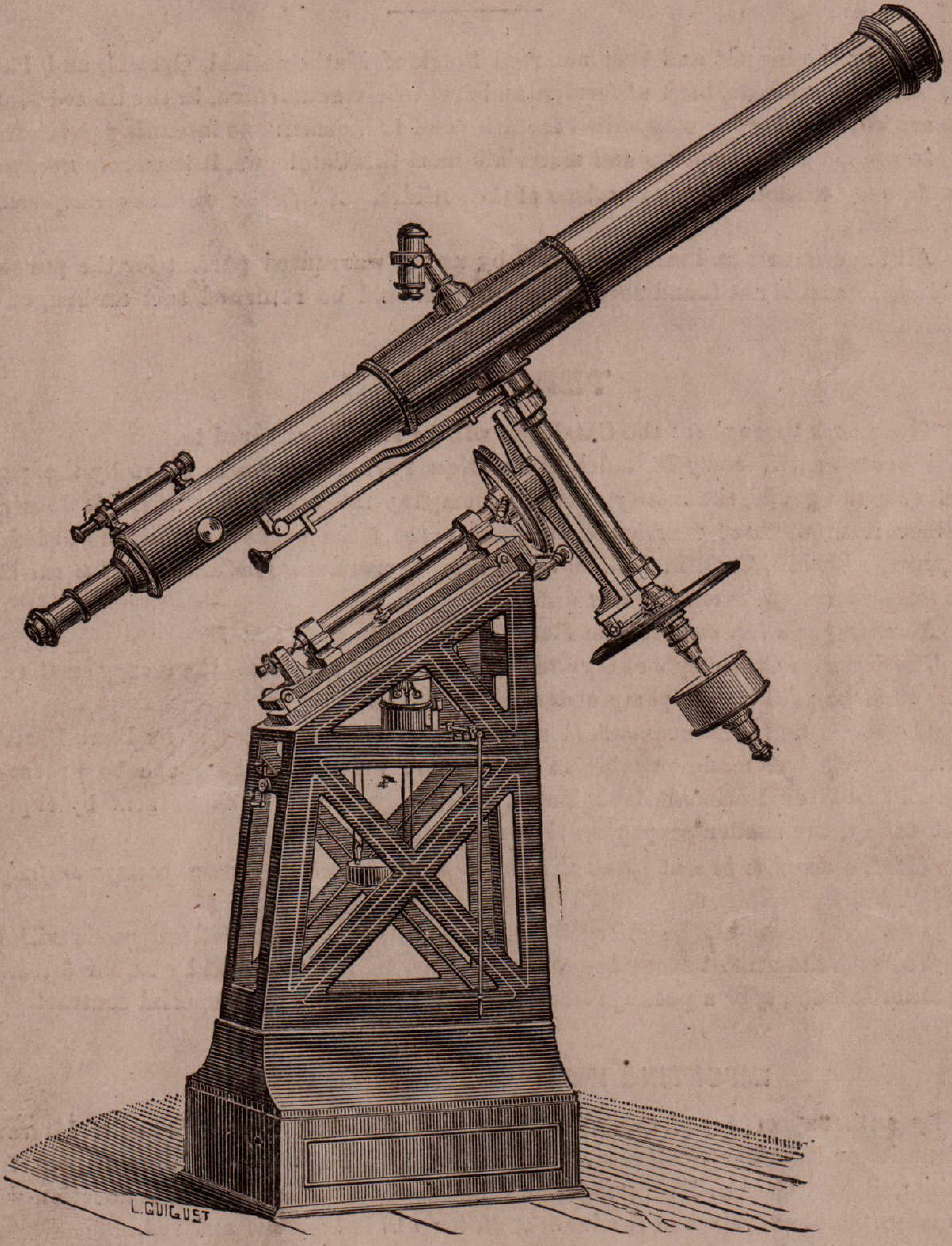
From Warner & Swasey

SUPPLEMENT TO PART SECOND. (YEAR 1884)

PRICED AND ILLUSTRATED CATALOGUE

OF

ASTRONOMICAL TELESCOPES.



L. GUIGUET

JAMES W. QUEEN & CO.,

No. 924 CHESTNUT STREET, PHILA.

1884.

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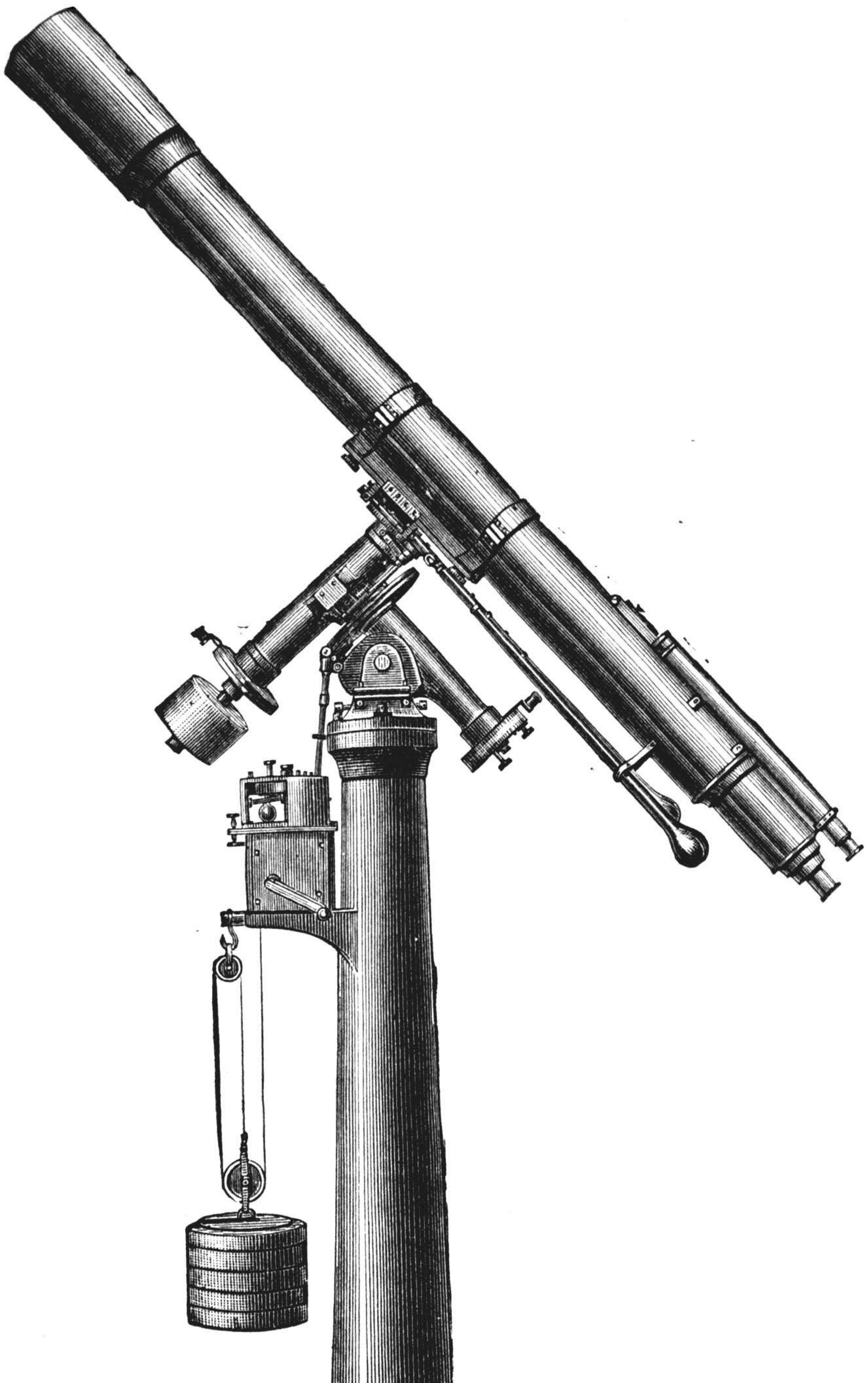
JAMES W. QUEEN & CO.

PHILADELPHIA, 1884.



Equatorial Telescope, with cast-iron pillar, clock, and tangent. Screw motions brought down to eye-end.

CLASS C.

SUPPLEMENT TO PART SECOND.

PRICED

AND

ILLUSTRATED CATALOGUE

OF

Astronomical Telescopes.

PHILADELPHIA:
JAMES W. QUEEN & CO.,
No. 924 CHESTNUT STREET.
1884.

ASTRONOMICAL TELESCOPES.

The unaided eye of an observer may indeed gaze upon the wonders and beauties of the vault of the heavens, lost in the effort to count the stars which stud the firmament or trace their configurations in silent admiration; he may survey the Milky Way, which like a fleecy cloud spans infinite space; or he may study the everchanging positions among the stars of the brighter planets, the occasional comet, or the pale Moon. It is but natural that the observer should desire to obtain some means of examining closely and minutely these orbs which, by their radiance, fill the nocturnal vault with splendor, to enable him to follow more closely the motions of the brilliant planet, the erratic comet, the changing moon. Now the telescope comes to his aid, with its powers of penetrating the chambers of infinite space; objects hitherto unknown are revealed to the astonished vision; in the distant realms of space nebulæ are discovered, clouds of stars and clusters of innumerable glittering points; satellites are found to accompany the several planets, and the spotted surface of the Moon becomes a very map of craters, plains and mountains; the Milky Way is found to consist of numberless stars, glittering in brilliant fields of ether like jewels; whilst Saturn, with his rings, presents an object of never-ceasing wonder. When turned on the Sun, the telescope reveals spots and features grouped strangely enough, by the motion of which we are led to the discovery of solar rotation. With the more powerful instruments the eclipses and transits of Jupiter's moons may be observed, their periods ascertained, and the velocity of light determined, and volumes are now written of the details of astronomical research, teeming with wondrous accounts of the achievements of THE TELESCOPE.

There are two distinct classes of Astronomical Telescopes in use at the present time: **the Refractor,** which forms an image of any celestial object by light transmitted through a lens termed the objective, or object-glass, and the Reflector, producing a similar image by light reflected from a concave mirror; the image thus obtained is then magnified by a set of lenses termed the eye-piece, or ocular.

The art of constructing either class of telescopes at the present day commands the highest talent, and the greatest skill and accurate workmanship are pressed into its service.

THE REFRACTING TELESCOPE or "Refractor" consists of a large lens, styled the object-glass, which forms the image for observation; and a set of two lenses called the eye-piece or ocular, which serves to magnify the intercepted image. All the better refracting telescopes of the present day are furnished with an achromatic object-glass; this is composed of two kinds of glass: the crown and the flint; by this combination of elements of different density and dispersing power, both chromatic aberration (fault of color) and spherical aberration (defect of curvature) can be corrected. When either of these defects exist, the image will appear misty, or not very distinct when magnified by the eye-piece; a well-corrected lens on the other hand will readily bear a power of 50 times to each square inch of its diameter with *perfect distinctness.* Very small bubbles in the glass of an objective are no impediment to its good performance (Webb's celestial objects), but if it contains striæ or waves, however minute or unnoticeable, the objective will be of no use for astronomy.

The larger telescopes are generally provided with a finder, which is a small telescope of small magnifying power mounted parallel with the large tube, so that an object seen in the centre of the finder may also be found in the large instrument; two wires crossing at right angles are inserted in the tube of the finder so that they are distinctly seen; the object, as a star for instance, is brought near the intersection of these wires, and will, if in proper adjustment, be visible in the telescope. The eye-pieces commonly in use are the positive, sometimes styled Ramsden's, and the negative, known as the Huyghenian; the positive eye-piece is composed of two plano-convex lenses of similar focus, the convex sides turned inward and placed at a distance of $\frac{2}{3}$ the focal length of either lens. The equivalent of a single lens to this eye-piece is found thus:

Divide the product of their focal lengths, by their sum less the distance between them.

$$\text{A} \quad \frac{1.5 \times 1.5}{3 - 1} = \frac{2.25}{2} = 1.125 \text{ inch.}$$

The focus of this eye-piece being beyond the field lens, it is best suited for instruments requiring wires or micrometers.

The *negative* eye-piece is also composed of two plano-convex lenses, but both convex surfaces are turned away from the eye, and the ratio of their focal length is 3 to 1, the shortest lens nearest the eye; a stop is also placed between them—the distance between them equals half the sum of their focal length, the focal length of an equivalent lens is equal to twice the product of the focal lengths divided by their sum, thus:

$$\text{B} \quad \frac{3 \times 1 \times 2}{4} = \frac{6}{4} = 1\tfrac{1}{2} \text{ inches.}$$

The power of the telescope is ascertained by dividing the focal length of the object-glass by the focal length of the equivalent lens of the eye-piece employed: $1\frac{1}{2} : 72$ inches $= 48$ times or diameters for a telescope of 6 feet with eye-piece as figured at B.

A very convenient way of increasing the power of any eye-piece is by placing some 4 or 5 inches from the eye-piece, an achromatic concave lens, which intercepts the converging rays coming from the object-glass, rendering them less convergent, and, therefore, increasing the virtual focal length of the objective; the result being an enlarged image equivalent to higher power; this lens is now generally sold as the "Barlow lens."

For celestial tests, the list by J. N. Lockyer, in his work entitled, *Star Gazing*, 1878, are reported below. It must, however, be understood, that some of those test-objects require considerable experience in order to make them out; this is the case more particularly where a very small star is close to a star of great brilliancy.

TESTS FOR TELESCOPES.

2 inches diameter, powers 60 to 100.

α Polaris	γ Arietis.	α Geminorum.
α Piscium.	ρ Herculis.	γ Leonis.
μ Draconis.	ζ Ursæ Majoris.	ζ Cassiopeiæ.

4 inches diameter, powers 80 to 120.

β Orionis.	α Lyræ.	δ Genimorum.
ε Hydræ.	ε Leonis.	σ Cassiopeiæ.
ε Bootis.	γ Ceti.	ε Draconis.

6 inches diameter, powers 240 to 300.

ε Arietis.	20 Draconis.	ζ Herculis.
32 Orionis.	κ Geminorum.	ζ Boötis.
λ Ophiuchi.	ι Equulei.	

Scale of Diameters of Achromatic Objectives, Giving the Smallest Stars Visible.

(*From Newcomb & Holden's Astronomy.*)

MAGNITUDE OF STARS ACCORDING TO STRUVE'S SCALE.

Aperture. Inches.	Minimum Magnitude.	Inches.	Minimum Magnitude.
1.0	9.0	4.5	12.3
1.5	9.9	5.0	12.5
2.0	10.5	5.5	12.7
2.5	11.0	6.0	12.9
3.0	11.4	6.5	13.1
3.5	11.7	7.0	13.3
4.0	12.0		

EQUATORIAL STANDS.

The equatorial movement is the most convenient for following a celestial object with but one motion; it is constructed with an axis which points to the pole and carries at right angles another axis; to this the telescope is fastened at one end, and at the other a counterpoise. **The first axis** is revolved in an opposite direction to that which the earth rotates, either by the hand or by an endless screw, and the most complete instruments are moved by clock-work. **The second axis** serves to elevate the telescope to any point above or below the equator, and when the object to be observed is in the field, the axis is clamped. The two axes give two movements—the first in **right ascension,** the second in **declination.** When an Equatorial is intended for use at places many degrees distant, it is convenient to make the **polar axis adjustable** to the elevation of the true pole.

Equatorial stands are mounted in two ways: when on an iron or stone pedestal, it is termed a **fixed equatorial,** and when mounted on three long wooden legs, it is called a **portable equatorial.**

For more accurate observation, the two axes are provided with circles, divided into degrees and minutes, and furnished with vernier and reading microscopes, and by means of these the exact position of any celestial object at a given time can be registered, or, on the other hand, the telescope may be directed at any time, day or night, to a celestial object with certainty, the correct time being ascertained and the position of the object obtained from astronomical tables.

The adjustments necessary in setting up

The **Simple Equatorial** are the following:

1st. The polar axis must be elevated to a point equal to the co-latitude of the place, or, approximately, by pointing telescope to polar star.

2d. It must be set in the meridian line, that is due north and south and for

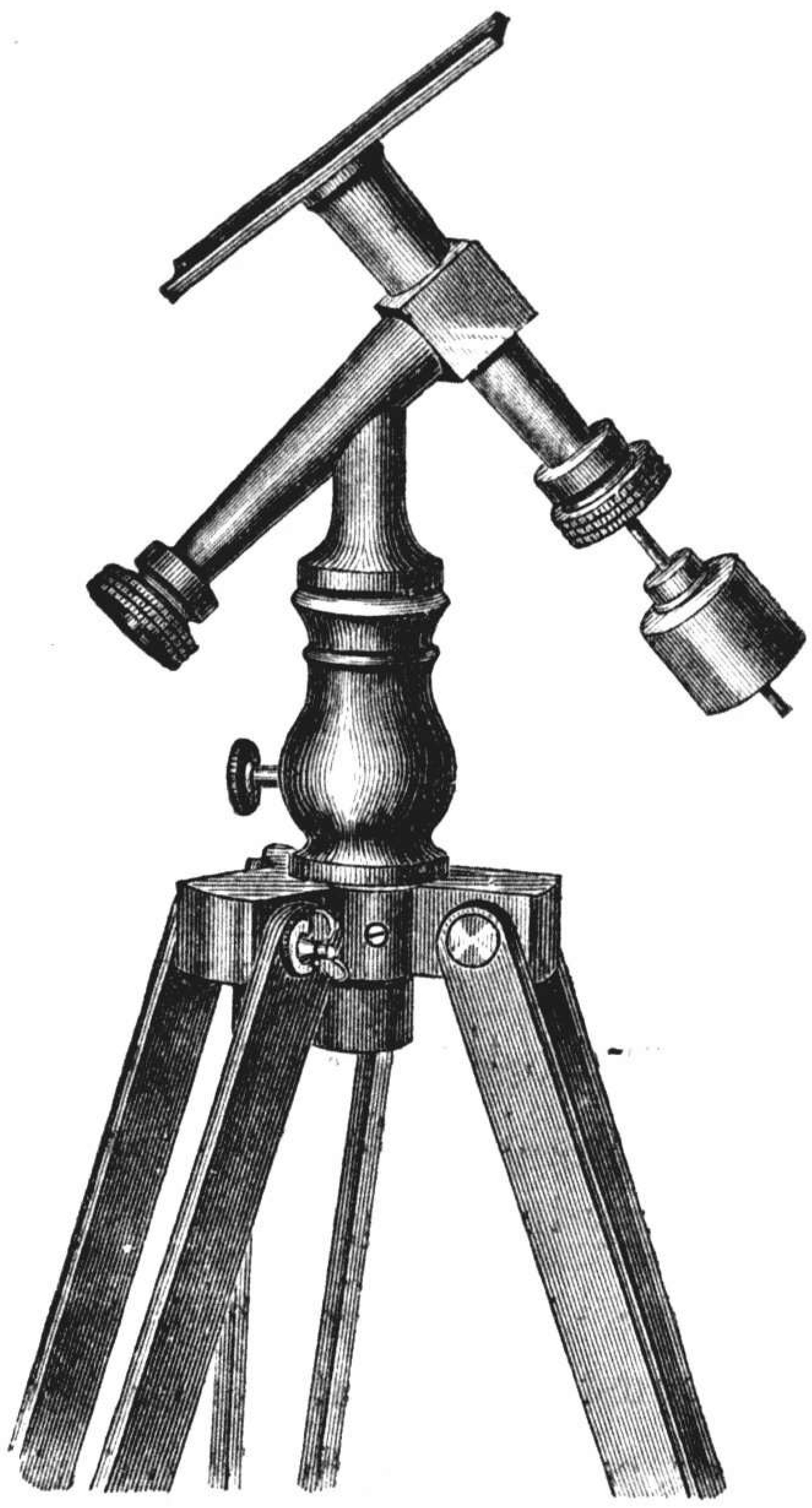
The Equatorial with circles:

3d. The index of the declination circle must point to 0° when the optical axis of the telescope points to the equator.

4th. The index of the hour circle must point to 0 h. when the declination axis is horizontal.

In order to effect these adjustments properly, the equatorial must be constructed with great accuracy, not only in regard to the movable but also in the rigid parts, as any defect in that respect would make it unfit for its work, no matter how well finished it may be otherwise.

SIMPLE CAST-IRON EQUATORIAL MOVEMENT.



Simple cast-iron equatorial movement, with steel axes and brass collars and clamps, smooth motion, mounted on a firm, tall, wood tripod, suitable for telescopes 3 inches to 3¾ inches diameter....... .... $40 00

CLASS A.

Equatorial mounting, with tangent screw movement in R. A., made for latitude required, with cradle-piece and leather straps for holding tube, and mounted on a tripod stand.

For telescopes 3 inches to 3¾ inches.. $65 00
For telescopes 4 inches to 4½ inches,.. 90 00

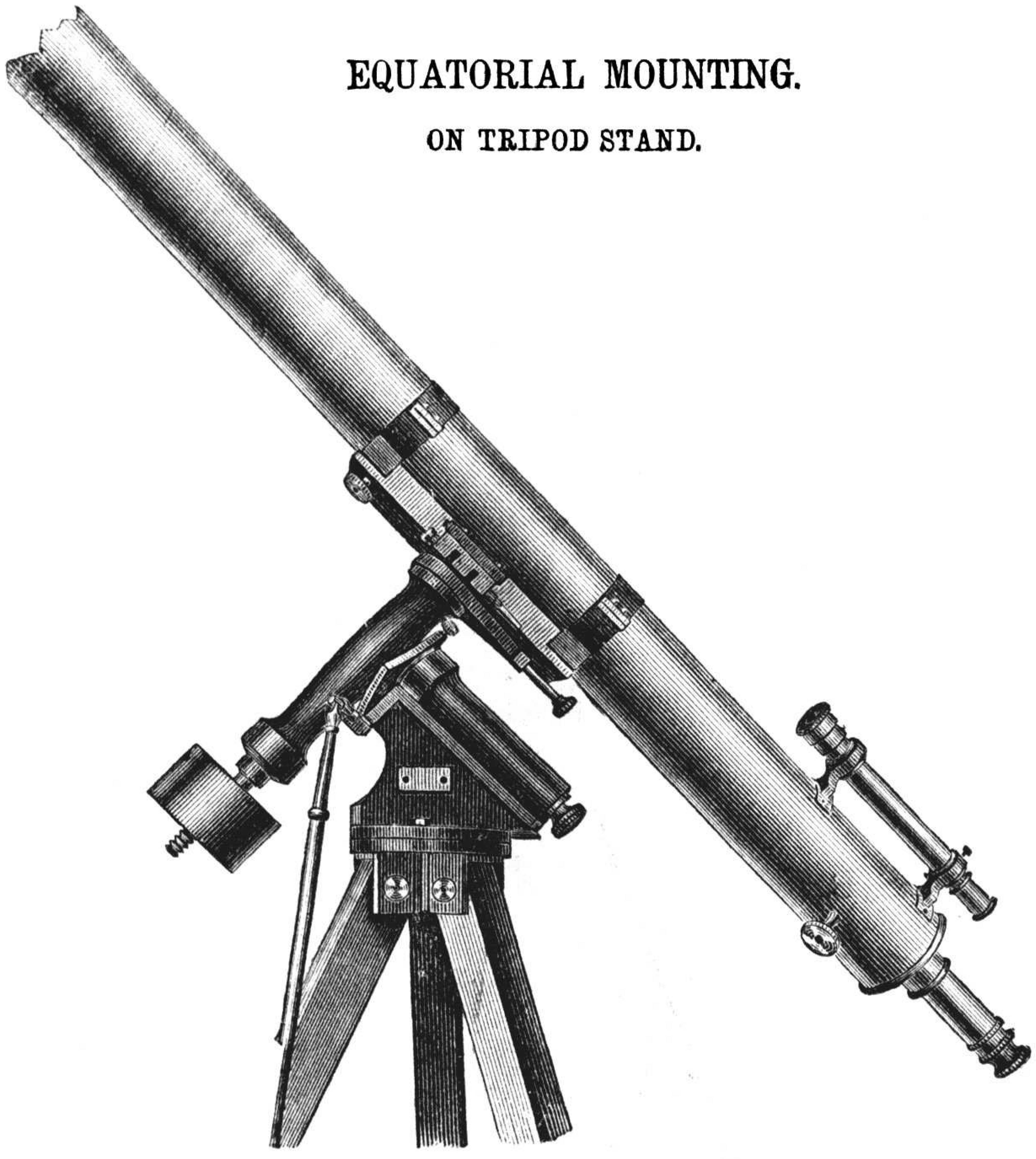
With slow motion in declination and in R. A.

For telescope 3 to 3¾ inches.. $75 00
For telescope 4 to 4½ do. 100 00

Metal clasps, instead of leather, extra.

EQUATORIAL MOUNTING.

ON TRIPOD STAND.

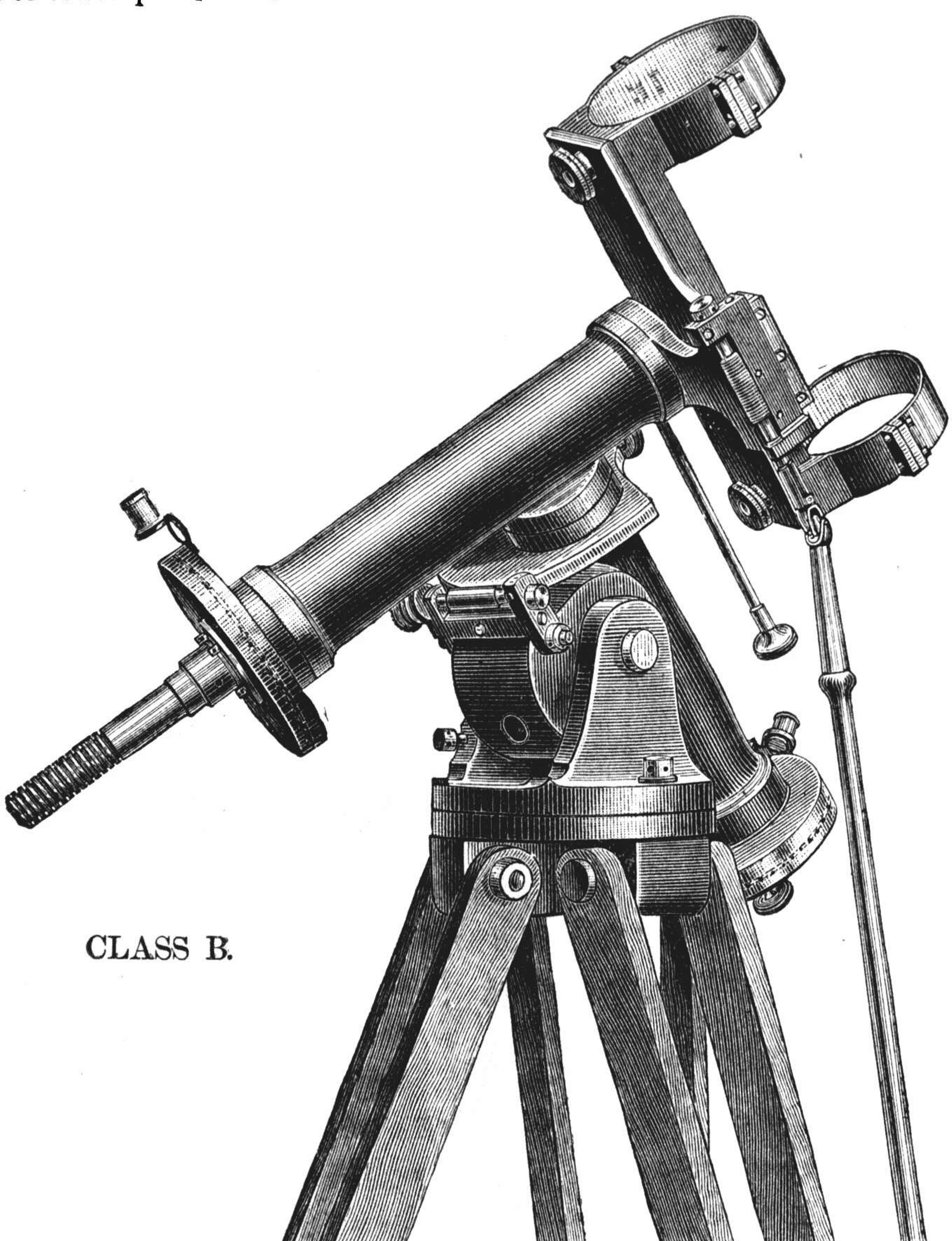


CLASS A.

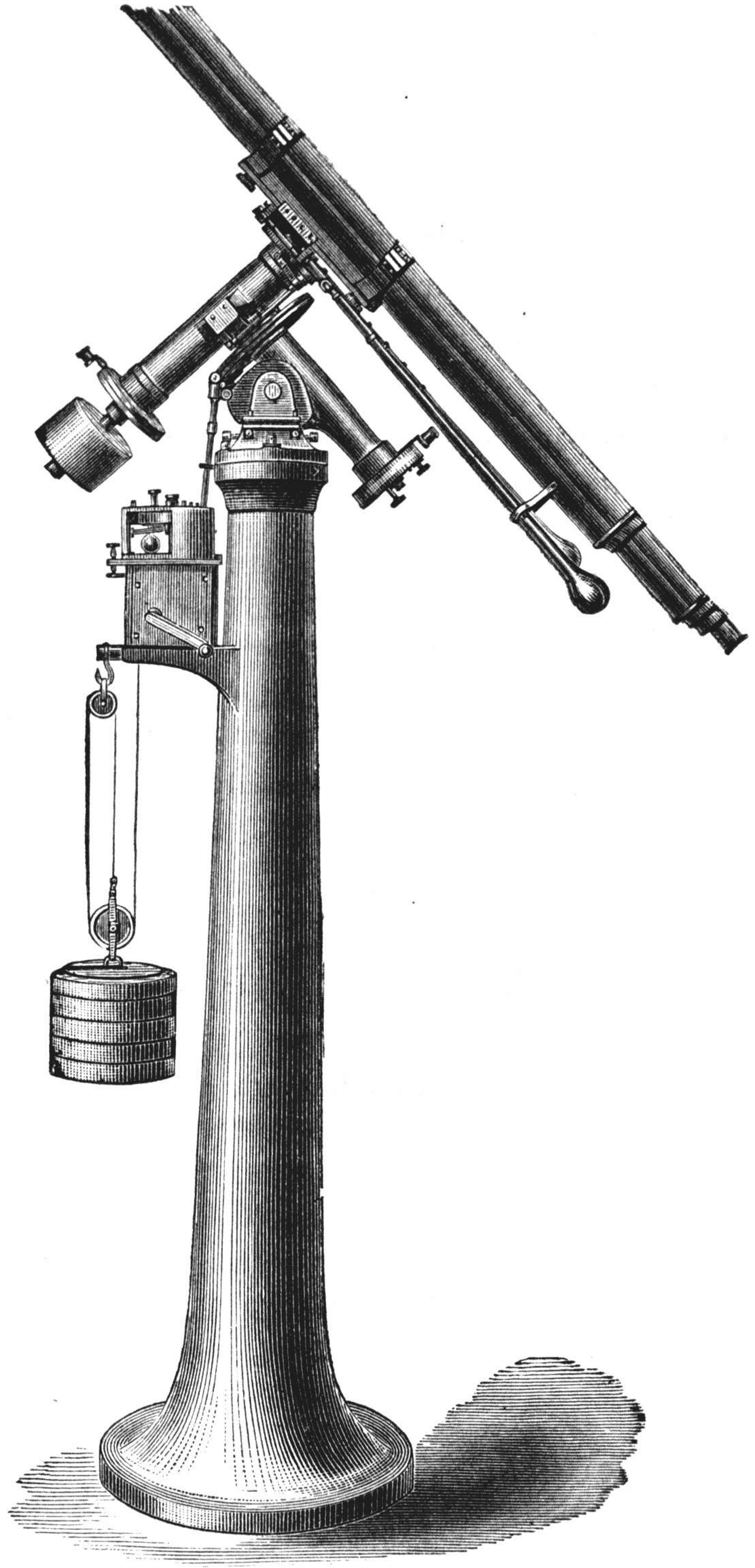
CLASS B.

Equatorial mounting, with universal adjustment for different latitudes. Declination and hour circle graduated on gun metal; reading microscope to each. Tangent screw motion in right ascension and declination; brass clasps to hold telescope; stout tripod stand.

For telescope 3 to 3¾ inches	$275 00
For telescope 4 to 4½ do.	350 00
For telescope 4¾ to 5½ do.	475 00



CLASS B.



CLASS C.

CLASS C.

Equatorial mounting, on cast-iron pillar (with clock bracket), with adjustment for different latitudes; declination and hour circles are graduated on silver, verniers and reading microscopes; tangent screw working in R. A., and declination brought down to eye end, brass clasps for holding telescope, cross-levels attached to pillar; striding level for declination axis.

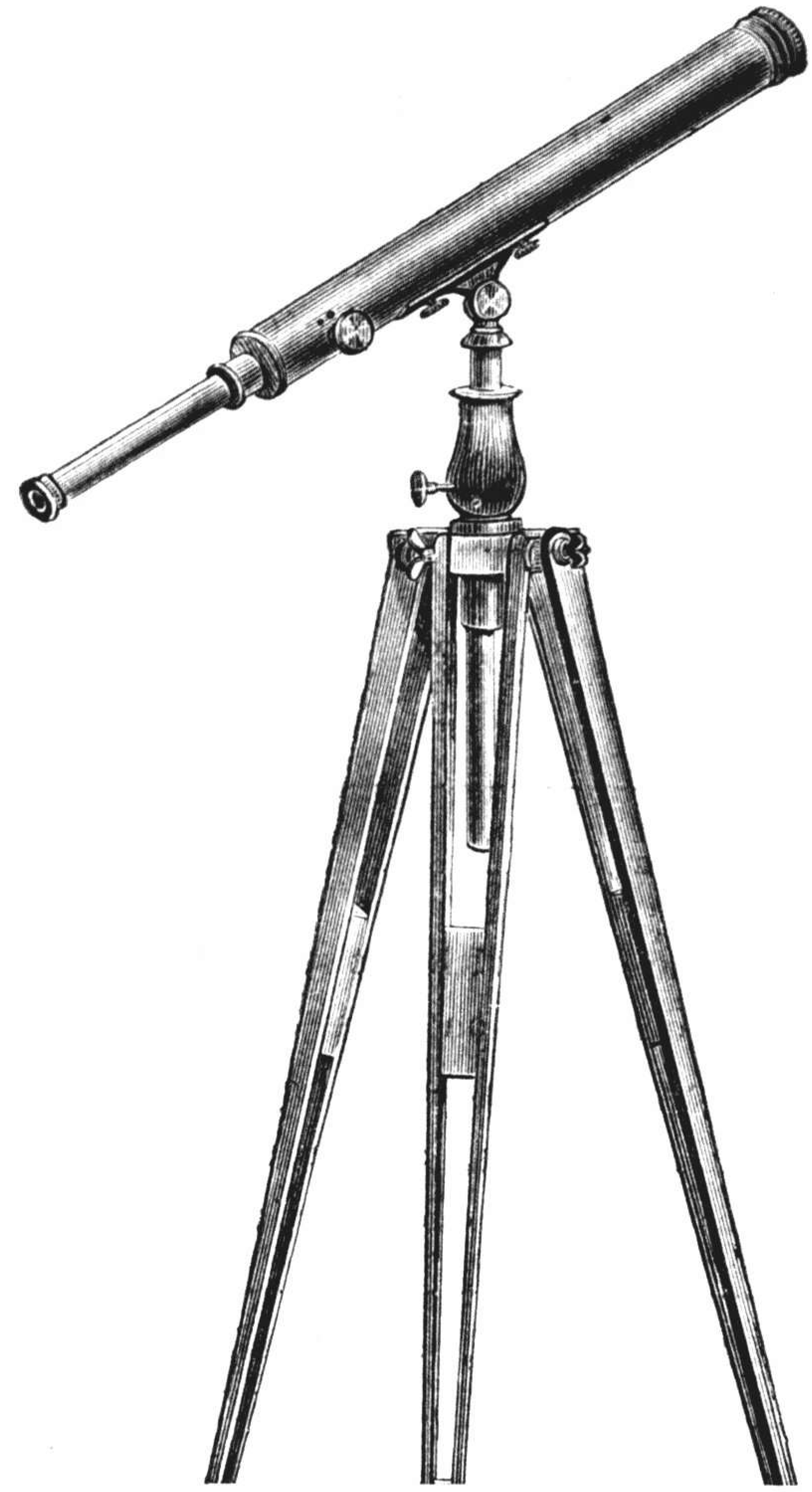
For telescope 3 to 3¾ inches aperture	....	$350 00
For telescope 4 to 4½ do.	....	425 00
For telescope 5 to 6 do.	....	550 00

Governor-driving Clock and connections to the telescope, with arrangement for additional motion by hand... 140 00

The above mountings are complete and exact in their adjustments, and are recommended especially for High and Normal Schools and also Colleges, WHO MAY *have them imported duty free.*

They are as smooth and solid in their movement as the largest instrument.

The driving clock is also furnished with an arrangement to change stellar to lunar motion.



2313.

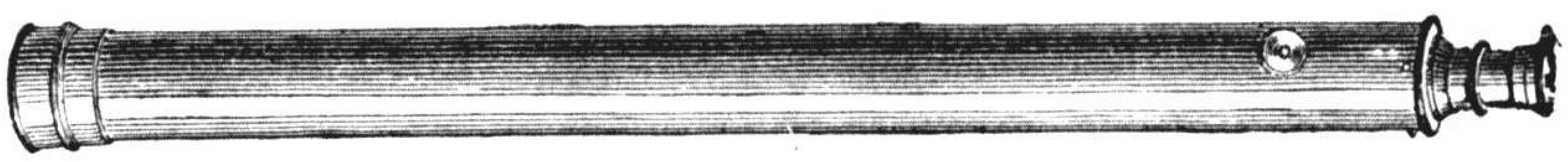
ACHROMATIC, TERRESTRIAL, AND ASTRONOMICAL TELESCOPES.

2312. **Refracting Telescope,** objective 67 mm (2½ inch) diameter; polished brass body; rack adjustment for focus, one terrestrial eye-piece (40), and one celestial (80); mounted on mahogany stand with brass joint for vertical and horizontal movement; packed in walnut box, nickel-plated mountings. $75 00

2313. **Refracting Telescope,** objective 75 mm (3 inch) diameter; polished brass body, rack adjustment for focus, one terrestrial eye-piece (50), one celestial (100); mounted and packed as above.......... 100 00

2314. **Refracting Telescope,** objective 88 mm ($3\frac{1}{2}$ inch) diameter; polished brass body, rack adjustment for focus, one terrestrial eye-piece (60), one celestial (135); mounted and packed as 2312............ $175 00

2315. **Refracting Telescope,** objective 102 mm (4 inch) diameter; polished brass body, rack adjustment for focus, one terrestrial eye-piece (70), one celestial (145); mounted and packed as 2312............ 250 00



Astronomical Telescopes, without stands, intended to be mounted equatorially on stands, described on pages 8 to 11; polished brass body, rack movement for focus, one astronomical eye-piece.

2316. **Astronomical Telescope,** achromatic objective 75 mm (3 inches diameter), one celestial eye-piece, with sun-glass.. 75 00

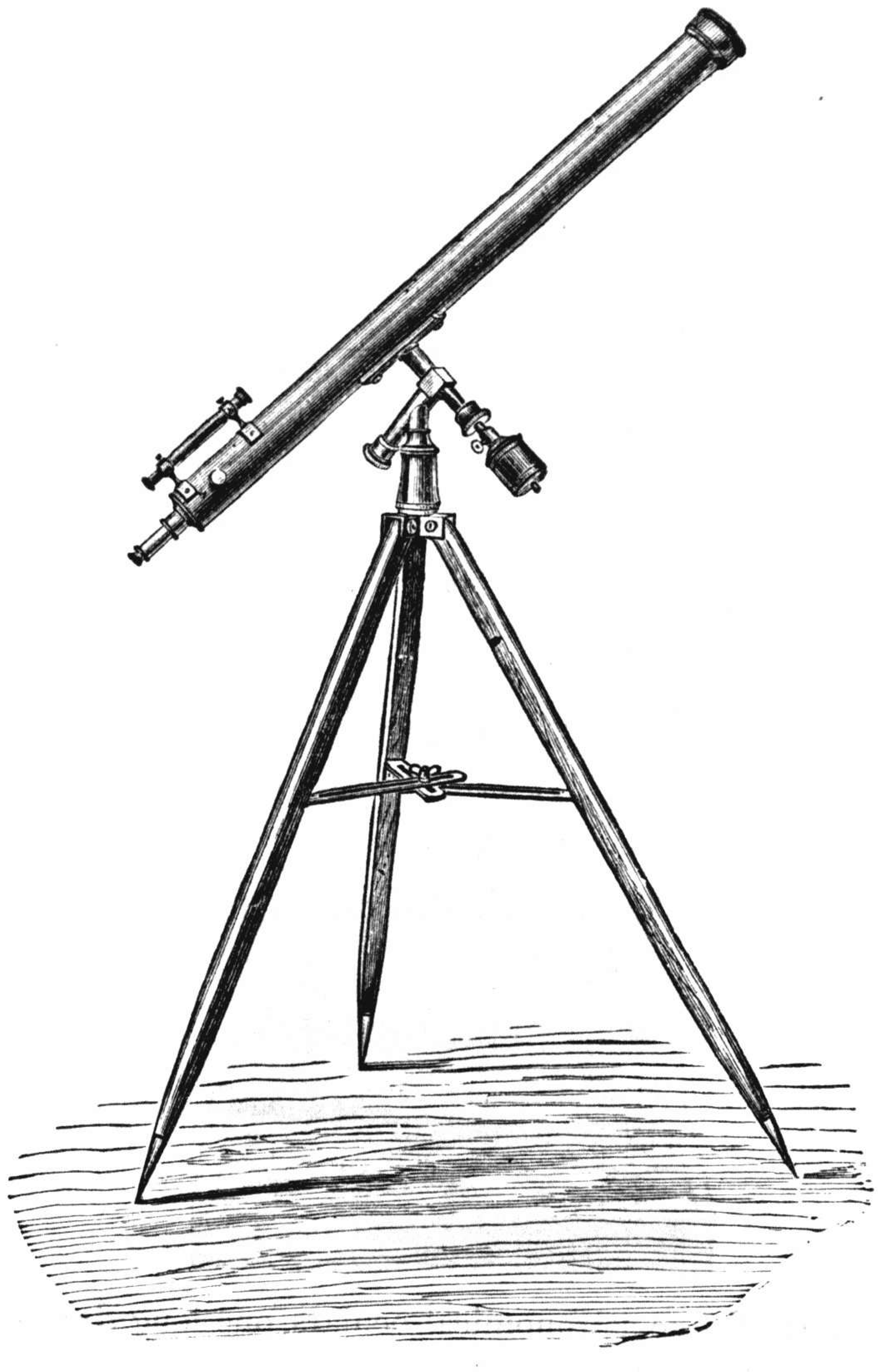
2317. **Astronomical Telescope,** achromatic objective 88 mm ($3\frac{1}{2}$-inch diameter); one celestial eye-piece with sun-glass.. 125 00

2318. **Astronomical Telescope,** achromatic objective 102 mm (4-inch diameter); one celestial eye-piece with sun-glass.. 225 00

2319. **Astronomical Telescope,** achromatic objective 115 mm ($4\frac{1}{2}$ inch diameter); one celestial eye-piece with sun-glass.. 325 00

2320. **Astronomical Telescope,** achromatic objective 128 mm (5-inch diameter); one celestial eye-piece with sun-glass.. 450 00

A **Finder** can be attached to any of the above telescopes if ordered. For price see page 18.

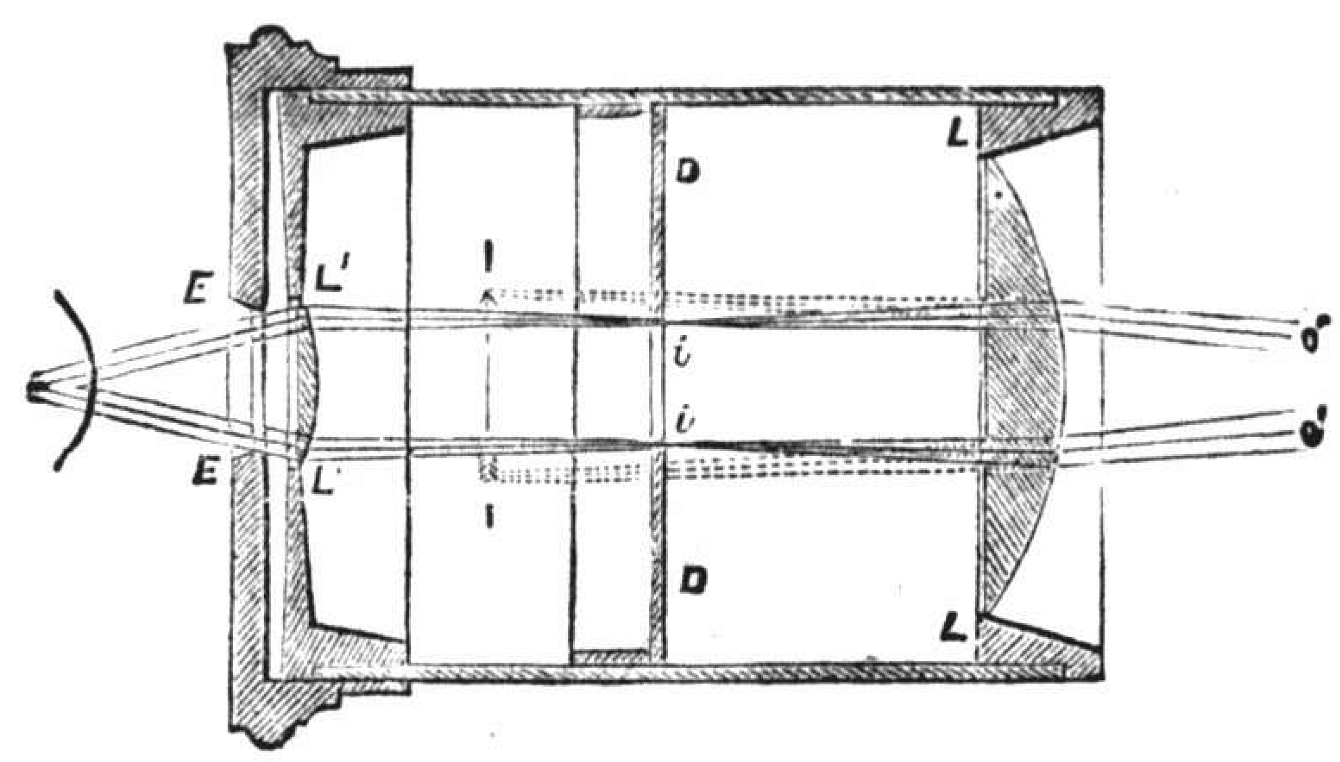


Telescope 2316, mounted on simple cast-iron equatorial and furnished with finder.

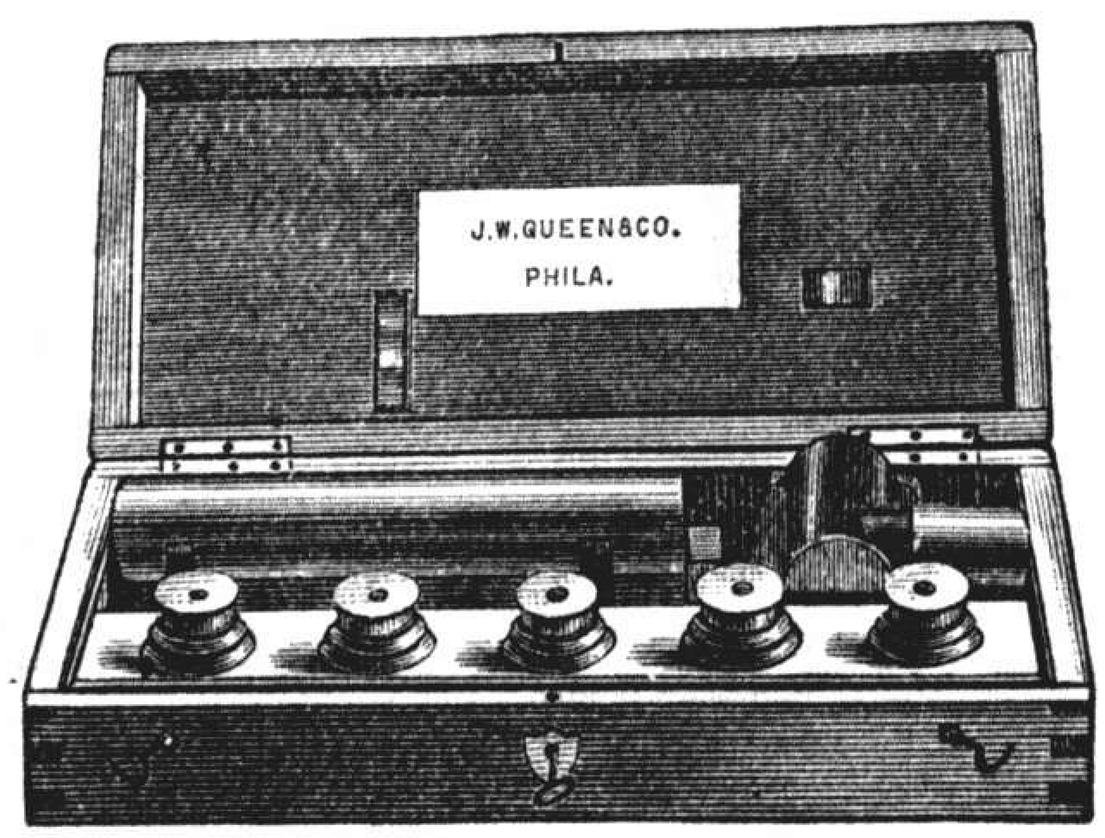
ACHROMATIC OBJECTIVES IN CELL.

2325.	Objective	68 mm,	2½ inch diameter,	$15 00
2326.	do.	72 do.	2¾ do. do.	20 00
2327.	do.	75 do.	3 do. do.	25 00
2328.	do.	88 do.	3½ do. do.	50 00
2329.	do.	102 do.	4 do. do.	90 00
2330.	do.	115 do.	4½ do. do.	125 00
2331.	do.	122 do.	4¾ do. do.	150 00
2332.	do.	128 do.	5 do. do.	200 00

ASTRONOMICAL OCULARS (Eye-pieces).



2333. Huyghens, with sun-glass, equivalent to a single lens of $1\frac{1}{2}$, $1\frac{1}{4}$, 1, $\frac{3}{4}$, $\frac{1}{2}$, $\frac{3}{8}$, $\frac{1}{4}$ inch........................ 5 50
O, A, B, C, D, E.



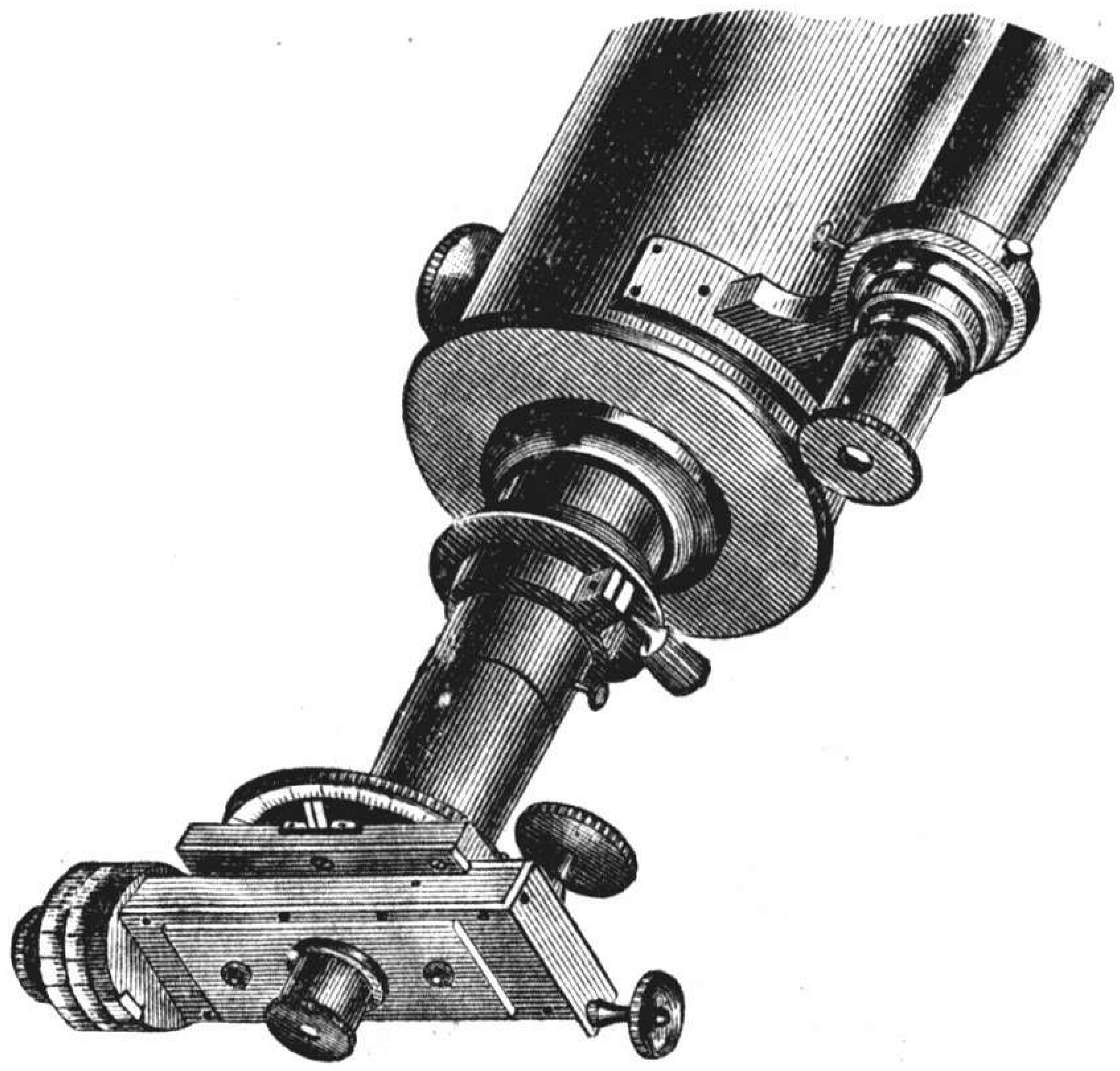
2335. **Battery** of five astronomical oculars, one long draw-tube, diagonal for zenith observations, three sun-glasses of different degrees of darkness, one moon shade and one Venus glass, complete in case....... 50 00

2340. **Barlow Lens,** to double the magnifying power of celestial oculars, mounted in cell and draw tube... 10 00

STEINHEIL'S MONOCENTRIC APLANATIC OCULARS.

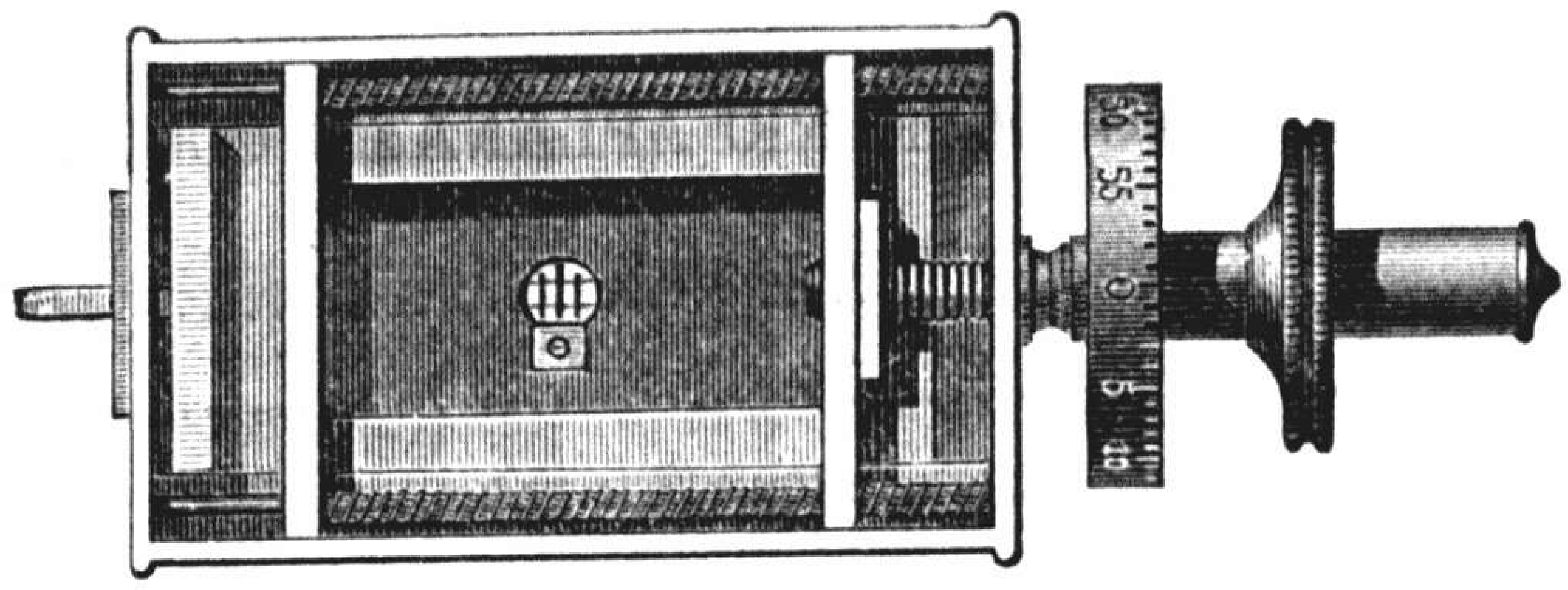
A. 1 inch	$12 75
B. ¾ do.	12 75
C. ½ do.	12 75
D. ⅓ do.	12 75
E. ¼ do.	12 75
2341. Terrestrial eye-piece	7 50
do. do. large size	9 00

MICROMETERS FOR TELESCOPES.



2342. **Queen & Co.'s Position Micrometer,** with lamp for diagonal illumination 90 00

2343. **Queen & Co.'s Position Micrometer,** with new prismatic illuminator giving bright lines on dark field 110 00

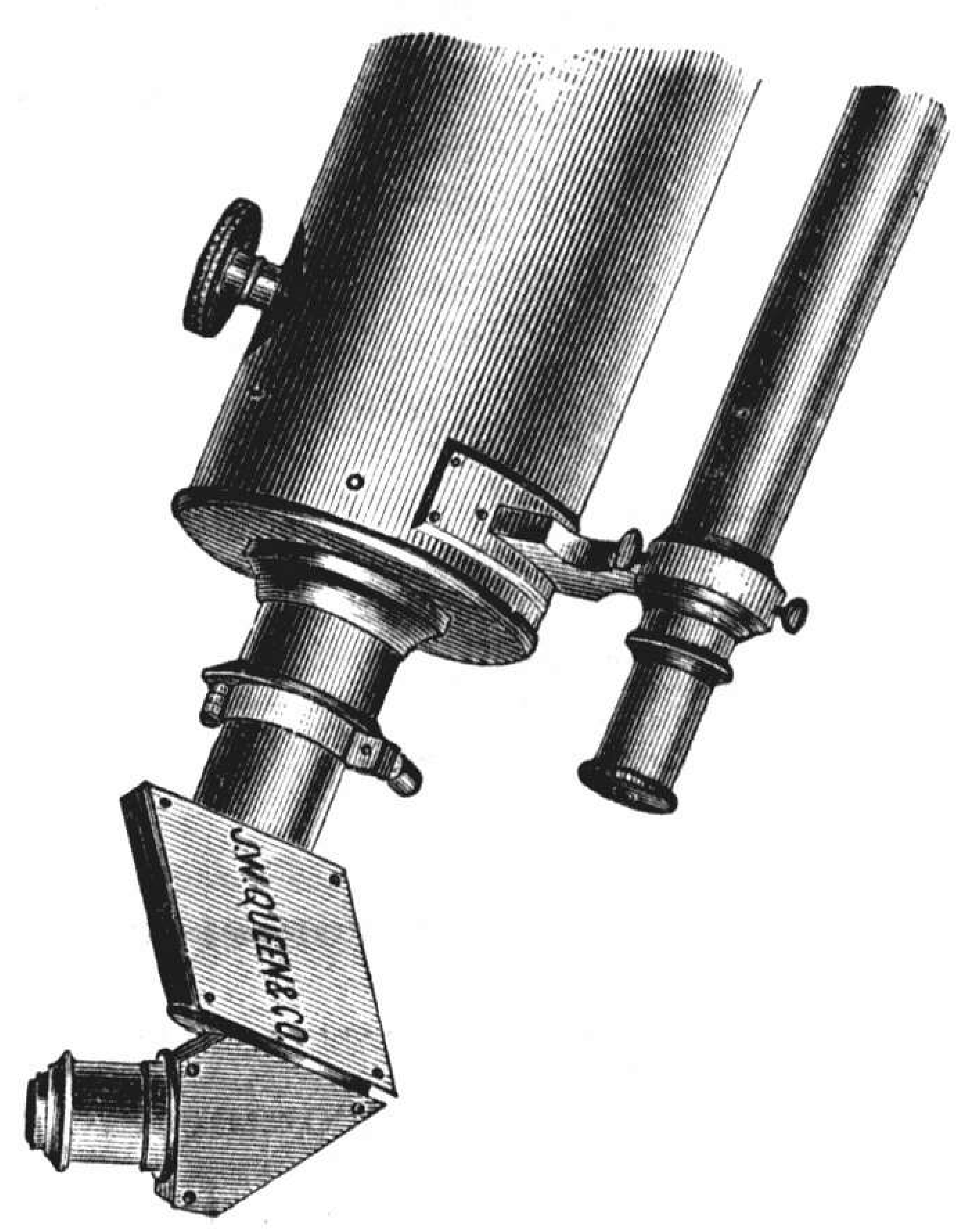


2344.	**Queen & Co.'s Filar Micrometer**		$50 00
2345.	**Ring Micrometer**		15 00

RECTANGLE PRISMS, OPTICAL GLASS, FOR DIAGONALS.

2346.	½-inch square	each,	2 50
2347.	⅝ do. do.	do.	3 50
2348.	¾ do. do.	do.	4 50
2349.	1 do. do.	do.	6 00

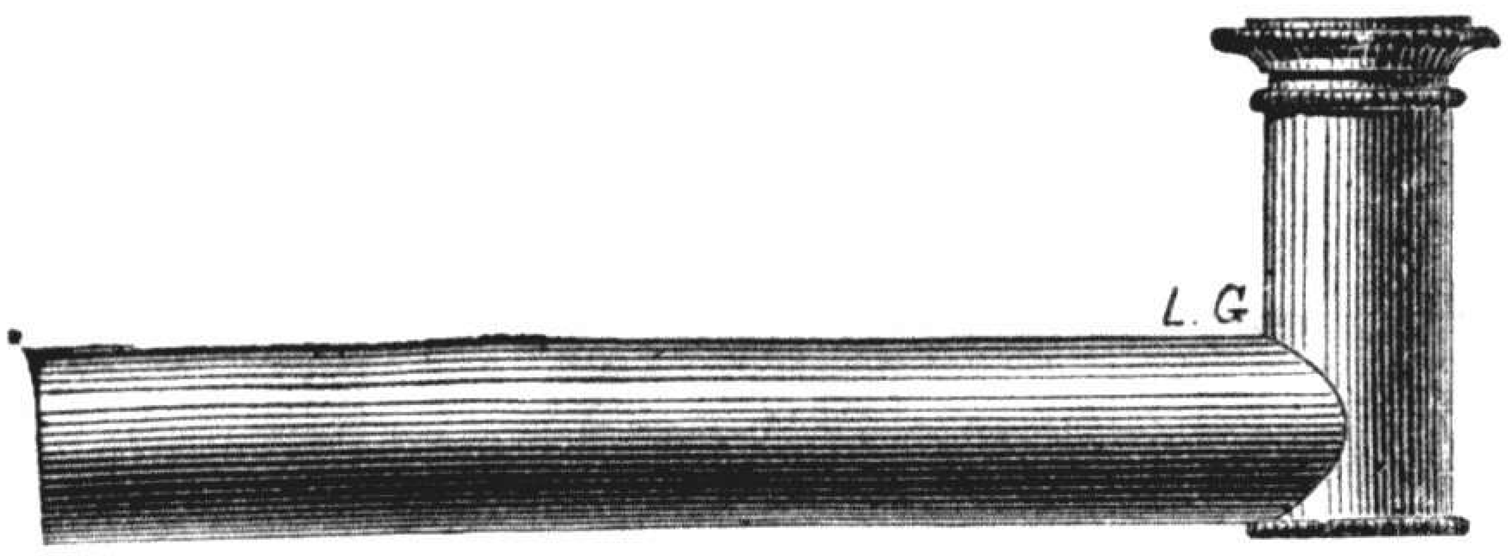
HELIOSCOPE, OR POLARIZING SOLAR EYE-PIECE.



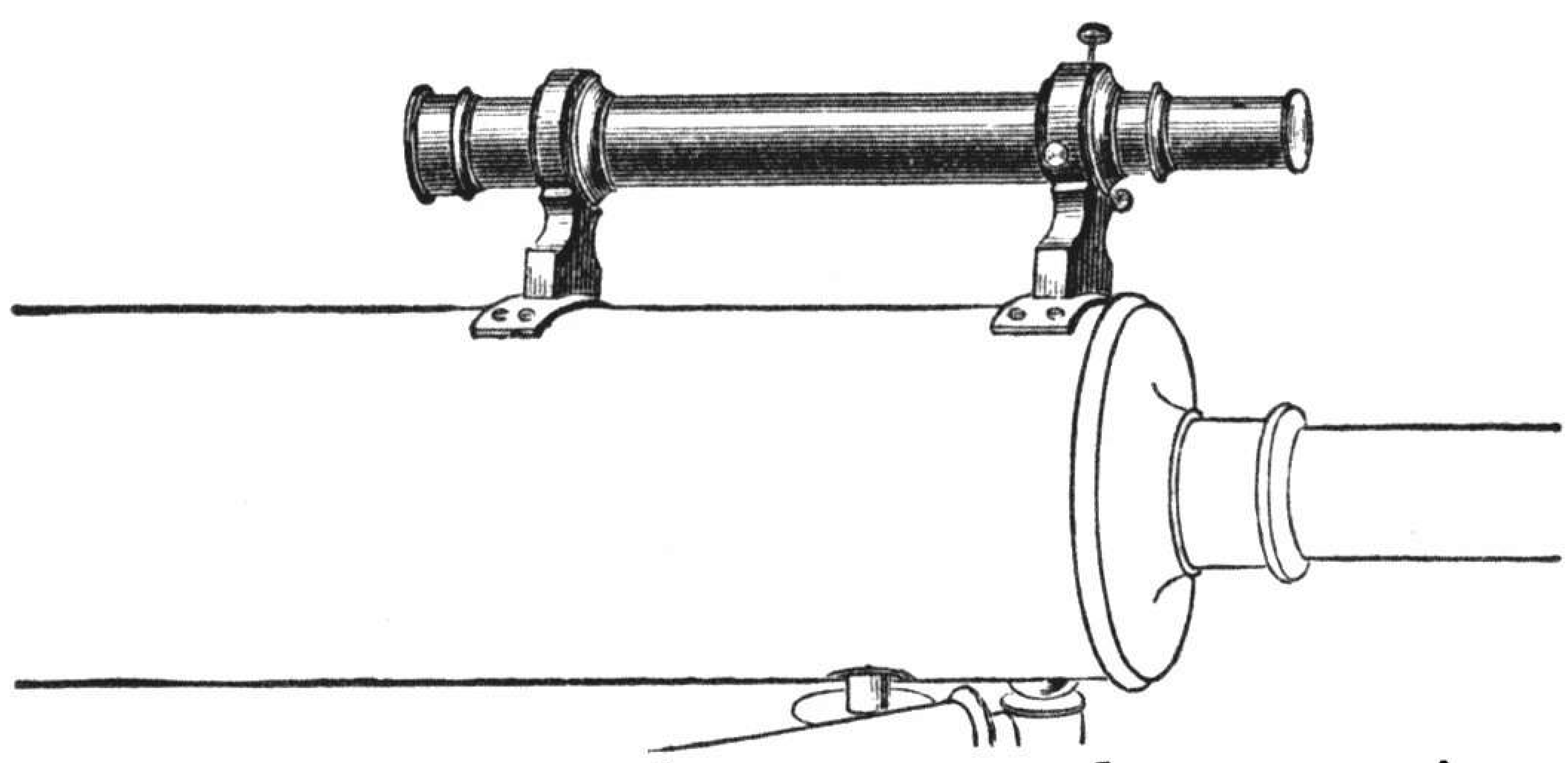
The construction of this instrument depends upon the property of light, that when reflected at a certain angle it becomes polarized; the reflecting surfaces being arranged obliquely to each other, and with a rotary motion to the surface nearer the eye (without, however, altering the angle), the sun's light is diminished or increased, without disturbing the natural tint by colored glasses.

This eye-piece is made with either two, three or four reflecting surfaces; new construction.

2350. **Helioscope,** with 2 ~~prisms~~ planes.............................$30 to $50 00
2351. do. do. 3 do. .... 45 to 65 00
2352. do. do. 4 do. .... 60 to 80 00



2353. **Total Reflection Diagonal Prism,** for zenith observation 12 00
2354. **Solar Diagonal Prism** with dispersing lens.............. 15 00
2355. **Combined Total Reflection and Solar Diagonal,** 25 00

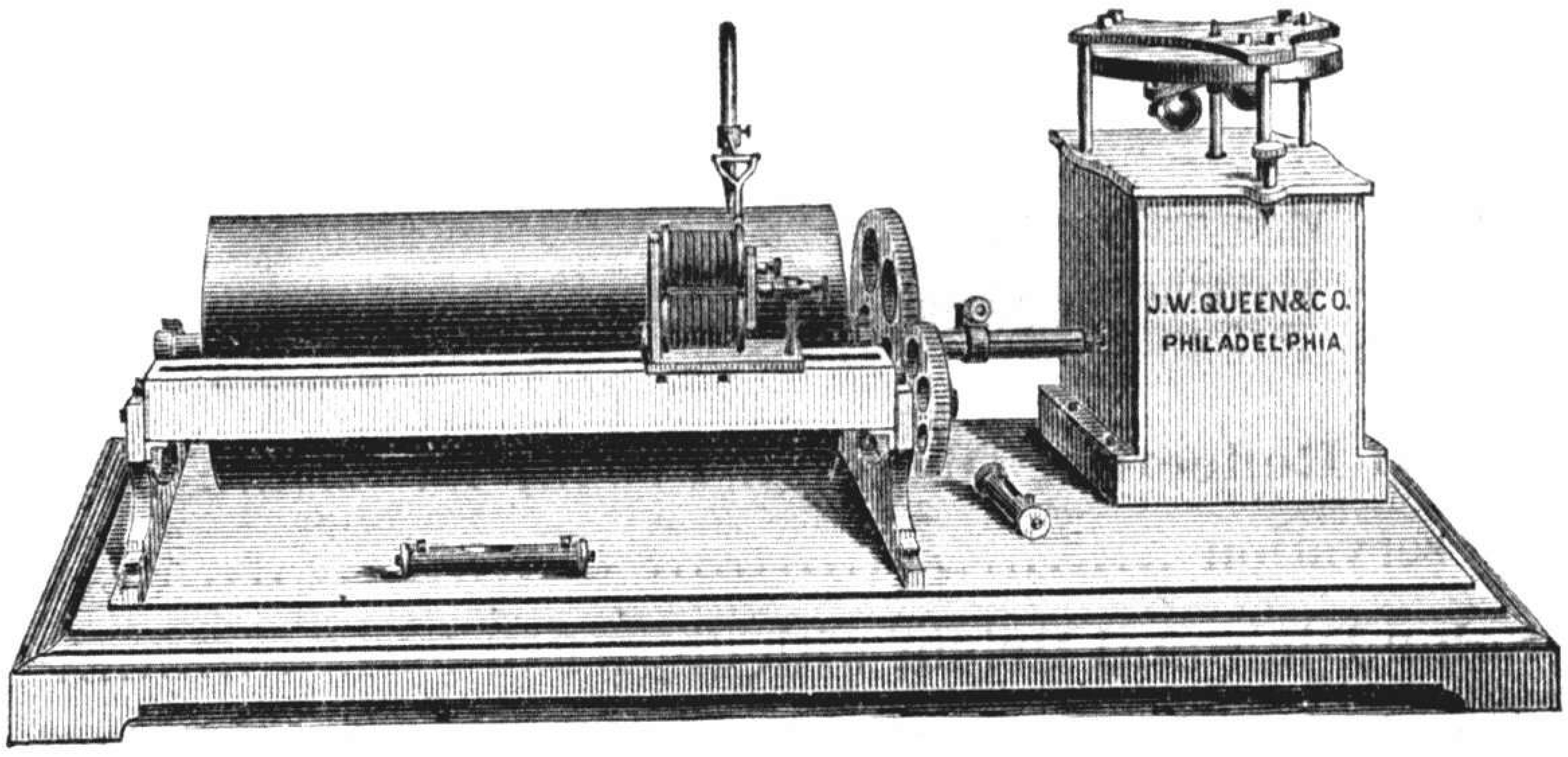


2356. **Achromatic Finder,** brass mounted, cross wires, suitable for 2313 and 2314.................................. 15 00
2357. **Achromatic Finder,** same as above, but suitable for 2315 and 2316.. 20 00

STAR SPECTROSCOPES.

2358. **Star Spectroscope,** 1 prism.............................. 72 00
2359. do. do. 2 do.. 115 00
2360. do. better construction—2 prisms, comparison prisms, micrometer, vernier, and extra eye-piece, 175 00
2361. **McLean's Star Spectroscope**............................ 25 00

CHRONOGRAPHS.



This instrument is constructed for the purpose of correct registration of time as indicated by the siderial clock.

It is composed of a cylinder on which a sheet of paper is firmly fixed and a wheel-movement to cause the cylinder to revolve once in every minute of time. There is also a magnet, carrying a pen, connected with the movement. As the cylinder revolves, lines are traced by the pen on the paper, and when connected electrically with the clock, the pen can mark every passing second on the paper, by means of contact-key, the observer can also inscribe a mark at any moment, thus affording an opportunity to record a series of observations, and when completed, read off in fraction of a second each passage of a star across the lines of the eye-piece.

Estimates furnished on application.

ASTRONOMICAL OR SIDERIAL CLOCKS.

These clocks are very carefully constructed on the latest plans, provided with the most recent escapement, and capable of being regulated for keeping accurate time; they are furnished with means for electric attachment to communicate time to either the Chronograph or other sympathetic clock.

Astronomical Clock, pallets not jeweled, pendulum compensated by zinc and iron rods, case of polished walnut or ash.. $225 00

Astronomical Clock, jeweled pallets, dead beat, pendulum compensated by steel rod and mercury column, case of polished walnut or ash, plate-glass door.. 325 00

Astronomical Clock, same as number above, but polished mahogany case, with plate-glass sides and door..... 375 00

Astronomical Clock, with Dennison's gravity escapement, absolute dead beat, pendulum compensated with steel rod and mercury columns, polished walnut case.. 250 00

Same as above, finest workmanship; in polished mahogany case, plate-glass door and sides.................... 325 00

All the above clocks are made to stand on the floor.

REFLECTING TELESCOPES:

THEIR HISTORY, CONSTRUCTION AND USE.

THE REFLECTING TELESCOPE appears to have been proposed as early as 1639, by Mersenne, but nothing was accomplished till Newton, 1669, turned his attention to make reflectors; finding it impossible to overcome the aberration of color in the object-glass, he gave up all hope that refracting telescopes were likely to be of any great use, and set about producing a suitable alloy, which he ground with his own hands, and early in 1672 completed two telescopes.* A stimulus was thus imparted to others, and the reflecting telescope received various improvements, and its history is made luminous by the discoveries of Newton and Herschel. We have to pass over a considerable period of time without noticing any further improvements in this telescope. Dollond's discovery (1758) of the achromatic combination for objectives, which was successfully worked out by many others, soon worked a change, and the refracting telescope again became a rival to the reflector; the mechanical part or mounting, as well as its optical properties, were so much improved by Fraunhofer, of Munich, in their equatorial telescopes, as to place them in the front rank.

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* Phil. Trans., 1672, vol. vii.

About the middle of the present century, however, Liebig published his discovery of precipitating bright metallic silver on glass from a solution, and now a new era dawned upon the reflecting telescope. Steinheil first availed himself of this discovery, and produced a reflecting telescope with a glass speculum, silvered on the surface;* a year later Foucault also announced his success in constructing similar instruments,† and since then the manufacture and perfection of the Reflector has constantly progressed and increased, and the many advantages of this style of telescope, as now manufactured, are justly appreciated. Among these the following may be enumerated:

The image produced by the mirror is **entirely free from color** or chromatic aberration, and a **true figure** can be worked so as to destroy all spherical aberration, so that the highest powers may be employed. Then the **mounting of a Reflector,** especially the **Newtonian form,** which is generally adopted, can be made very steady, and the observer can remain in a comfortable position even when the instrument is directed near to the zenith; with a Refractor, on the other hand, the position the observer has to assume is often a painful one. **The tube of the Reflector** being short, the observatory can also be much smaller, and in most cases the stand is so constructed that it can be left in the open air, the mirror alone being taken away. **The cost of mounting a Reflector** is also much less than that of a Refractor, whilst the mirror can be procured at a mere fraction of the cost of an achromatic objective of similar dimensions.

The history and performance of the Achromatic Refractor being familiar to all persons interested in astronomical observations, we add a few remarks in regard to **the capabilities of various sized Reflectors.**

Jupiter affords the telescopic observer one of the **grandest sights in the heavens,** a magnifying power of only 40 diameters sufficing to give it an apparent diameter equal to our moon. Very interesting views of the **belts of Jupiter** may be obtained with a 6½-inch **speculum,** and powers of from 250 to 300. The continually chang-

* Augsberg Gazette, 3, 24th, 1856.

† Comptes Rendus, February, 1857.

ing position of his four satellites, their **eclipses,** as they successively pass through the shadow of their primary, and their transits across his disc, accompanied by their shadows, are phenomena of great interest, the beauty of which is of course enhanced by increased aperture. The **8½-inch speculum** shows the **deep coppery hue** of the equatorial bands and the varied but less intense tints of other portions of his disc, as well as those minute details of his belts, the **continual changes of which** have of late rendered this planet an object of peculiar interest.

Saturn requires more telescopic power than Jupiter, not only on account of his smaller diameter and increased distance, but owing to his complicated system of rings and the number and minuteness of his satellites. **The four brightest** of his moons are readily visible in a 6½-inch speculum, and the principal division of the ring, as well as the inner dusky ring, and traces of the faint belts on the globe. The shadows of rings on the globe and the globe on the rings are sharply defined, and may be observed continually varying, owing to the continually changing relative position of the planet with regard to the sun and earth. In addition to the above details, the 8½-inch speculum shows the delicate gradations of light on the rings, and under favorable atmospheric conditions, the fine division of the outer ring. In a 12¼-inch speculum this planet presents a spectacle of singular beauty.

The sharply defined globe with its numerous belts symmetrically placed within the gracefully-encircling system of rings, the varied tints of which are strikingly visible with this large aperture, as well as his numerous and ever-changing attendant moons, form a picture which when once seen is never forgotten.

The 8½-inch speculum will show six satellites, and in addition to all the foregoing details, the gradations of light on the rings, and under the most favorable circumstances, the division in the outer ring.

The snow caps on Mars, as well as some **of the seas** which intersect his ruddy globe, can be seen with a 6½-inch silvered glass reflector, but the $8\frac{1}{2}$-inch aperture is about the smallest size with which a successful view of this planet can ordinarily be obtained, since owing to his small apparent diameter, which, in the most favorable situations, does not amount to half that of Jupiter, a comparatively high power is required to enable his markings to be made out distinctly.

No spectacle can well be more fascinating than the sight of this miniature of our globe suspended in space, revolving slowly on its axis, and bringing continents and seas in slow succession under the gaze of **an observer.**

It is not pretended that the details just mentioned will be seen easily at any time by an untrained observer; but practiced observers under favorable circumstances, will certainly be able to do more than is here stated.

To bring out the full powers of these or any other telescopes, the objects must be **favorably situated,** the **air must be fine**—that is, clear and steady—and, beyond this, the observer must have had some practice in seeing minute details with low powers.

It seems **but little understood that the eye is capable of being trained no less than the hand.**

It may be well to give the power of reflecting telescopes as compared with refracting. From a comparison of the results of several observers, it may be stated that in light-grasping powers they are equal to an achromatic **one-sixth less** in diameter, while as regards their **dividing power,** or their power of separating double stars, they are **superior to the finest achromatics** of the same aperture.

The $4\frac{1}{2}$-inch, with powers from 100 to 150, will divide:

Lyræ.	32 Orionis.
α Geminorum.	ε Hydræ.
ξ Ursæ Majoris.	ο Draconis.
ε Bootis.	39 Draconis.
γ Ceti.	ε Draconis.

And as a test of light-grasping qualities, the companion of α Lyræ, α Tauri and Rigel. The attendants of the first two stars are of the 11th magnitude and the last of the 9th.

The 6½-inch will divide, with powers from 200 to 300:

Arietis.	α Herculis.
ε Bootis.	32 Orionis.
ι Equulei.	η Coronæ Borealis.
36 Andromedæ.	

And clearly show the delicate pair between ε^4 and ε^5 Lyræ, also the companion of α Serpentis, rated by Smyth as of the 15th magnitude.

The 8½-inch, with powers from 300 to 350, in a favorable state of the air, will divide:

γ^2 Andromedæ.
μ^2 Bootis.

With a mirror of this size and a power of 250, the close double, following Procyon is clearly separated by a distinct, dark interval, and a somewhat higher power easily splits the difficult double near Castor on any night of ordinary clearness.

HINTS ON OBSERVATION.

Always select the time and circumstances most suitable to the particular observation to be made.

A dark night, on which the stars appear of great brilliancy, is generally most suitable for the examination of faint objects.

The character of the definition depending on atmospheric influences can generally be ascertained by putting a star's image out of focus and noticing if the enlarged disc appears covered with undulating waves or perfectly quiet; the latter state is, of course, the better. This experiment should not be tried until the telescope has been for a few minutes exposed to the air.

The most important element in obtaining the finest definition is **correct focusing.** Before observing nebulæ, clusters, or difficult double stars, sharply focus on a moderately-bright *single* star.

Endeavor to cultivate **the use of both eyes**; it frequently happens that the habit of using only one eye prevents the employment of that most sensitive to light or planetary details.

Never overpress magnifying power. A skilled observer will see far more with a moderately-low power than a tyro with the deepest ocular ever made. Very faint objects can often be seen when looking at another part of the field, or as it is technically called, "oblique vision." If the eye be kept a few minutes in the dark before observing faint objects, it will be more sensitive to them.

Nearly all the best drawings of planets have been made with powers of from 200 to 300.

Several instruments for ascertaining star magnitudes have been invented, but nothing is better than an adjustable aperture.

The color of a star can often be best estimated as an out-of-focus disc, especially with reflectors. Never judge the color of a star near the horizon.

When viewing the Moon with powerful telescopes, employ a light-blue or neutral-tinted glass to diminish the amount of light, which from a large aperture is perfectly unbearable, especially to observers whose eyes are weak.

Never attempt to view the sun without a special ocular. A neglect of this simple precaution may, in an instant, cause the observer the loss of his sight.

Observations of Mercury and Venus are most satisfactory if made during the day: for this purpose an equatorial is almost indispensable, though both planets may be sometimes picked up without that assistance if their ascension and declination are compared with other objects visible in the daylight.

Of the satellites of Saturn a telescope of 3 inches aperture should show Titan; one of 3½ inches Titan and Japetus; 4 inches, both these and Rhea and Dione; 6 inches, all the former, Tethys and perhaps Enceladus; the fainter satellites cannot possibly be seen with a less aperture than 10 inches, and that with exceptionally favorable definition.

Stops can be cut out of card-board, or thin zinc or tin, and should always be blacked with some lamp-black and gold size.

Stops should be supported a few inches in front of the tube of a reflector, in order that the air may have free egress between the end of the tube and the stop, and not pass through the stop.

Stops are seldom required with telescopes of less than 4 inches aperture, unless the edge of the object-glass, or mirror, is imperfect.

Mirrors should perform up to the extreme edge, and only require stops from defective atmospheric conditions. With large telescopes a series of stops of various sizes are most useful.

The first stop should be just enough to cover the extreme margin and then a series, diminishing by inches of diameter. Thus, for a 12-inch mirror, or object-glass, they should be of the following sizes: $11\frac{1}{2}$, 11, 10, 9, 8, 7, 6, 5 and 4 inches. The latter will probably never be wanted, except for comparison or viewing the sun. Never employ a smaller stop than is absolutely necessary.

The diameter of the field of each ocular should be ascertained. To do this, notice the time a star, whose declination is almost nil, takes in passing across the centre of the field. This time multiplied by 15 will give the diameter of the field in arc.

To preserve the silver film of a glass mirror never bring it uncovered from a cold to a warmer place, as a deposition of moisture is sure to take place, which will sometimes do more damage than a shower of rain. If an accidental deposition takes place, do not attempt to wipe the moisture off, but place the mirror at some distance in front of a fire until it has been driven off.

At sunrise there is often a rapid rise in temperature after a cold night, and, therefore, there is a chance of moisture being deposited on the speculum of a telescope left in a closed observatory. The chance of this taking place is much lessened by the ventilated tubes now employed, and it may be still further obviated by placing a small lamp, with its flame distributed, with a piece of wire gauze, at some distance under the speculum during a cold night.

sufficient to gently warm the mirror and the air above it a few degrees.

Do not polish the silver film more than is absolutely necessary or too often. A few spots will only occasion a small loss of light, and will not materially affect definition.

The best light for an observatory is an ordinary dark bull's-eye lantern, burning head-light oil.

The best material to clean lacquered brass work is a piece of chamois leather and a little sweet oil.

Always make notes of each observation, showing the power used, the character of the definition, etc.

PRICE AND DESCRIPTION OF REFLECTORS.

SILVER-ON-GLASS REFLECTING TELESCOPES.

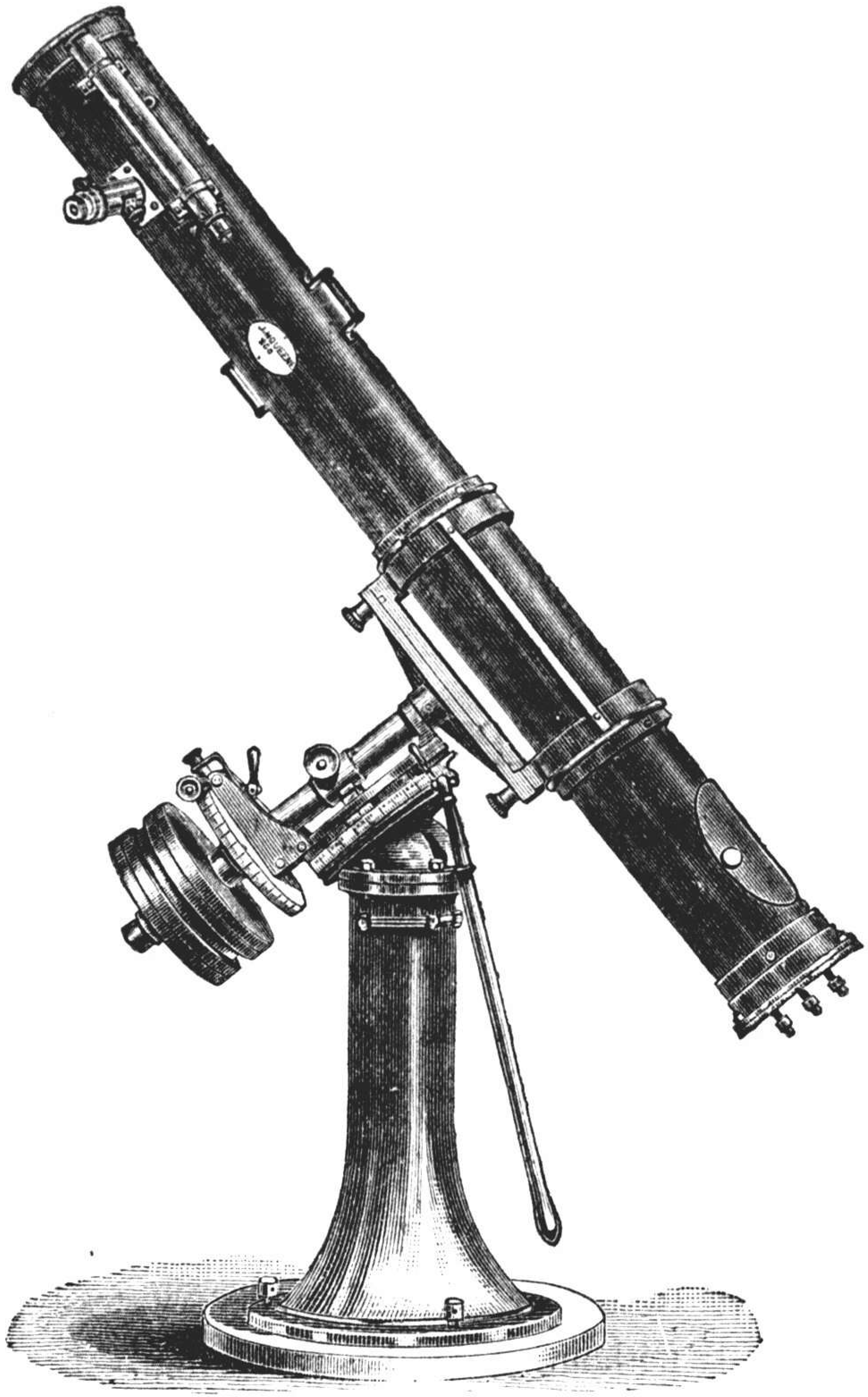
For importation free of duty, see note on 2d page cover.

These Instruments are imported to order and *guaranteed in every respect.*

The mirrors (specula) are made by Calver, of Widford, England, whose reputation as a manufacturer of these instruments is unrivaled, and is attested by hundreds of testimonials which will be furnished on application.

The Educational Reflector is a plain and very steady instrument, mounted equatorially without circles, has revolving body and a finder, screw motion in R. A.

No.		Price.
2367.	6½-inch speculum, 6-feet focus, 2 oculars; power 100 to 200	$250 00
2368.	8½-inch speculum, 6-feet focus, 3 oculars; power 100, 200 and 300	375 00
2369.	**Equatorial Reflector,** speculum 6½ inches, finder, 10-inch rotating hour-circle, reading to 5 sec. time, and declination circle to 1″ arc, 3 oculars; power 100 to 300. Fig. 2369	375 00



2369.

2370. **Equatorial Reflector,** speculum $8\frac{1}{2}$ inches, 10-inch circle, 4 powers.......... $600 00

Larger sizes; estimates on application.

2371. **Driving Clock,** for above.......... 225 00

SILVERED-GLASS SPECULA (Unmounted.)

2373.	$6\frac{1}{2}$-inch	diameter,	focus,	6	feet..........	50 00
2374.	$8\frac{1}{2}$ do.	do.	do.	6	do.	110 00
2375.	10 do.	do.	do.	7	do.	225 00
2376.	$12\frac{1}{2}$ do.	do.	do.	8	do.	325 00

The above are of the finest quality, guaranteed.

A LIST OF NOTED CLUSTERS AND NEBULÆ.*

I. Clusters seen by the naked eye.

Pleiades in Taurus.
Hyades " "
Praesepe " Cancer.
Coma Berenices.
Clusters in Sword-handle of Perseus.

II. Clusters resolvable by Telescopes.

Cluster in Cassiopeia—visible by 2-inch Telescope.
" " Auriga.
" " Gemini.
" " Canes Venatici—1,000 small stars.
" " Libra—very compressed.
" " Scorpio—like a comet.
" " Hercules—barely visible to naked eye.
" " Sagittarius—bright cluster.
" " Antinous—fan-shaped.
" " Pegasus—bright cluster.

III. Nebulæ.

Nebula in Andromeda.
" " Orion.
" " Ursa major—planetary nebula.
" " Virgo—many " "
" " Canes ven.—spiral "
" " Sagittarius—trifid "
" " Scutum Sobieski—horse-shoe nebula.
" " Lyra—ring nebula.
" " Vulpecula—dumb-bell nebula.

SATELLITES OF MARS.

1. Deimos..	very close.
2. Phobos..	about 3 diameters distant.

* *From Profs. Sharpless and Philips' Astronomy. By Permission.*

THE SATELLITES OF JUPITER.

Name.	Mean Distance—Miles.	Sidereal Period.			Appar. Star Magnitude.	Duration of Eclipse.	
		D.	H.	M.		H.	M.
1 Io	267,300	1	18	28	7	2	20
2 Europa	425,100	3	13	14	7	2	56
3 Ganymede	678,300	7	3	43	6	3	43
4 Callisto	1,192,800	16	16	32	7	4	56

THE SATELLITES OF SATURN.

Name.	Mean Distance—Miles.	Sidereal Period.			Appar. Star Magnitude.
		D.	H.	M.	
1 Mimas	120,800	0	22	37	17
2 Enceladus	155,000	1	8	53	15
3 Tethys	191,900	1	21	18	13
4 Dione	245,800	2	17	41	12
5 Rhea	343,400	4	12	25	10
6 Titan	796,100	15	22	41	8
7 Hyperion	963,300	21	7	7	17
8 Japetus	2,313,800	79	7	53	9

SATELLITES OF URANUS.

Name.	Mean Distance—Miles.	Sidereal Period.		
		D.	H.	M.
1 Ariel	122,800	2	12	28
2 Umbriel	171,200	4	3	27
3 Titania	280,800	8	16	55
4 Oberon	375,600	13	11	6

SATELLITE OF NEPTUNE.

	Mean Distance—Miles.	Sidereal Period.			Appar. Star Magnitude.
		D.	H.	M.	
1	220,000	5	21	8	14

A few interesting objects follow here:

COLORED DOUBLE STARS.

NAME.	R. A. 1870.			Decl. 1870.		Mag. of Components.		Color of A.	Color of B.
	H.	M.	S.	°	′				
η Cassiopeiæ	0	41	15	+57	7 8	4	7½	Yellow.	Purple.
α Piscium	1	55	18	+ 2	8.1	5	6	Pale green.	Blue.
γ Andromedæ	1	55	55	+41	42.4	3½	5½	Orange.	Sea green.
ι Cancri	8	38	49	+29	14.0	5½	8	Orange.	Blue.
ε Boötis	14	39	18	+27	37.4	3	7	Pale orange.	Sea green.
ζ Coronæ	15	34	29	+37	3.6	5	6	White.	Light purple.
α Herculis	17	8	43	+14	32 2	3½	5½	Orange.	Emerald green.
β Cygni	19	25	28	+27	41.3	3	7	Yellow.	Sapphire blue.
σ Cassiopeiæ	23	52	26	+55	1.8	6	8	Greenish.	Bright Blue.

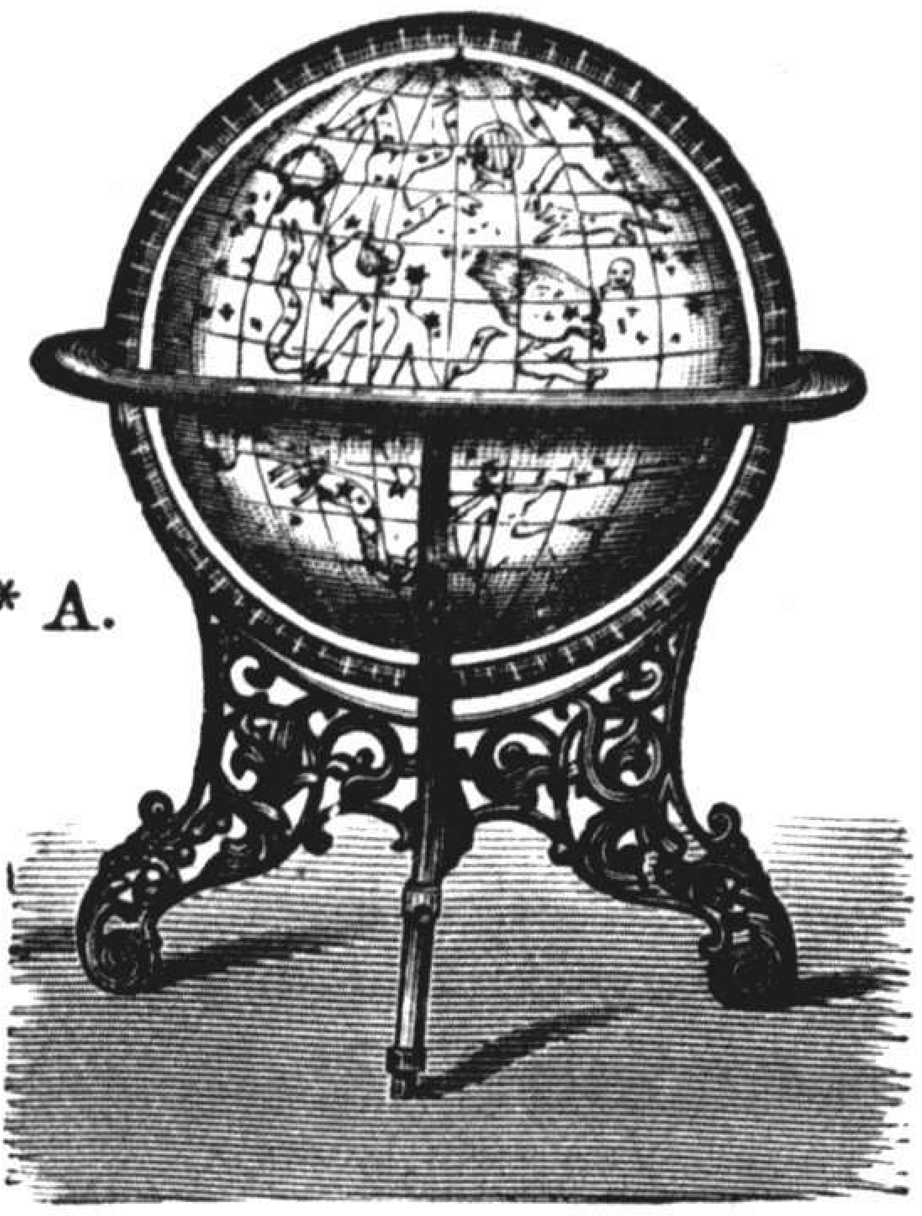
MISCELLANEOUS OBJECTS.

NAME.	R. A. 1870.			Decl. 1870.		Mag.	NOTES.
	H.	M.	S.	°	′		
* in Auriga	4	43	22	+28	18.2	8	Red star.
R. Leporis	4	53	41	—15	1.0	var.	Max. mag., 6; min., 9. An intense crimson.
* in Gemini	6	18	0	+14	47.5	7	Reddish yellow star.
R. Leonis	9	40	34	+12	1.8	var.	Max. mag., 5; min., 10. A ruby star.
β Libræ	15	10	0	— 8	54 2	2½	Beautiful pale green star.
α Scorpii	16	21	25	—26	8.5	1	Fiery red star.
* in Cygnus	21	38	58	+37	16.1	8½	Extremely intense ruby star.
μ Cephei	21	39	31	+58	11.1	var.	Max. mag., 4; min., 6; period, 5 or 6 years. Very fine deep garnet.

A LIST OF ALL THE STARS OF THE FIRST THREE MAGNITUDES WHOSE NAMES ARE IN COMMON USE.—(Proctor.)

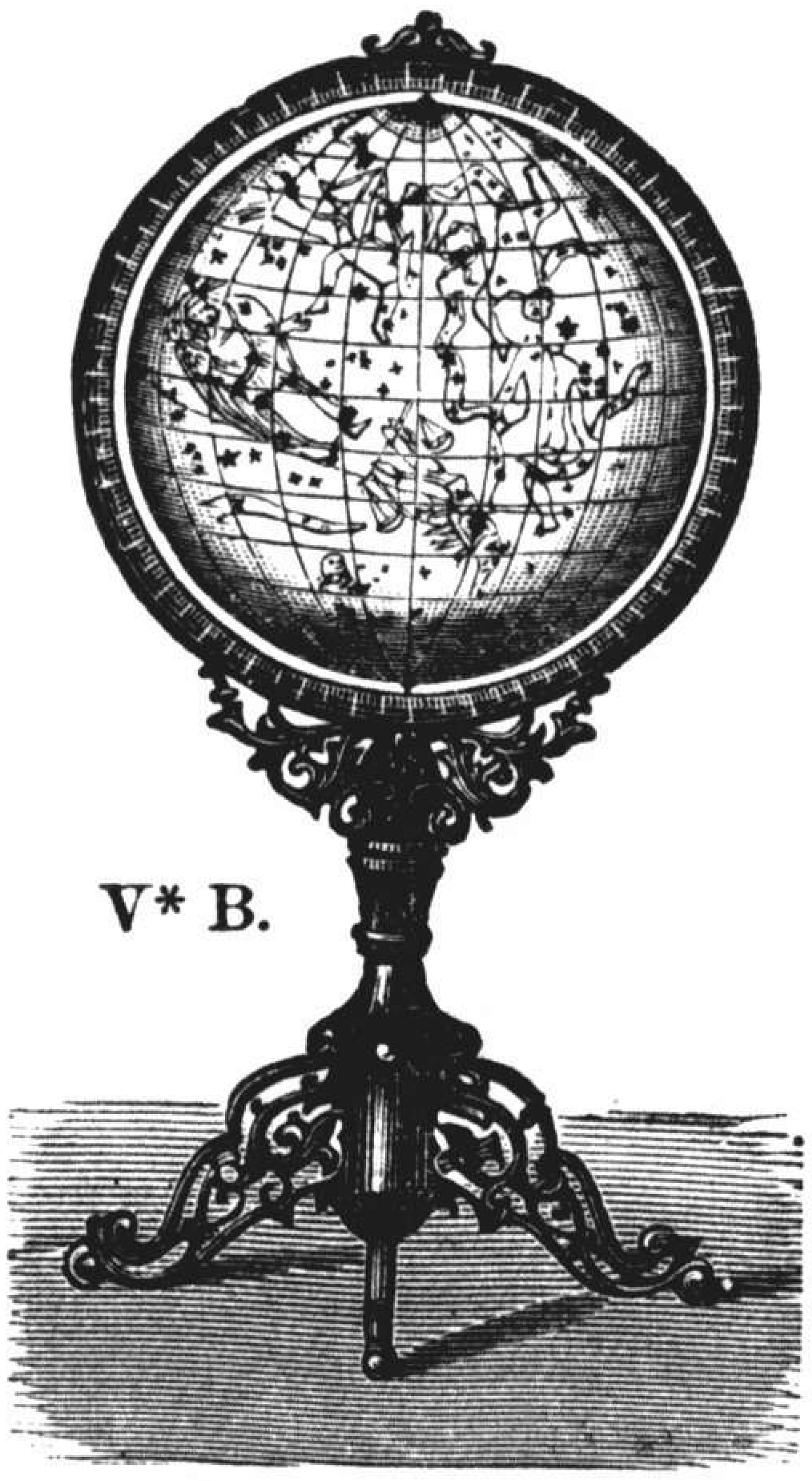
α Andromedæ, Alpheratz.
β " Mirach Mijar.
γ " Almach.
α Aquarii, Sadalmelik.
β " Sadalsmed.
δ " Skad.
α Aquillæ, Altair.
β " Alshain.
γ " Tarazed.
α Arietis, Hamal.
β " Sheratan.
γ " Mesartim.
α Aurigæ, Capella.
β " Menkalinan.
α Bootes, Arcturus.
β " Nekkar.
ε " Izar.
η " Muphrid, or Mirac.
α Canum Ven, Cor. Caroli.
α Canis Maj., Sirius.
β " Mirzam.
ε " Adara.
α Canis Min., Procyon.
β " Gemeisa.
α^2 Capricorni, Secunda Giedi.
δ " Deneb Algiedi.
α Cassiopeia, Schedar.
β " Chaph.
α Cephei, Alderamin.
β " Alphirk.
γ " Errai.
α Ceti, Menkar.
β " Diphda.
ζ Ceti, Baten Kaidos.
ο " Mira.
α Columbæ, Phact.
α Cor. Borealis, Alphecca.
α Corvi, Alchiba.
δ " Algores, Algorab.
α Crateris, Alkes.
α Cygni, Deneb Adige-Arided.
β " Albiero.
α Draconis, Thuban.
β " Alwaid.
γ " Etanin.
β Eridani, Cursa.
γ " Zawrac.
α Geminorum, Castor.
β " Pollux.
γ " Alhena.
α Crucis, Australis-Acrux.
δ Geminorum, Wesat.
ε " Mebsuta.
α Herculis, Ras Algethi.
β " Korneforos.
α Hydræ, Al Fard-Cor. Hydræ.
α Leonis, Regulus.
β " Denebola.
γ " Algeiba.
δ " Zosma.
α Leporis, Arneb.
α Libræ, Zuben el Genubi.
β " " el Chamali.
γ " " Hakiabi.
α Lyræ, Vega.
β " Sheliak.
γ " Salaplat.
α Serpentarius Ras Alhague.
β " Cebalrai, or Chedd.
α Orionis, Betelgeux.
β " Rigel.
γ " Bellatrix.
δ " Mintaka.
ε " Alnilam.
α Pegasi, Markab.
β " Scheab.
γ " Algenib.
ε " Enif.
ζ " Homan.
α Persei, Mirfak.
β " Algol.
α Pis. Austr, Fomalhaut.
ε Sagittarii, Kans Australii.
α Scorpionis, Antares.
α Serpentis, Unukalhi.
α Tauri, Aldebaran.
β " Nath.
η " Alcyone.
α Ursæ Major, Dubhe.
β " Merak.
γ " Phecda.
ε " Alioth.
ζ " Mijar.
η " Alkaid.
ι " Talitha.
α Ursæ Minor, Polaris.
β " Kochab.
α Virginis, Spica.
β " Zavijava.
ε " Vindemiatrix.

CELESTIAL GLOBES.

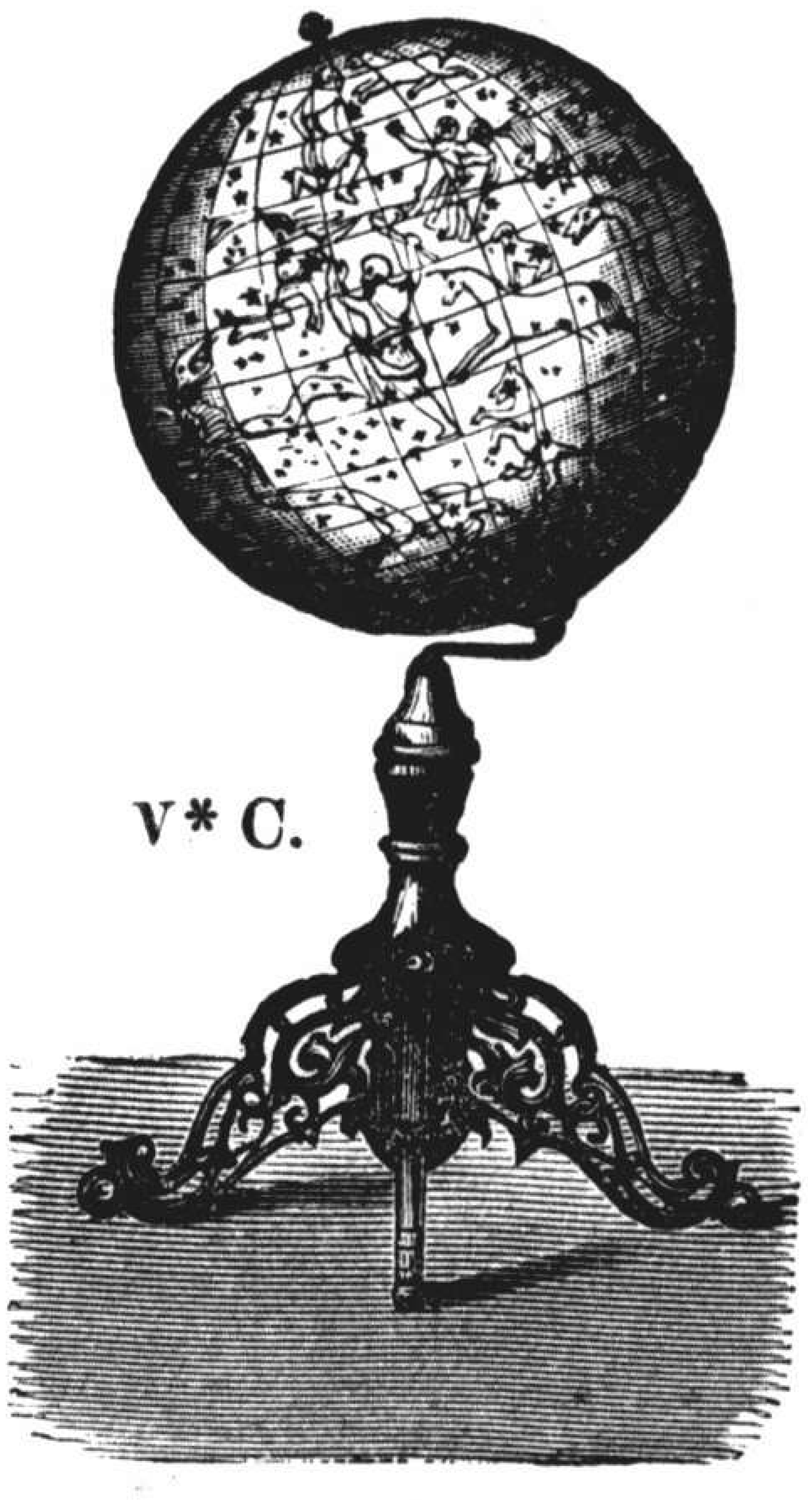


V* A.

V*A. **The Cabinet Celestial Globe,** (12 inches) complete, bronzed stand $22 00

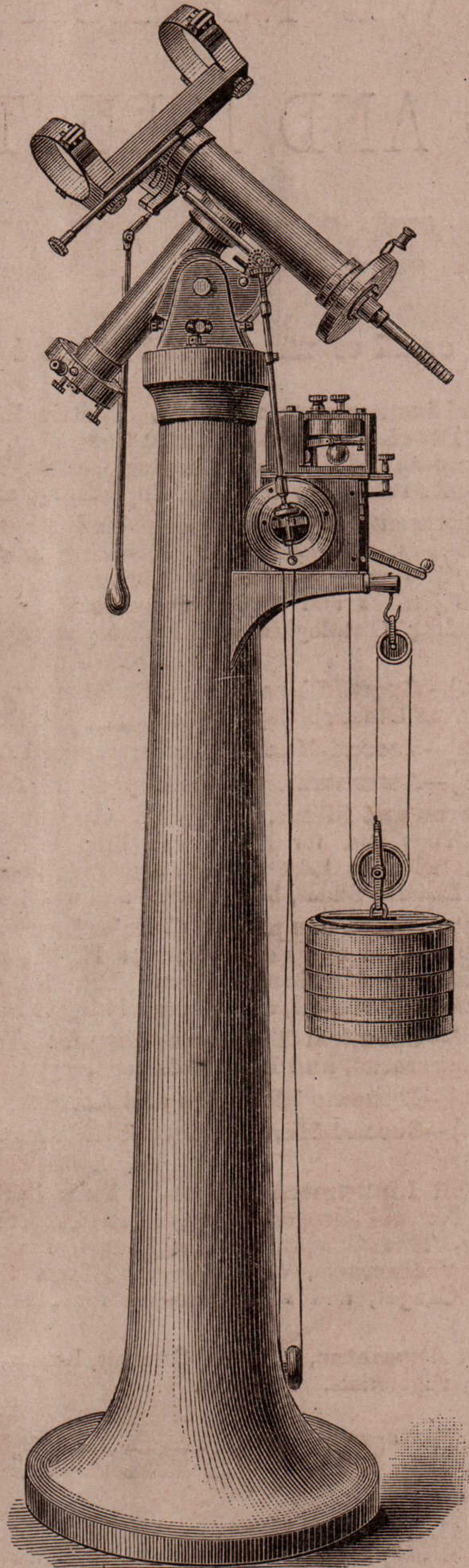


V* B.



V* C.

V*B.	**The Cabinet Celestial Globe,** (12 inches) full merid., bronzed stand				16 00
V*C.	**The Cabinet Celestial Globe,** (12 inches) plain, bronzed stand				14 00
V*AR.	**The Celestial School Globe,** complete				18 00
V*S.	do.	do.	do.	full merid.	15 00
V*T.	do.	do.	do.	plain	12 00



Equatorial Mounting, with Iron Pillar, Clock, slow motion in R. A., controlled by Differential Wheels attached to Clock.