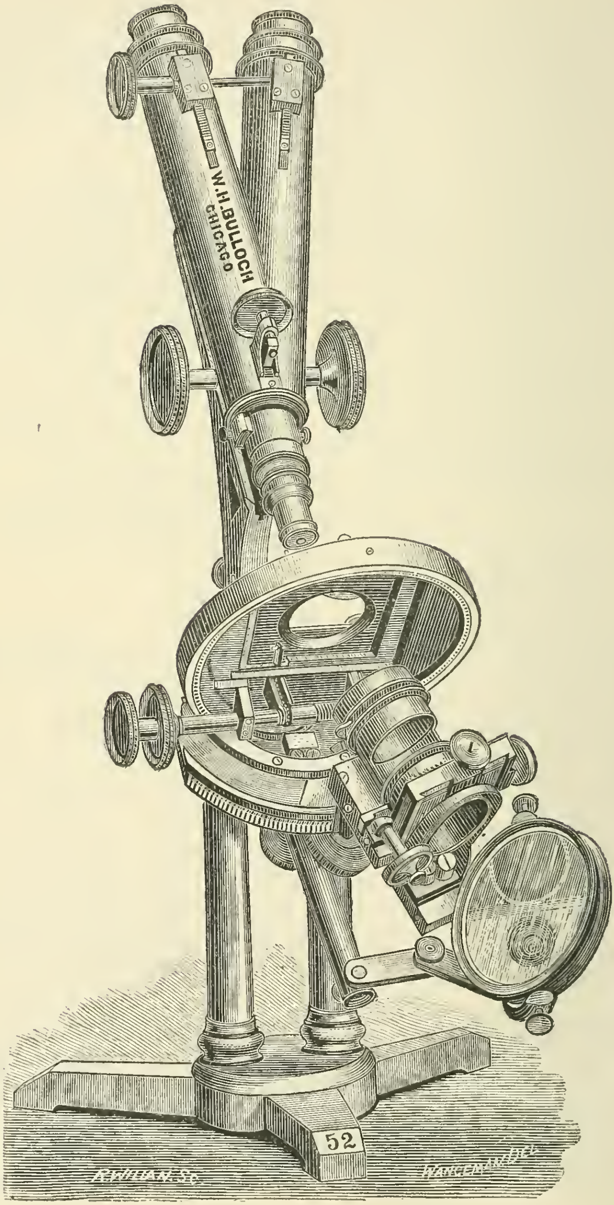
The sectoral arc is shown in the figure just below the stage, as well as the rack and milled head of the pinion by which the substage is moved. The mirror is on a separate bar and can be swung above the stage and clamped by a screw, the milled head of which is seen at the back of the instrument.

Zentmayer's Centennial and Histological Microscopes.—(1) *Centennial.*—This Microscope, shown in Fig. 134, was first exhibited at the Academy of Natural Sciences of Philadelphia on April 2, 1876; and then at the Philadelphia Centennial Exhibition in 1876, and subsequently at the Paris Exhibition in 1878.

The following is Mr. Zentmayer's description of it.* "The instrument is 19 inches high when arranged for use. It is mounted on a

* 'Illustrated Price List,' 4th edit.

Fig. 133.



BULLOCH'S SECTOR MICROSCOPE.

broad tripod base with revolving platform, bevelled, silvered, and graduated in degrees for measuring the angular aperture of achromatic objectives. Upon this platform are two pillars, between which the bar and trunnions (which are of one piece) swing for inclining the instrument to any angle.

The *coarse adjustment* is effected by rack and pinion. The *fine adjustment* (in all other instruments of the Jackson principle in front of the body) is removed to the more stable part of the instrument, the bar, which is provided with two slides, one for the rack-and-pinion adjustment, and close to it, another one of nearly the same length, for the fine adjustment, moved by a lever concealed in the bent arm of the bar, and acted upon by a micrometer screw. In this way the body is not touched directly when using the fine adjustment, and the body does not change the relative distance of objective, binocular prism, and eye-piece. (A woodcut of the fine adjustment will be found at p. 321 of vol. ii.)

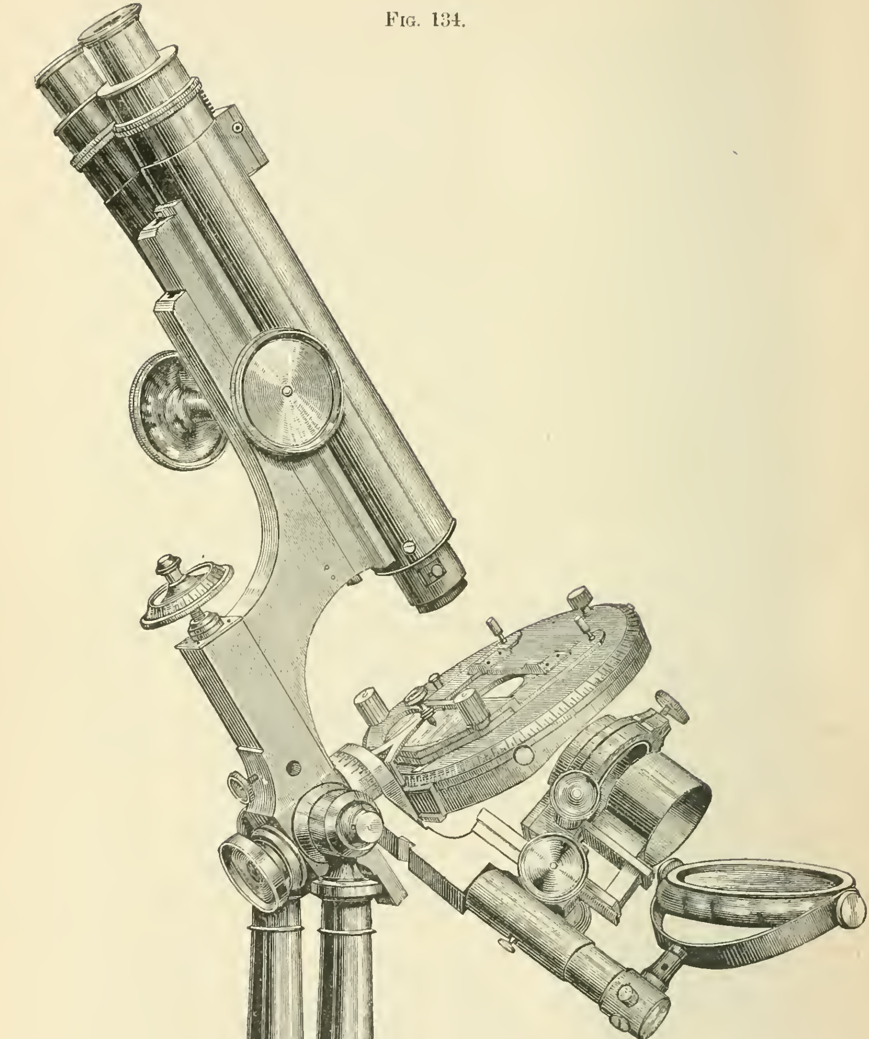
The *swinging substage*, which carries the achromatic condenser or other illuminating apparatus and the mirror, swings around a pivot placed behind the stage, of which the axis passes through the object observed, so that the object is in every position in the focus of the illumination. This most important arrangement, without which no Microscope can be considered complete, is carried out in an extremely simple and substantial manner. Although provided with but a single joint, it admits of being swung over any of the stages; a complete revolution is only interfered with by the body of the instrument. It is provided with a graduated circle at the upper collar for registering the degree of obliquity, and a stop to indicate when it is central with the main body.

The substage is divided into two cylindrical receivers, to facilitate the adaptation of several accessories at one and the same time. The upper cylinder has centering adjustment, the lower cylinder of the two can be moved up and down or entirely removed.

As an object placed on the stage is in a plane with the axis of the trunnions, it is obvious that, if the instrument is placed in a horizontal position, the object is in the axis of revolution of the graduated platform, and the angular aperture of an objective focussed on this object can be easily measured. It can be readily seen that in this position the object is in the centre of all the revolving parts of the instrument, the revolving stage, swinging substage, and the platform."

There are three *Stages:* 1st. One devised by Mr. Zentmayer in 1862 (shown in position on the stand, Fig. 134), which is 5½ inches in diameter and ½ inch in thickness. "It consists of a bell-metal ring, firmly attached to the bar, but adjustable by means of set screws, in order to make it perfectly concentric to the optical axis of the instrument. This ring receives the stage platform, which has a complete revolution. The outer edge is bevelled, silvered, and graduated into degrees to serve as a goniometer. The carriage on which the object is placed rests on a piece of plate glass, kept down by a spring with an ivory-pointed screw to the two rails on the revolving stage platform, which gives an exceedingly smooth and firm movement, and a

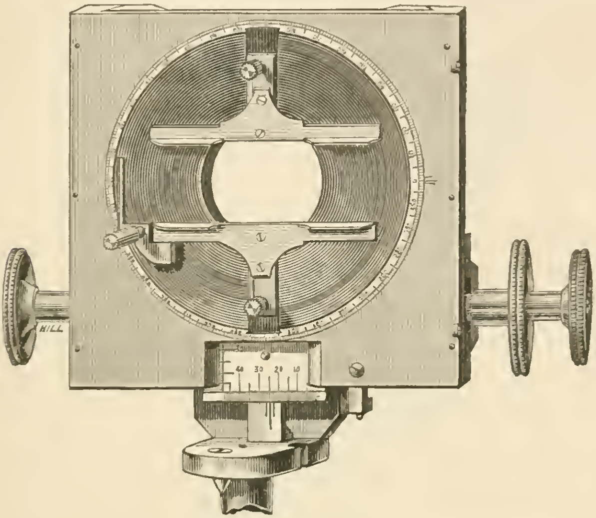
Fig. 134.



ZENTMAYER'S CENTENNIAL MICROSCOPE.

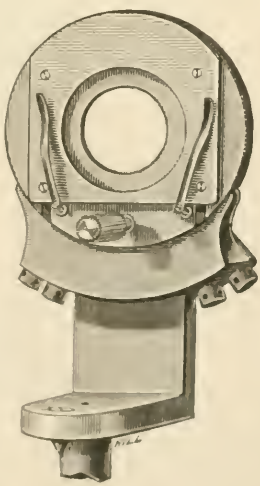
freedom of motion not obtained by any other arrangement. Owing to its simplicity, convenience, and durability, it has been extensively copied at home and abroad. The stage may be detached with facility,

FIG. 135.



by simply unscrewing the nut at the back of the bar, to be replaced by another stage, as, for instance, the Mechanical stage or the Diatom stage."

FIG. 136.

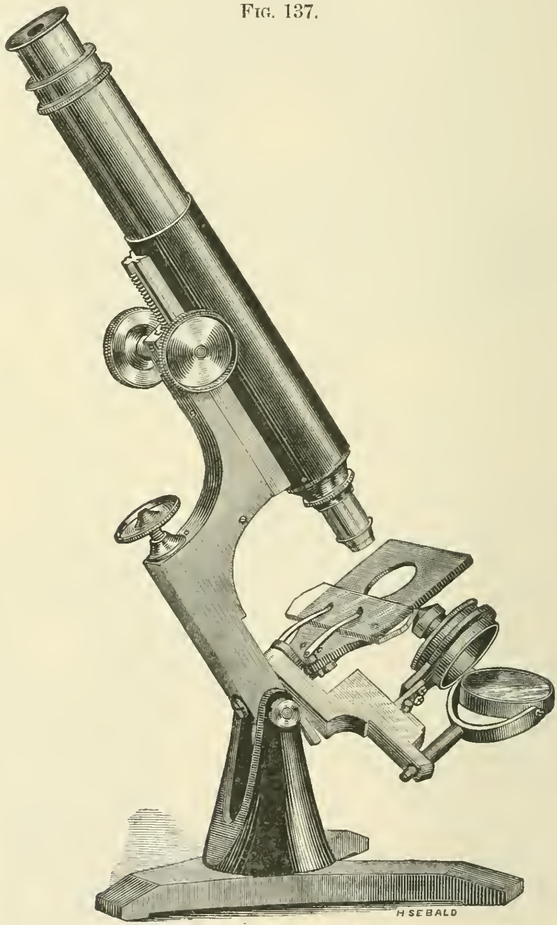


2nd. The Mechanical stage (Fig. 135, half-size) is 4 inches square and $\frac{3}{16}$ inch thick, with rectangular movements of 1 inch by the milled heads shown on the right and left. The forward motion of the stage is by means of a fine chain winding on a spindle beneath the stage acted on by the outer milled head, and is provided with a set-screw by which any stretching of the chain can be at once compensated. The cross-motion is effected by a travelling screw-socket attached beneath the stage, acted on by the inner milled head. These movements are extremely well constructed by Mr. Zentmayer. The graduated scales shown at the base serve as a finder.

The central circular plate (graduated at the margin) rotates in the plane of the stage, and is provided with two clips for the object. Inasmuch as this rotating centre-piece moves out of centre with every touch of the rectangular motions, the utility of the rotation is very much curtailed; a rotatory motion of the stage, unless it be approximately concentric with the optic axis, appears to us to be practically useless.

3rd. The Diatom stage (Fig. 136, half-size) is $2\frac{1}{2}$ inches in diameter and is bevelled out beneath, so that its thickness is only $\frac{1}{30}$ inch at

Fig. 137.



the centre. The lower plate rotates in the ring of the stage, and the upper one can be slipped backwards and forwards (beneath the spring clips) in two grooves. The four adjusting screws for centering are shown in the figure. Owing to its small size, it is very solid; it is especially convenient in that the swinging substage can be moved almost to the horizon of the object.

All of the stages are reversible on the stand, thus admitting of unlimited obliquity, and still keeping the object in the centre of the swinging bar.

(2) *Histological.*—This, constructed in 1876 (Fig. 137), shows the adaptation of the swinging substage to a cheap form of Microscope, and was earlier in date to that which we recently described at p. 532 as being the first cheap form that we had seen.

Mr. Zentmayer also constructed two other forms intermediate between this and the Centennial (" U.S. Army Hospital stands ").

Bulloch's Congress and Biological Microscopes. — (1) *Congress* (*older form*).—In 1877 the form shown in $\frac{1}{3}$ scale in Figs. 138 and 139 (19 inches high) was brought out (patented in 1879).

The figures render any detailed description of the parts of the instruments unnecessary, with the exception of the substage and mirror arrangements. These both move about the same centre, which is at a point the thickness of an ordinary slide above the stage, and they can be rotated by hand above and below the stage either *together*, when connected by the spring stop S (Fig. 138), or *separately* (as shown in Fig. 139).

The two arms (D D and O E) carrying the substage and the mirror are attached to the graduated circles shown in the figure, by which the exact degree of obliquity can be registered.

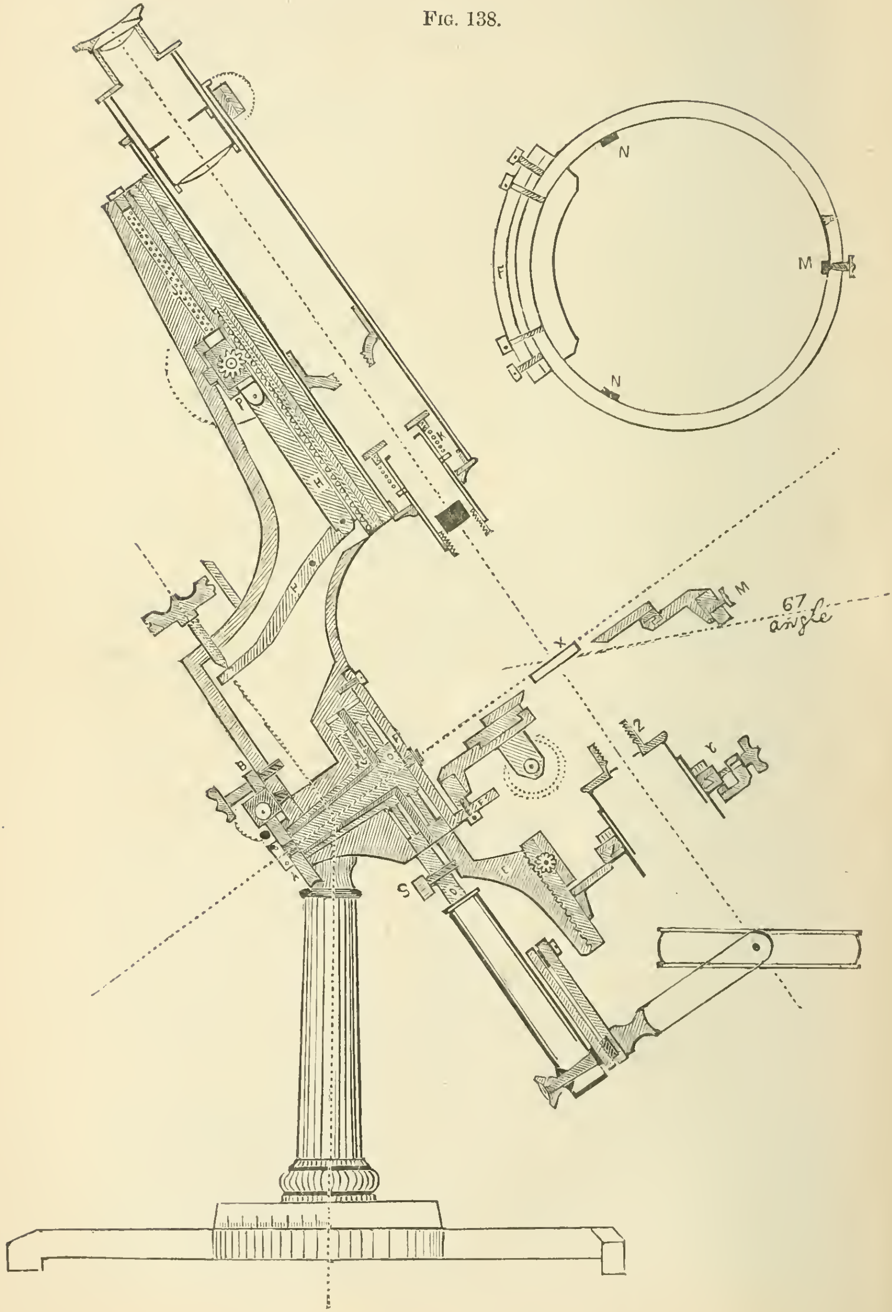
As originally constructed by Mr. Bulloch, the end of the substage pinion (passing through the limb) was provided with a toothed wheel A, upon which the tangent screw B acted, producing the lateral rotation of the substage bar. This mechanical rotation has since been replaced by friction motion that can be clamped by the milled head shown on Fig. 140 in the place of A in Fig. 138.

When placed horizontally as for drawing, every part moves accurately about the same centre X (in direct line with the object on the stage).

The fine adjustment is on the Franco-German principle, and moves the entire body without changing the distance between the objective and the eye-piece. The levers H H act directly upon the sliding-box which contains the pinion of the coarse adjustment, and this is in turn pressed down by a strong spiral spring J above it. In addition (which is important with this form of fine adjustment) the Society screw at the end of the body is arranged as a safety nose-piece K with spring. The arrangement of this form of fine adjustment differs from that of Mr. Zentmayer, as the latter uses an independent slide for the coarse and for the fine adjustment, and not one slide for both.

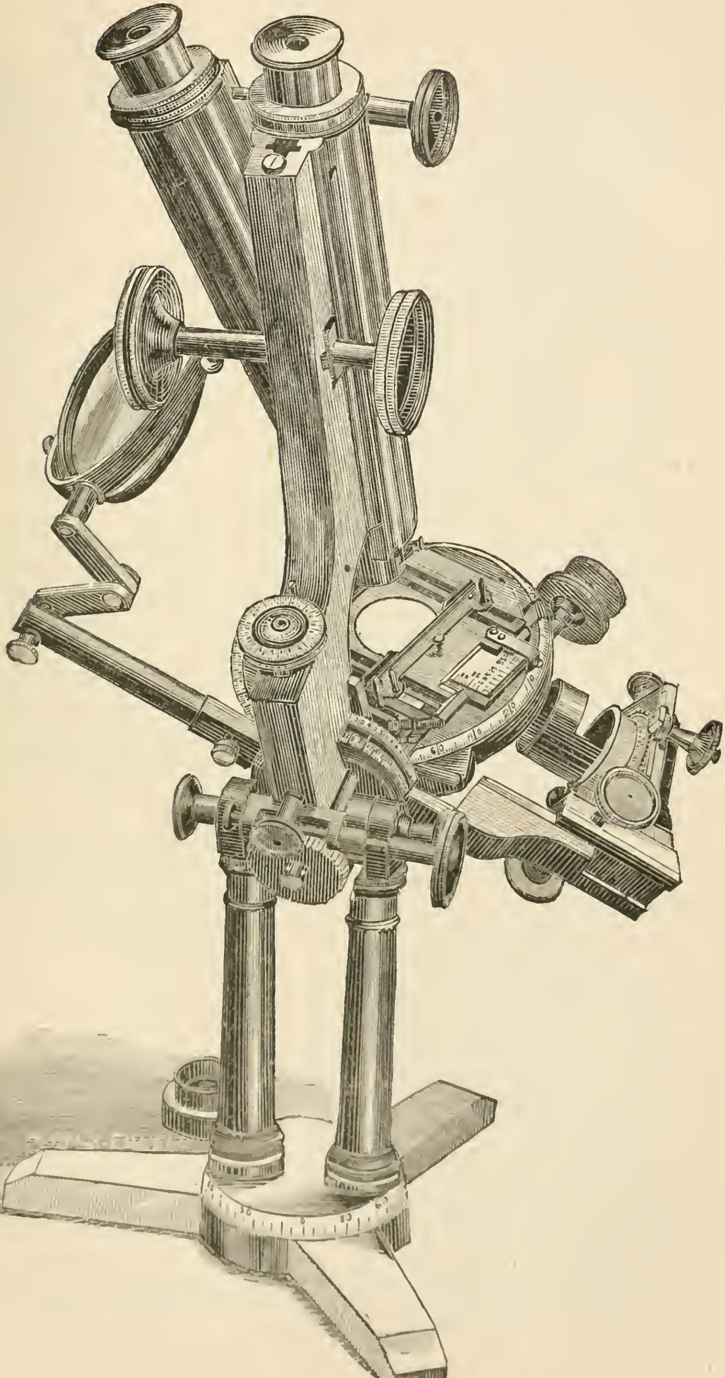
Heretofore in centering the stage to the optical axis it has been done by a ring within another one, in which the screws operate either to draw or push the interior ring into position. By this method the stage, in order to use it for oblique light, has to be made unnecessarily large. In place of a complete ring, Mr. Bulloch therefore uses a segment or " saddle piece," to which the stage-ring is attached. The arrangement is shown in the upper section of Fig. 138, where F is the saddle-piece, with the four centering screws passing through

Fig. 138.



Bulloch's Congress Microscope (older form).

Fig. 139.



BULLOCH'S CONGRESS MICROSCOPE (OLDER FORM).

it, being firmly fastened to the limb. The ring may be clamped in any position by a screw passing through the base of F, and the stage may be clamped in any position by M. The projections at N (and M) afford bearings for the stage to move upon and diminish friction.

The stage is thin enough to admit oblique light up to 134°.

(2) *Congress* (*newer form*).—Mr. Bulloch writes : "I have recently made several improvements and additions to the stand.

"As originally intended, the front end of the centre of the substage passed through and supported the stage support or saddle-piece; but for the finer work of measuring angles of aperture as Dr. Blackham does, any connection between substage and stage would cause the object to move to one side when the substage was swung from one side to the other; as now made there is no connection between substage or mirror and the stage; the stage is fixed to the limb by an angle-piece quite independent of the swinging arms, which I consider an important improvement. (Cf. Figs. 140 and 141.)

"I have also improved the arrangement of the pinion box; the slide of the coarse adjustment is now provided with a V piece on each side of the rack-work, and these fit into corresponding slots: they act as guides to the movement and add to the steadiness. I have also added guide pieces outside the pinion box, that travel with the fine adjustment on the sides of the limb. (Cf. Figs. 140 and 141: they are shown above and below the large milled heads on the limb.)

"In the end of the tube is the new broad-gauge screw (the 'Dr. Butterfield broad-gauge screw'), $1\frac{1}{4}$ inch in diameter, for low-power objectives of extra high angle. In this screw are two separate nose-pieces containing the Society screw—one is for the binocular, which must have diaphragms, so that the full benefit of high angle is lost; the other has a clear aperture, the diameter of the Society screw.

"At the upper end of the slide of the tube is a scale reading to $\frac{1}{100}$ of an inch, and the slow-motion screw reads to $\frac{1}{1000}$, so that working distance of objective can be measured.

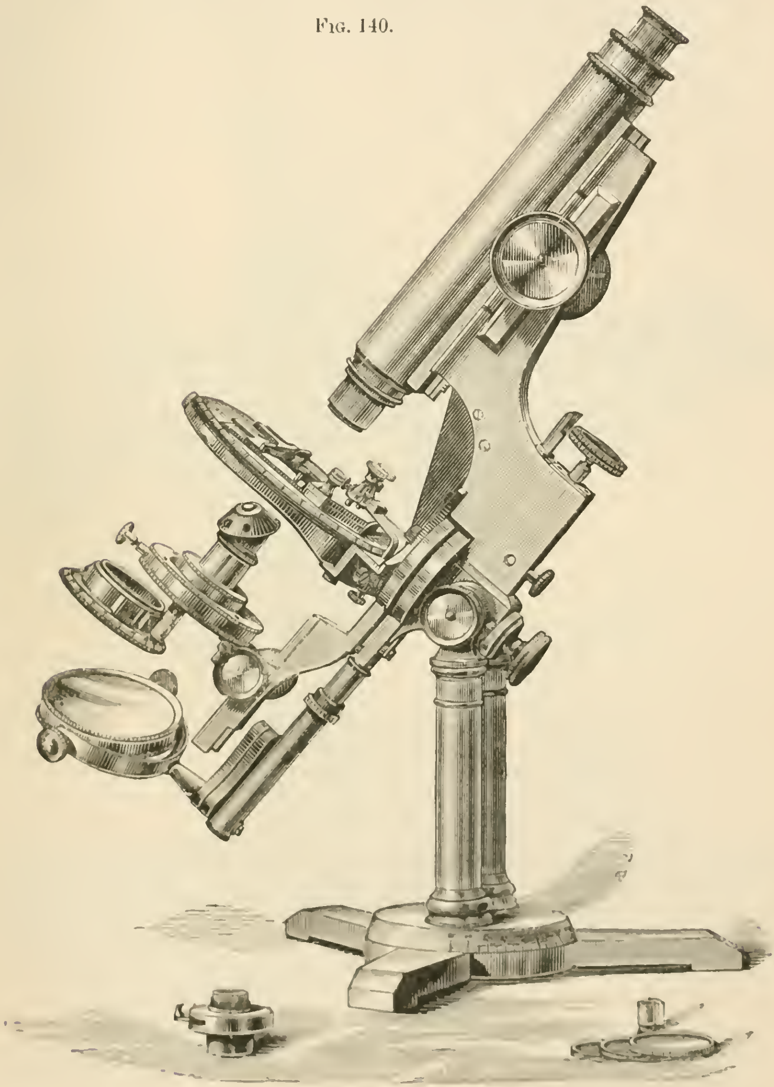
"There is also what I call a new adaptation of the Gillett diaphragm, which can be used close up to the object, or when using the hemispherical lens can be swung close round it. The Woodward prism and also the hemispherical lens are specially fitted to the under part of the stage support, so that the stage can be revolved in the axis without altering the position of the hemisphere."

Of the points mentioned in Mr. Bulloch's letter, we must certainly agree with him as to the importance of making the attachment of the stage substantial and rigid, as may doubtless be done by screwing it to the limb by an angle-piece. If it were desired to have a second stage adapted—say a small diatom stage—it would be quite possible to provide convenient means for changing the stage, and at the same time to ensure that either stage should, when in position, be exactly at right angles to the optic axis.

Still later Mr. Bulloch has modified the stand to make it more especially applicable for the examination of diatoms. The stand is shown in Figs. 140 and 141, the latter being a representation of the instrument in a horizontal position (with the lamp attached to the substage bar) for drawing, measuring apertures, &c.

Mr. Bulloch claims to have improved the construction of the

Fig. 140.

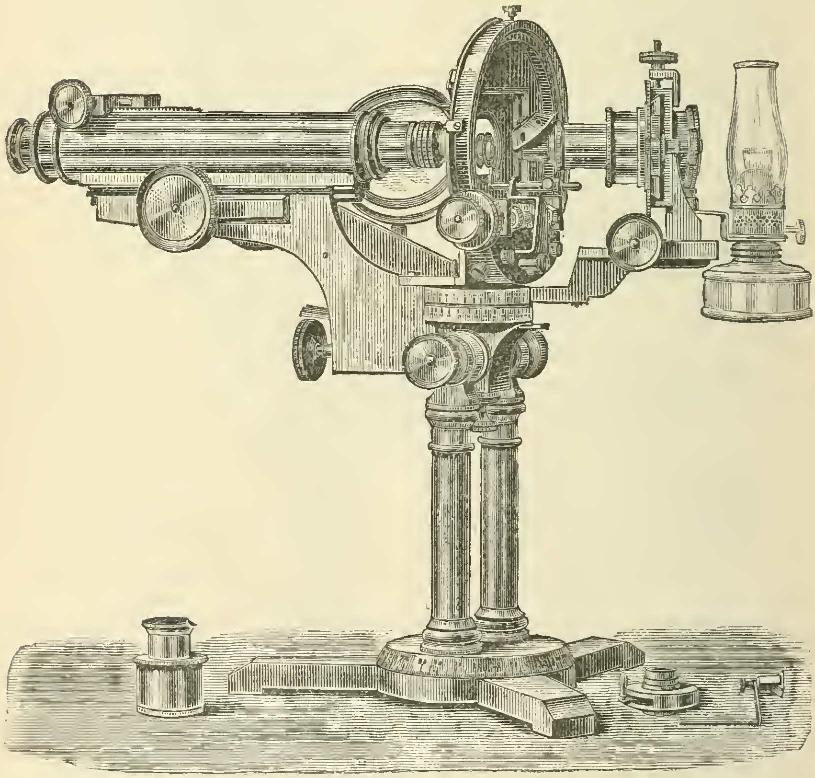


sliding glass stage; as previously made, there was always a liability to a sudden slipping of the stage if the Microscope were accidentally jarred. By using two pressure points fitted on one bar that turns on a swivel joint, the swivel accommodates for any difference of length in the points and thus equalizes the pressure and prevents slipping. The stage is thin enough to admit an angle of 160 degrees.

The substage is made in two parts, intended for the examination of polarizing objects when using an achromatic condenser. The lower part has a motion to one side, which leaves the condenser and light from the mirror in the same position. Fig. 140 shows the lower part swung out.

The Gillett diaphragm to the condenser—placed *above the lenses*—

Fig. 141.



is also shown, and a convenient plan for mounting a hemispherical lens for immersion illumination attached to an elbow-piece beneath the stage.

(3) *Biological.*—This (Fig. 142) is a smaller and more recent instrument (patented in 1879).

The substage and mirror can be moved independently round the focal point as a centre, and can be used above the stage if required.

They can also be clamped in any position by the milled head shown behind the limb.

The stage (with revolving concentric movement) is adjustable to the axis, measures 3½ inches in diameter, and is 3½ inches above the

FIG. 142.

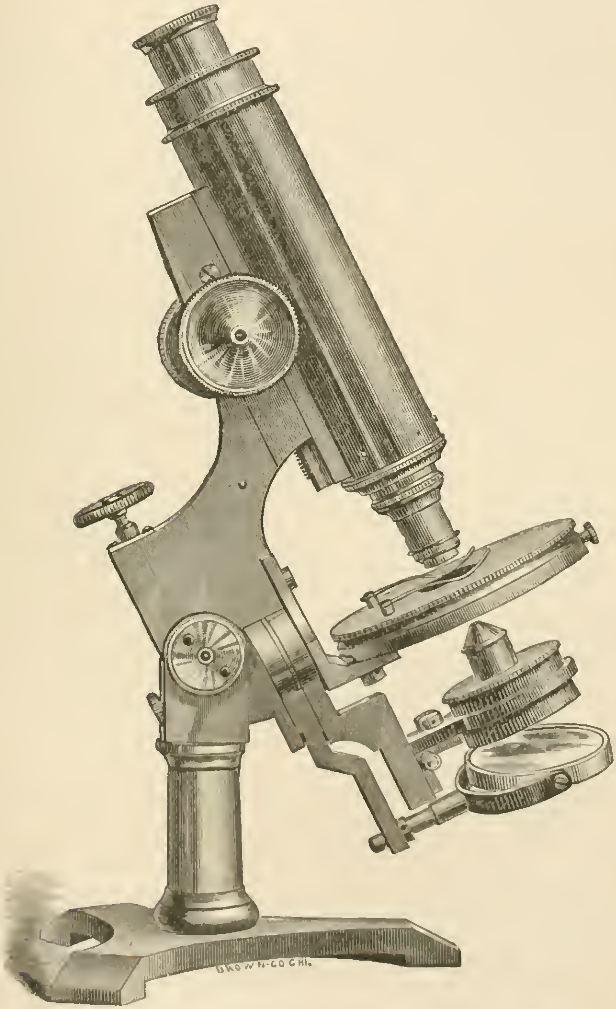


table. When not required to revolve, it can be clamped in any position by the milled head shown in front. When there is any danger of injuring the stage by the use of acids, it can be lifted out of the ring in which it revolves, and an ordinary piece of glass used on the top of the ring when the instrument is upright. The stand is 12½ inches in height, and the body and draw-tube are each 5 inches in length. The fine adjustment moves the whole body-tube, and there is the broad-gauge screw for high-angle low-power objectives, in which fits an adapter with the regular Society screw.

Other details are shown in the figure, which is about two-fifths the actual size of the instrument.

Standards of Length—Illumination for Opaque Objects.*— Professor W. A. Rogers has published an exhaustive paper on those standards of length which are in actual use, and which have the authority and sanction of either national or international law. Much of the paper is beyond our scope; but the author refers to two points bearing upon the use of the Microscope in verifying standards.

With regard to the magnifying power of the Microscope employed, which is best adapted to secure the greatest absolute accuracy in measurements, the result of the author's experience on the subject is favourable to high powers. With a proper illumination, and with lines having smooth edges, a power of 900 can be used with great ease, even in the comparison of two metres upon a longitudinal comparator. In all the earlier comparisons Microscopes of very low power were employed, varying from 40 to 60 diameters, and the International Commission have decided upon the low power of 40 to 50. M. Tresca, of the French section, however, is a firm believer in high powers, and prefers one of about 400.

On the best method of illumination for opaque objects, Professor Rogers says—"I cannot better illustrate the necessity for a proper illumination in making exact measurements than by saying that I have been obliged to reject a series of observations, extending over a period of four months, for the simple reason that I finally discovered that, during all this time, I have never once seen the actual lines ruled, but only their image. I used a parabolic reflector, giving a beautiful *white* line on a black background. The lines were traced upon a steel surface, nickel-plated, their width being about one ten-thousandth of an inch. Investigation showed that the positions of the lines could be changed by an amount more than half their width, by shifting the position of the parabolic reflector.

The method of illumination employed by Baily and Sheepshanks seems to me radically defective. With the Microscopes used by Sheepshanks I found myself unable to separate lines ruled on a polished steel plate, though separated by an interval of only one-thousandth of a centimetre. As already stated, I have used with great satisfaction the form of illumination described by Mr. Tolles in the 'Annual of Scientific Discovery' for 1866-67.† It is sufficient to say here, that, as none of the light is lost by the reflection, it is easy to get all, and even more than is needed. Diffused daylight falling upon the plane face of the prism inserted between the two front lenses affords an abundance of light for the most delicate tracings. With a 1-inch objec-

* 'Proc. Am. Acad. Arts and Sci.,' xv. (1880) pp. 273–312.

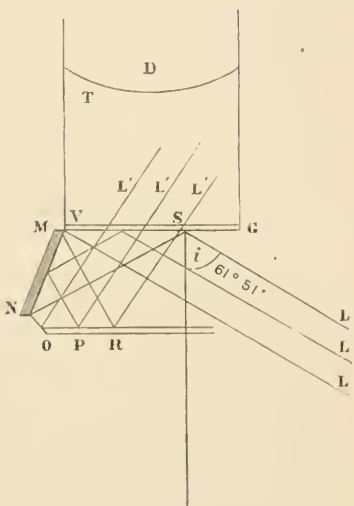
† See this Journal, *ante*, p. 754.

tive of the form recently constructed by Mr. Tolles, lines 30,000 to the inch, ruled on a polished steel surface, are resolved with the greatest ease."

Professor Rogers also refers to a "comparator" which he has designed as an improvement upon that described at p. 947 of vol. ii., a description of which we defer until a detailed account, with a drawing, has appeared.

Mirror for Illuminating Opaque Objects for the Projecting Microscope.*—The subject of this note, by Mr. P. Frazer, jun., (which we give verbatim) "is an arrangement for representing opaque objects through the gas Microscope, especially adapted to Zentmayer's $1\frac{1}{2}$-inch objective. It is only claimed to be better than the parabolic reflector of Smith and Beck, J. Lawrence Smith, Sorby, and others, where the working distance of the Microscope is comparatively large (i. e. the distance from the objective to the object on the stage is $\frac{1}{2}$ inch or more) and for the purposes mentioned. Where the distance is as great as that just mentioned, the dispersion of rays from the reflection at one point, of rays from very different parts of the mirror, is so great that only a few rays from the upper part of the mirror reach the lens at all. It would be different with a lens having a very small working distance, and in this case a parabolic reflector would be preferable.

FIG. 143.



G V, cover-glass. M N, reflecting mirror. O P R, reflection on object. L′, rays which pass through the objective. D, lens. T, sliding tube carrying reflecting mirror. Angle of incidence 62°.

The apparatus consists of a brass tube made to slide over the lens, on the lower end of which is fixed a glass plate about 1 mm. in thickness, so attached as to be capable of a sliding motion towards or away from the hinged mirror which is attached to the edge of the metal flange in which the glass plate slides. This simple contrivance permits the glass plate to be brought into close contact with the reflecting mirror, no matter at what angle the latter may be placed.

The mirror is made of nickel-plated German silver neatly mounted on a small hinge.

The light is admitted from below through a diaphragm after the rays have been rendered parallel by the condenser of the lantern, the

* 'Proc. Am. Phil. Soc. Phila.,' xviii. (1880) p. 503.

aperture of the diaphragm being adapted to the maximum thickness of beam which can be effective for illumination, and which (calling a the aperture of the lens and i the angle of incidence of the beam) $= a$ cos. i; or for an aperture of $\frac{7}{8}$ inch (= 0·875 inch) and an incident angle of 62°, 0·411 inch, or roughly 0·4 inch.

The less the incident angle, of course the larger the beam of light will be, and the greater the diameter of the diaphragm. The refractive index of the glass employed to make the plate being 1·5, in order that the critical angle 41° 48′ may not be exceeded in the refracted ray, this angle of incidence or i must not be less than 61° 51′, or roughly 62°.

This minimum value of i determines the area of surface which can be illuminated on the Microscope stage, but by altering the angle of the mirror very slightly, all parts of the object may be successively projected on the screen. This minimum value is easily obtained from the critical angle of the glass employed, which is 41° 48′. The complement of this, or 48° 12′, is equal to the angle of refraction (or r) when the minimum value of i is attained.

$$\frac{\sin. i}{\sin. r} = 1 \cdot 5,$$
$$\sin. i = 1 \cdot 5\ (\sin. 48° 12'),$$
$$i = 61° 51'.$$

In other words, the angle between the luminous ray and the glass plate can never exceed 28° 09′, or in round numbers 28°."

Ebonite in Microscopical Appliances.—In America ebonite has been adopted for some years for mounting eye-pieces, and for stages of laboratory Microscopes, principally by the Bausch and Lomb Optical Company, who claim for it special adaptability for these purposes as well as economy. M. Vérick, of Paris, has also used it for the diagonal sliding-boxes containing the prisms of his binocular eye-piece and the outer plates into which they fit, and it has also been adopted for rings for cells.

We are glad to see that ebonite is coming into use in this country, having been adopted for Stephenson's safety-stage* (by Mr. Teesdale), and now for Botterill's life trough.† There are many other pieces of apparatus for which the use of ebonite would be a great advantage in reducing weight.

* See this Journal, *ante*, p. 332. † Ibid., p. 148.