Invasion of the Astronomers

During the past decade Americans have been enthralled with the exploits of their men in space. The astronomical expenditures of the Federal Government in the space program have yielded many exciting dividends, the most spectacular of which culminated in 1969 with American astronauts twice landing on the moon. A generation ago such a feat would have seemed impossible; today we appear to be on the threshold of further magnificent achievements.

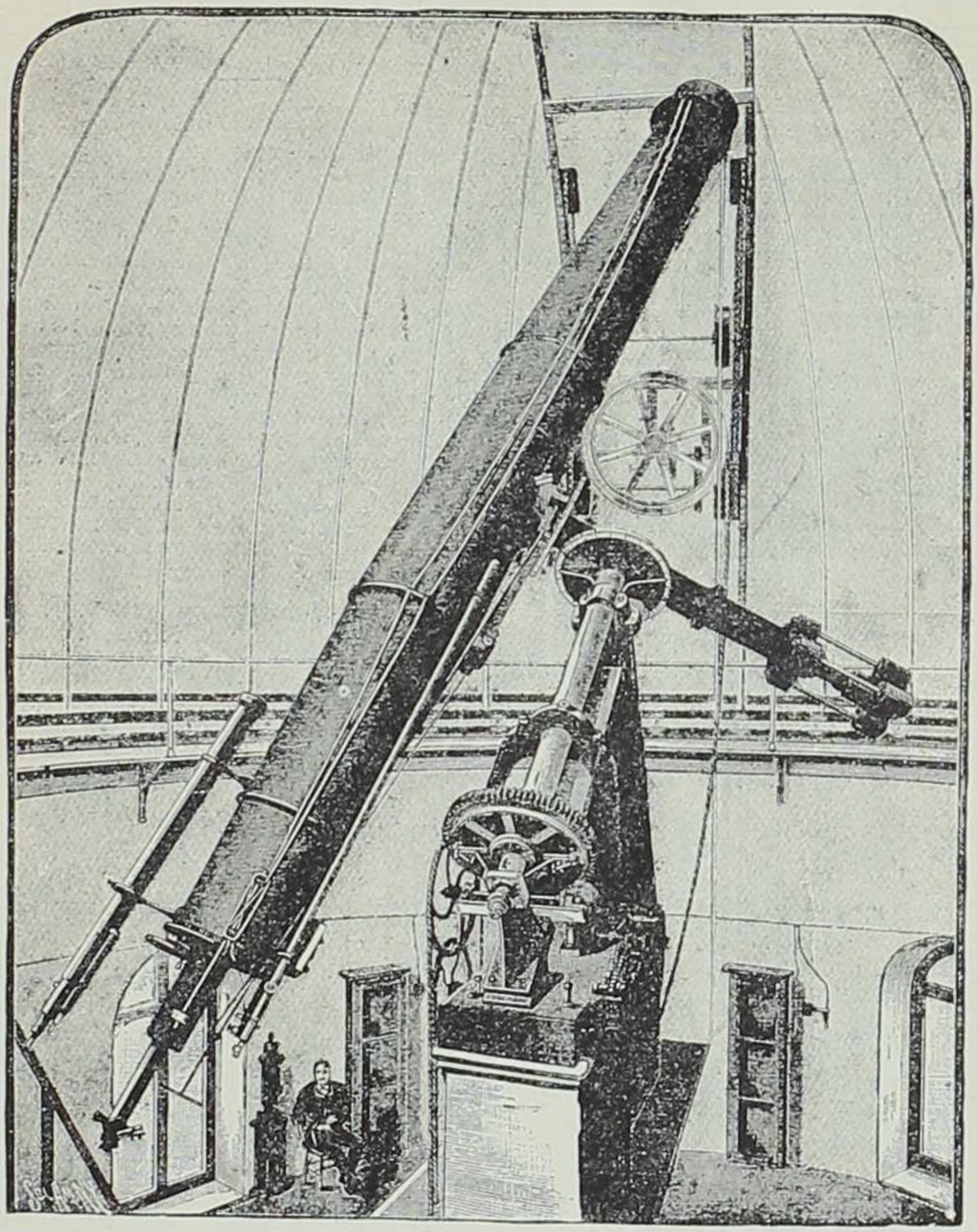
Of all the heavenly bodies, the moon has been best-known to mankind since long before the birth of Christ. The Chinese boast of their astronomical discoveries; they hold the first record of an eclipse of the sun in 2128 B.C. They apparently took their eclipses seriously for one Chinese emperor is said to have put to death his chief astronomers, Ho and Hi, for presumably getting drunk and failing to announce the solar eclipse of 2169 B. C.

The Chaldean priests were astronomers whose temples are said to have served as observatories. When Alexander the Great took Babylon in 331 B. C., he found records of their celestial observations dating back nineteen centuries. The princi-

pal early astronomical book, called the *Illumination of Bel,* was compiled for the library of Sargan of Akbad (2750 B.C.). Although the Asiatics were patient observers, they did not classify their knowledge, hence astronomers did not profit as much as they might otherwise have done from their discoveries.

It remained for western minds, especially the ancient Greeks, to classify and bring astronomical information together. Thus, Thales, one of the seven sages of Greece (640 to 548 B.C.), has been styled the "Father of Astronomy." Thales taught that the earth was round and that the moon received her light from the sun. He predicted an eclipse of the sun during a war between the Medes and Lydians. These nations, according to Herodotus, were engaged in deadly combat when an eclipse of the sun darkened the battlefield causing both sides to throw down their arms in terror and make peace. Anaximander, inventor of the sun-dial; Pythagoras, who conceived a system of the universe; and Hipparchus, the greatest astronomer of antiquity, were other early Greeks who attained fame as astronomers.

The Egyptians were also noted for their scientific minds. Their celebrated school at Alexandria attracted students from other nations, including Ptolemy, whose *Almagest* remained for fourteen centuries the text-book of astronomers. Tycho Brahe, Copernicus, Kepler, Galileo, and



The 23-inch Princeton Telescope.

PICTURES DERIVED FROM FOLLOWING SOURCES

Chambers, George F., *The Story of Eclipses,* (New York, 1903).

Report of Professor McClune on the Solar Eclipse of August 7, 1869, (Philadelphia, 1869).

Steele, Joel Dorman, *New Descriptive Astronomy,* (New York, 1869 and 1884).

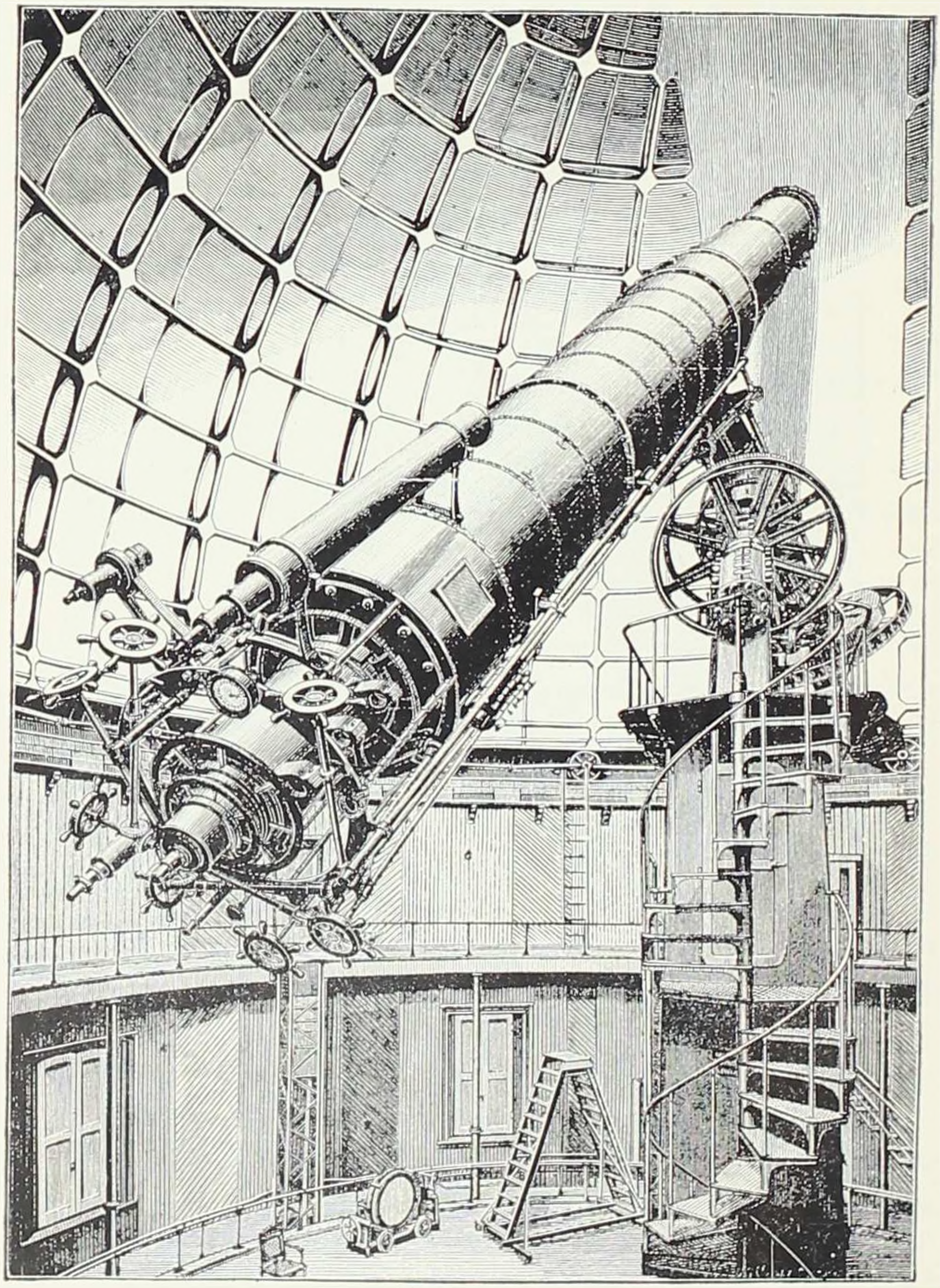
Young, Charles A., *A Text-Book of General Astronomy,* (Boston, 1900). The first nine pages of illustrations are from this text.

Pages 10 to 13 are from Chambers and Steele, listed above.

Pages 14 and 15 are loaned by the State Department of History and Archives.

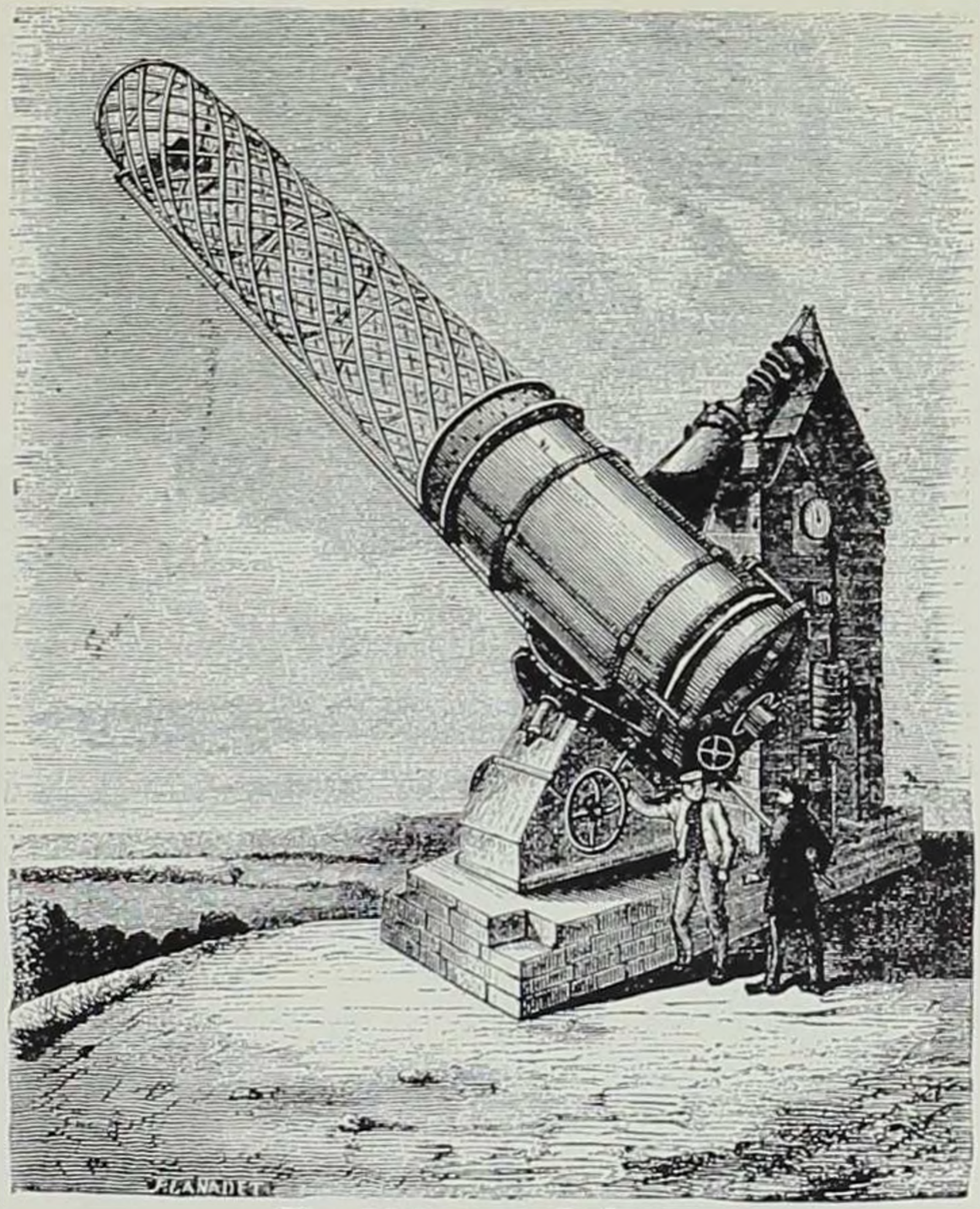
The front and back cover, and the inside back cover, are from the State Historical Scciety of Iowa Collections.

A Voyage to the Moon—1862 was taken from the *Iowa Homestead,* April 10, 1862.

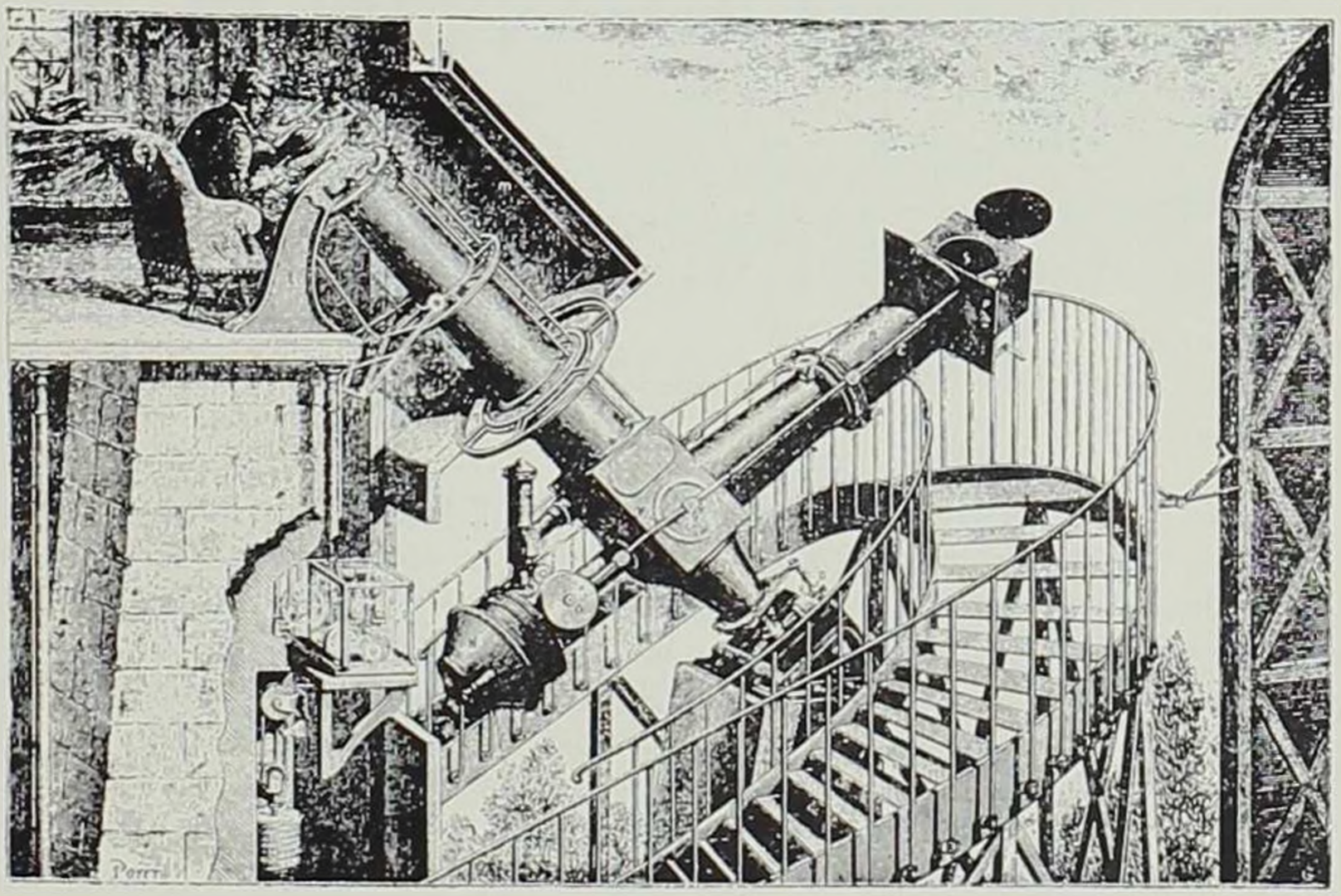


C. A. Young, *General Astronomy*

The Great Telescope of the Lick Observatory, Mt. Hamilton, Cal.
Aperture, 36 in.; Focal Length, 56 ft. 2 in.; Mounting by Warner & Swasey.



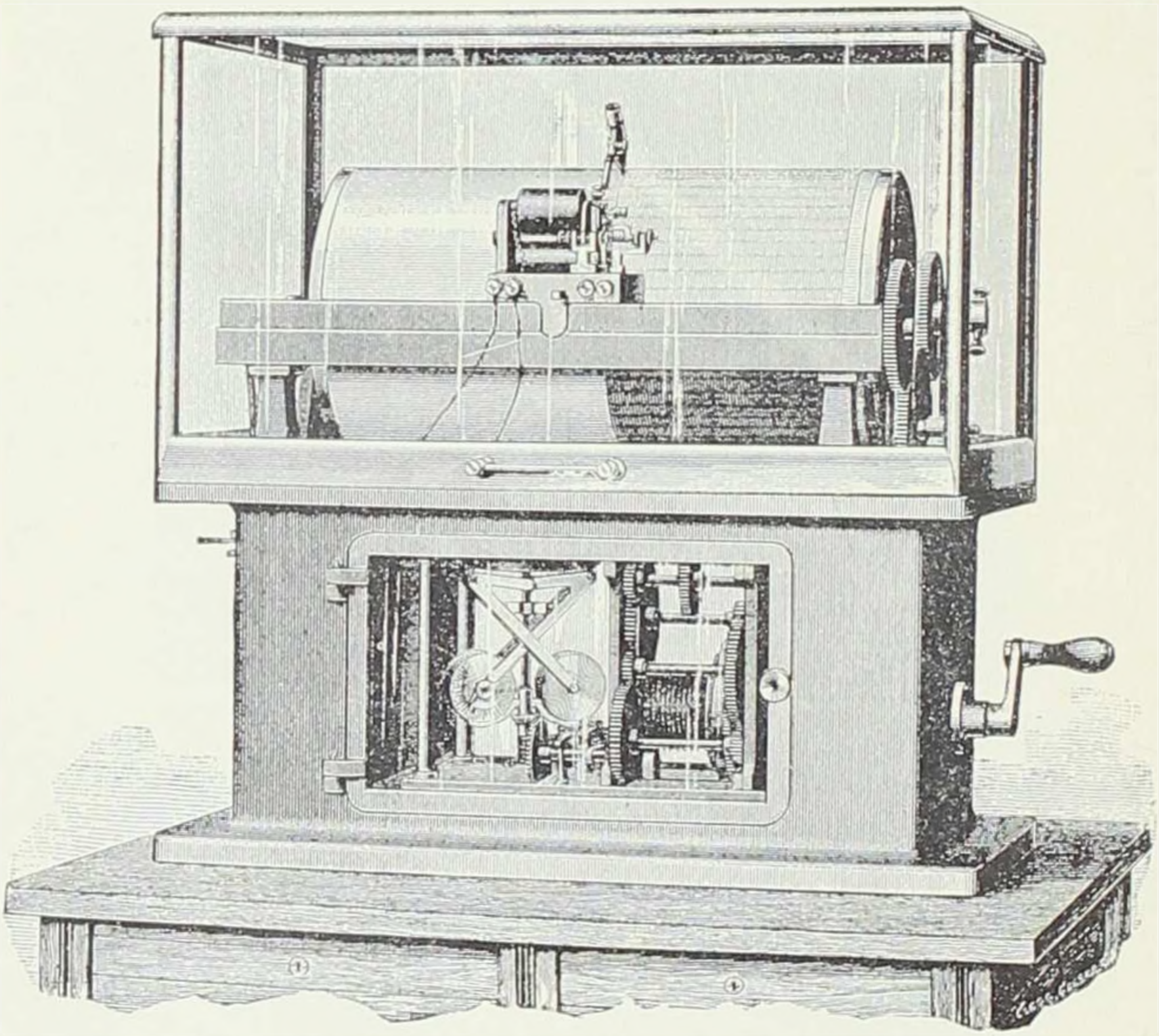
The Melbourne Reflector



The Equatorial Coude

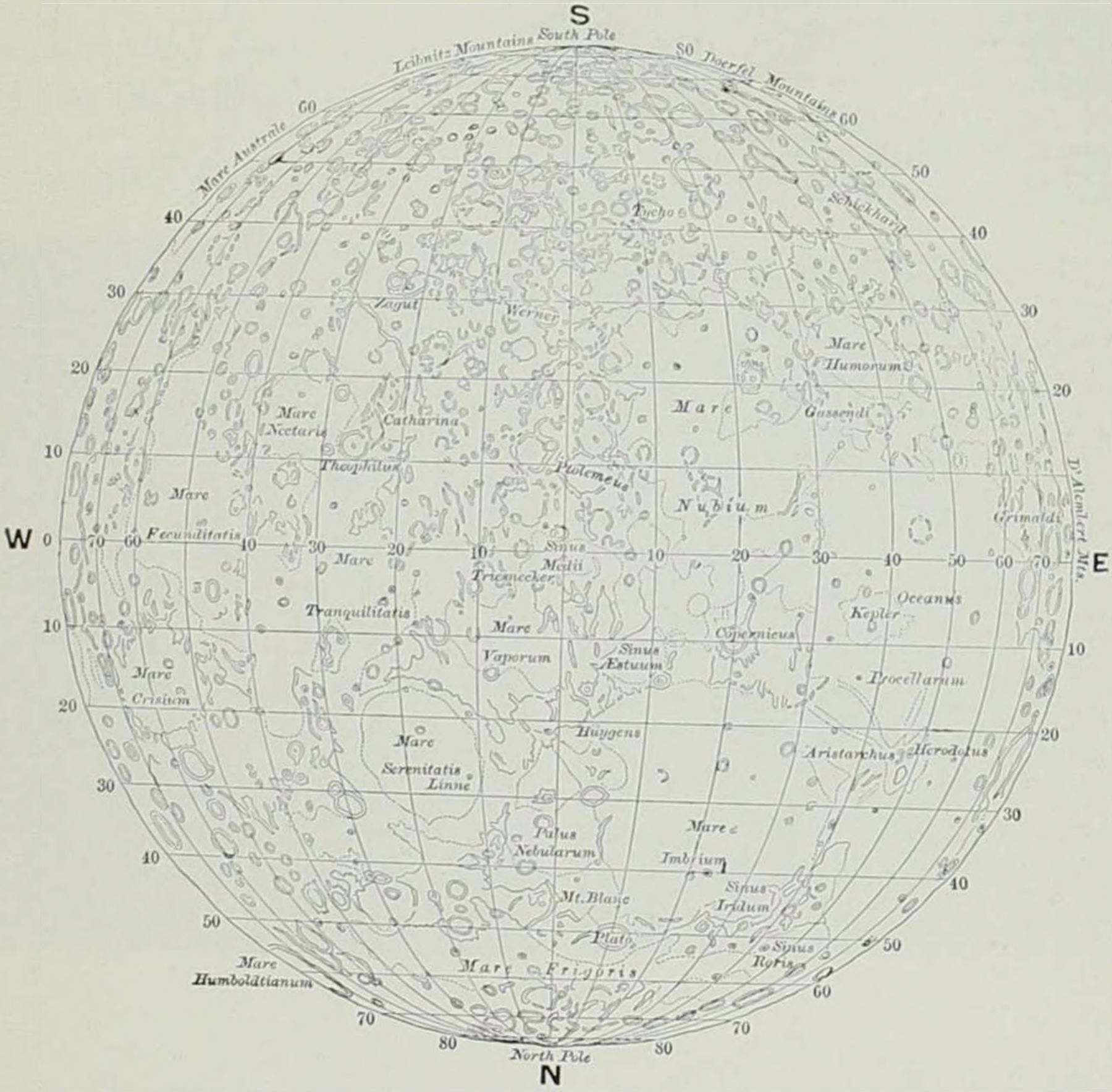
With large instruments of the ordinary form a great deal of inconvenience is encountered by the observer, in moving about to follow the eye-piece into the various positions into which it is forced by the inconsiderateness of the heavenly bodies. Moreover, the revolving dome, which is usually erected to shelter a great telescope, is an exceedingly cumbrous and expensive affair.

In the Equatorial Coude these difficulties were overcome by the use of mirrors. The observer sits always in one fixed position, looking obliquely down through the polar axis, which is also the telescope tube.



A Chronograph by Warner & Swasey

This is an instrument which carries the marking-pen and moves the paper on which the time-record is made. The paper is wrapped upon a cylinder, six or seven inches in diameter, and fifteen or sixteen inches long. This cylinder is made to revolve once a minute, by clock-work, while the pen rests lightly upon the paper and is slowly drawn along by a screw-motion, so that it marks a continuous spiral.



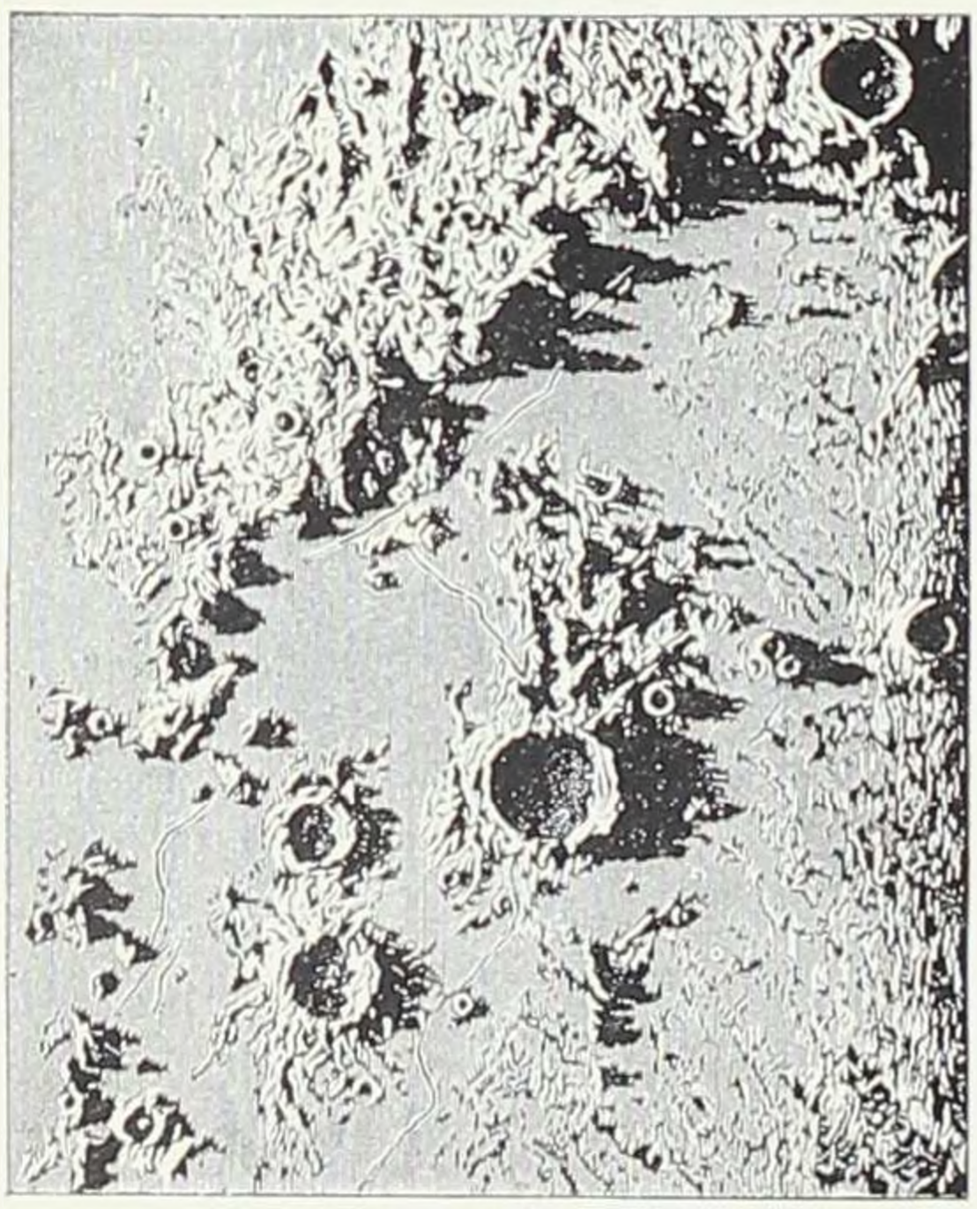
Map of the Moon (Reduced from Neison)

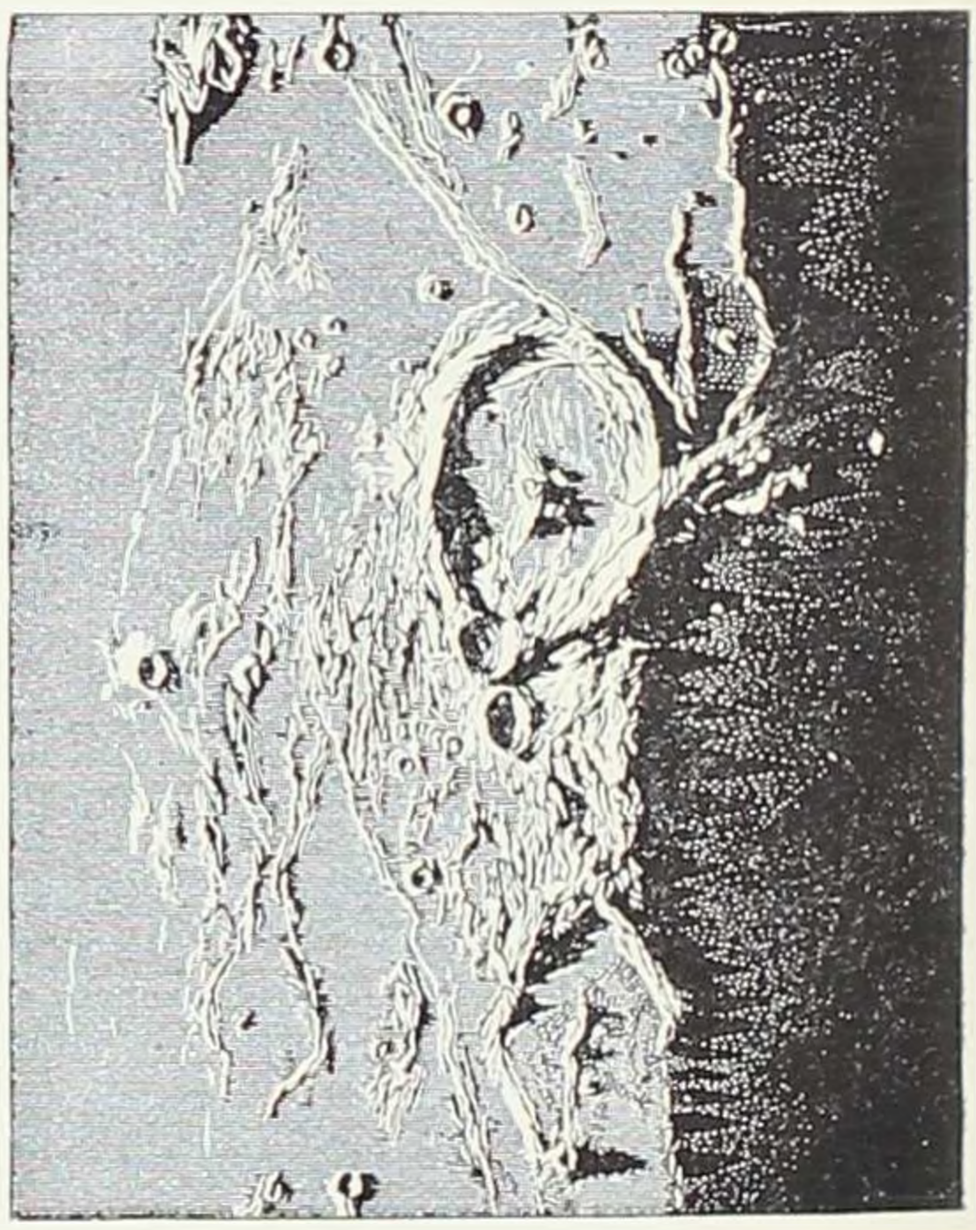
The great plains were called by Galileo oceans or seas (Maria), and some of the smaller ones marshes (Paludes) and lakes, for he supposed that the grayish surfaces visible to the naked eye, and conspicuous in a small telescope, were covered with water. Thus we have the "Oceanus Procellarum," the "Mare Imbrium," and a number of other "seas," of which "Mare Fecunditatis," "Mare Serenitatis," and "Mare Tranquilitatis," are the most conspicuous. There are twelve of them in all, and eight or nine Paludes, Lacus, and Sinus.

(Opposite) A Normal Lunar Crater.

(Below, left) Archimedes and the Apennines.

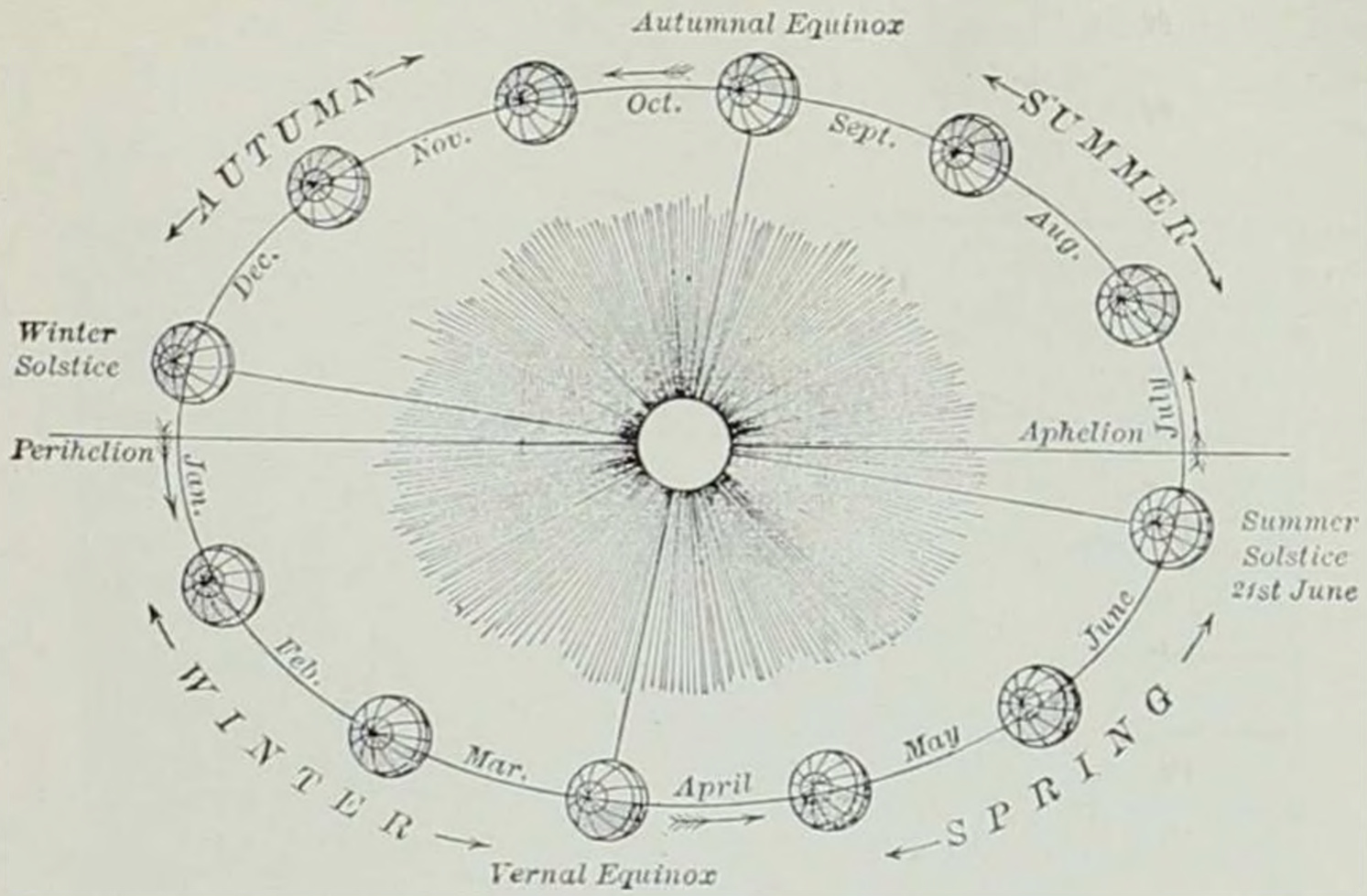
(Below, right) Gassendi (Nasmyth).





The Moon's Surface Structure

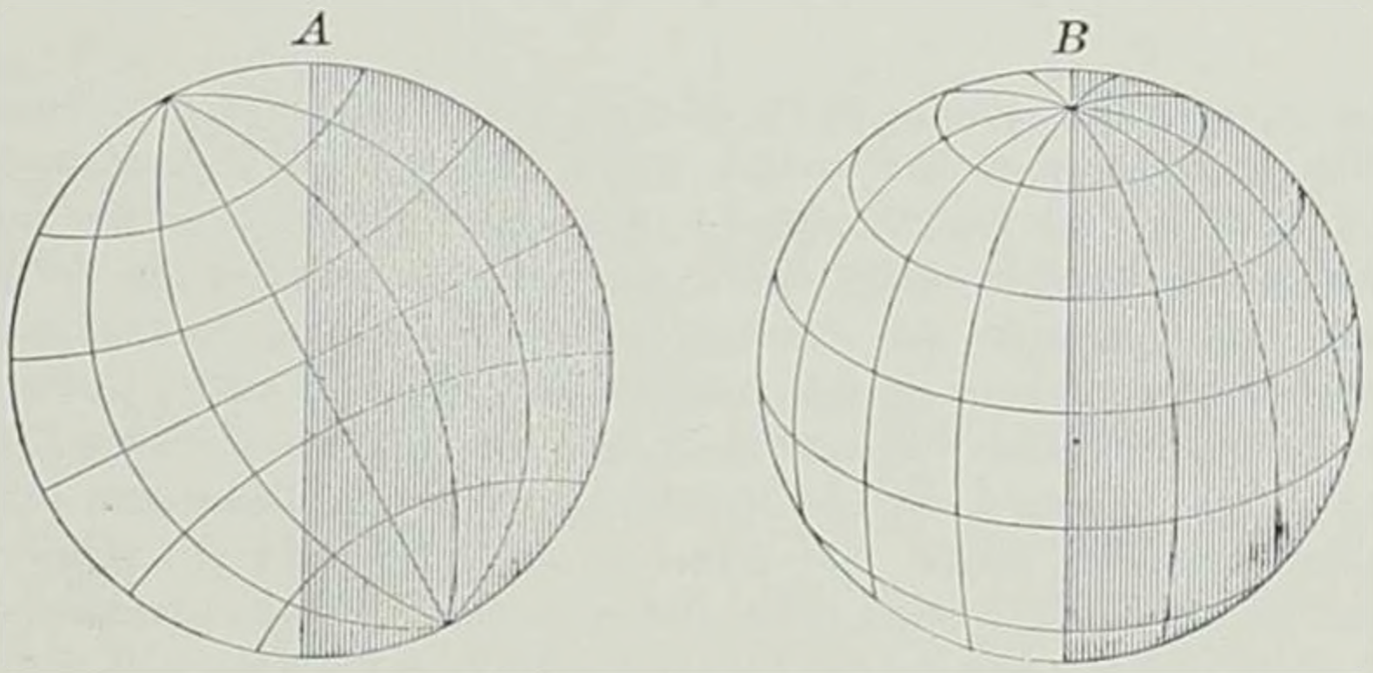
The moon's surface for the most part is extremely uneven and broken, far more so than that of the earth. The structure, however, is not like that of the earth's surface. On the earth the mountains are mostly in long ranges, such as the Alps, the Andes, and Himalayas. On the moon such mountain ranges are few in number, though they exist; but the surface is pitted all over with great craters, resembling very closely the volcanic craters on the earth's surface, though on an immensely greater scale. . . . The normal lunar crater is nearly circular, surrounded by an elevated ring of mountains which rise anywhere from 1,000 to 20,000 feet above the surrounding country. Within the floor of the crater the surface may be either above or below the outside level. Some craters are deep, some filled nearly to the brim. . . . On some portions of the moon these craters stand very thickly. Older craters have been encroached upon, or more or less completely obliterated by the newer, and the whole surface is a chaos, of which the counterpart is hardly to be found on the earth, even in the roughest portions of the Alps. This is especially the case near the moon's south pole.



The Seasons

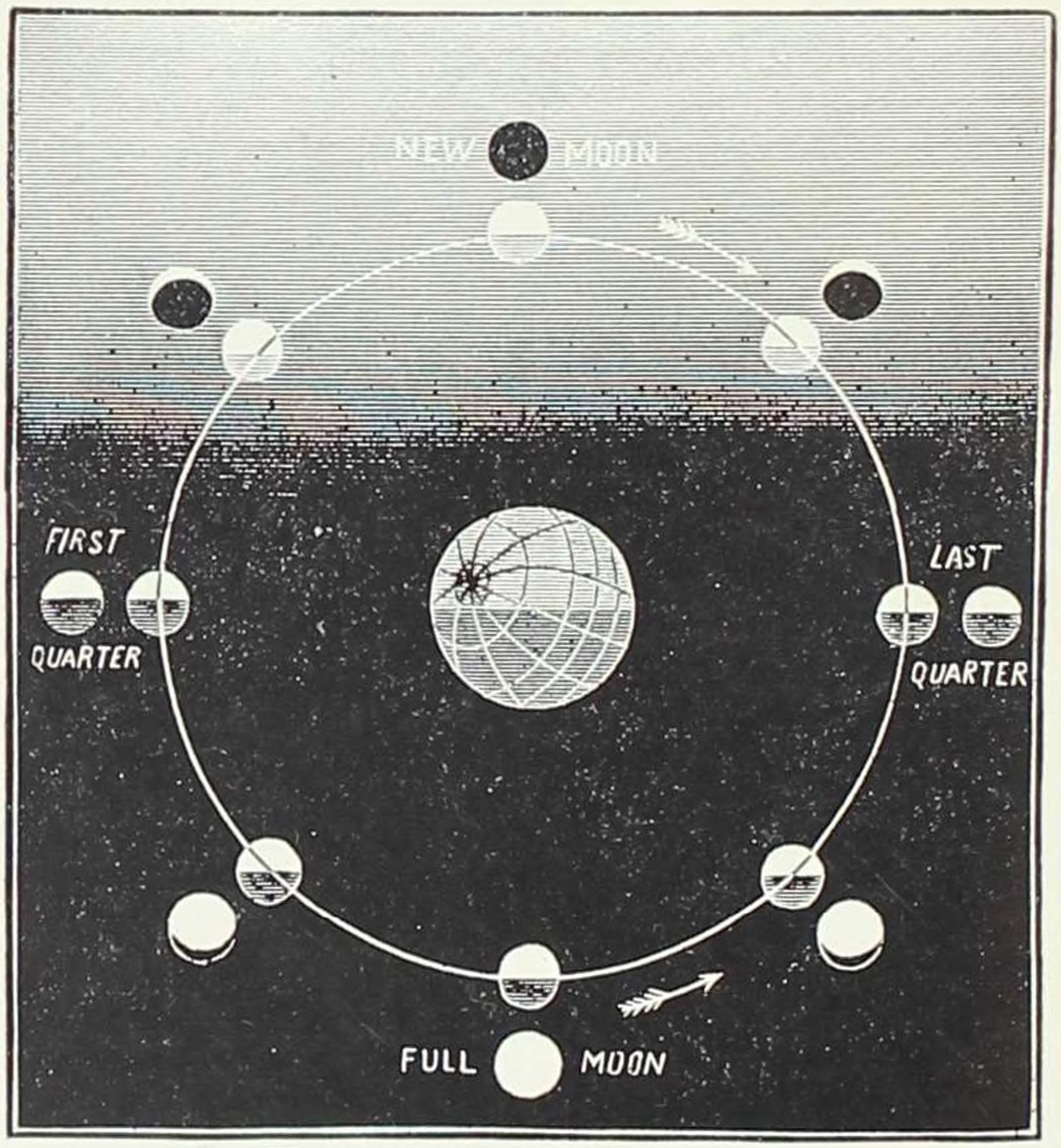
The earth in its motion around the sun always keeps its axis parallel to itself, for the mechanical reason that a revolving body necessarily maintains the direction of its axis invariable, unless disturbed by extraneous force, as is very prettily illustrated by the gyroscope. The above shows the way in which the north pole of the earth is inclined with reference to the sun at different seasons of the year.

About March 20 the earth is so situated that the plane of its equator passes through the sun, the sun's declination being zero on that day. At that time, the line which separates the illuminated portions of the earth passes through the two poles (as shown above and below), and day and night are everywhere equal. The same is again true of the 22nd of September, when the sun is at the autumnal equinox on the opposite side of the orbit.



Position of Pole at Solstice and Equinox

About the 21st of June the north pole receives sunlight all day long; and in all portions of the northern hemisphere the day is longer than the night . . . while in the southern hemisphere the days are shorter than the nights.



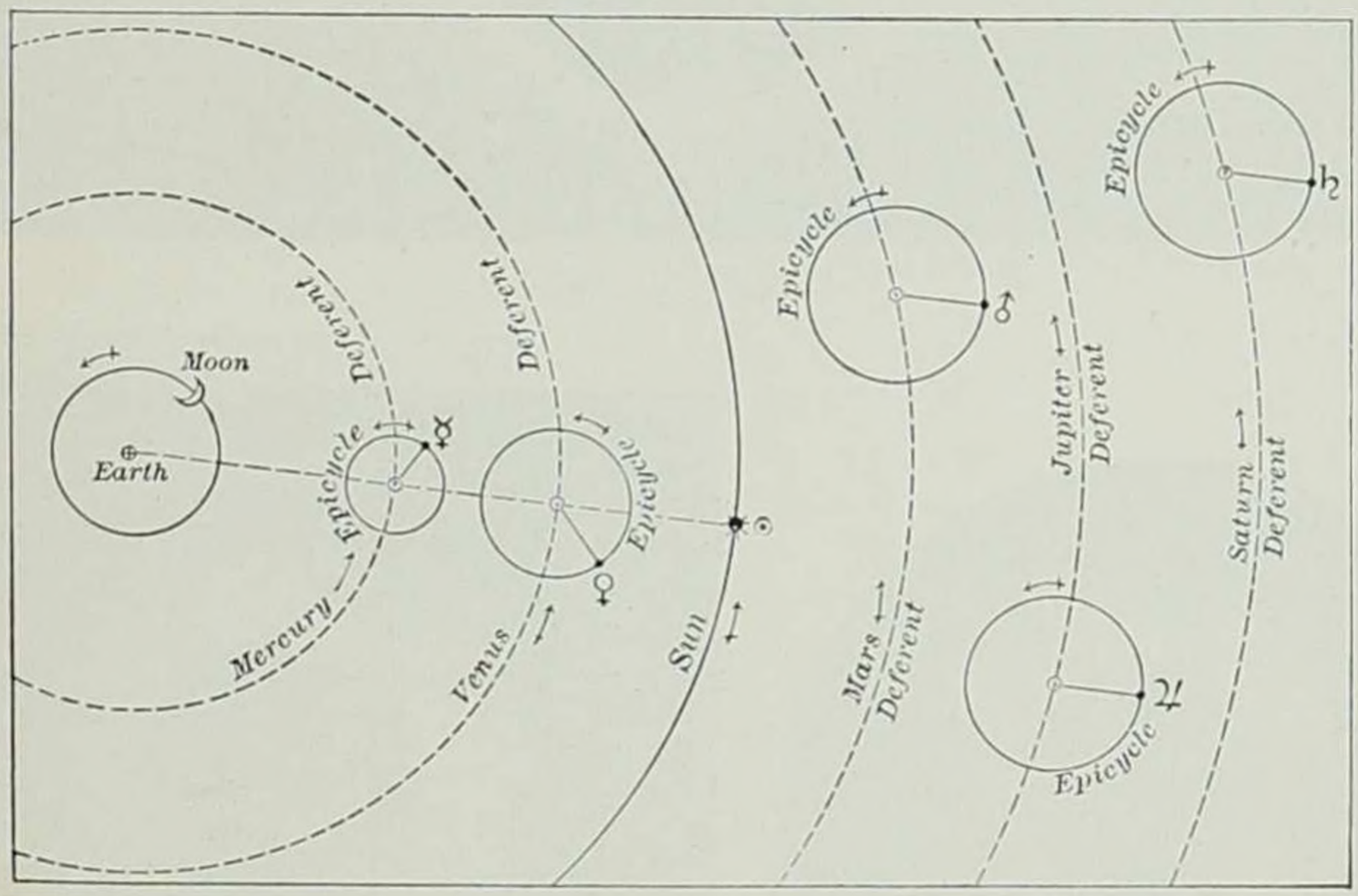
The Phases of the Moon

Since the moon is an opaque globe, shining entirely by reflected light, we can see only that hemisphere of her surface which happens to be illuminated, and of course only that part of the illuminated hemisphere which is at the time turned towards the earth. At new moon, when the moon is between the earth and the sun, the dark side is towards us. A week later, at the end of the first quarter, half of the illuminated hemisphere is seen, and we have the half moon, just as we do a week after the full. Between the new moon and the half moon, during the first and last quarters of the lunation, we see less than half of the illuminated portion, and then have the "crescent" phase. See above in which the light is supposed to come from a point far above the moon's orbit. Between the half moon and the full, during the second and third quarters of the lunation, we see more than half of the moon's illuminated side, and have what is called the "gibbous" phase.

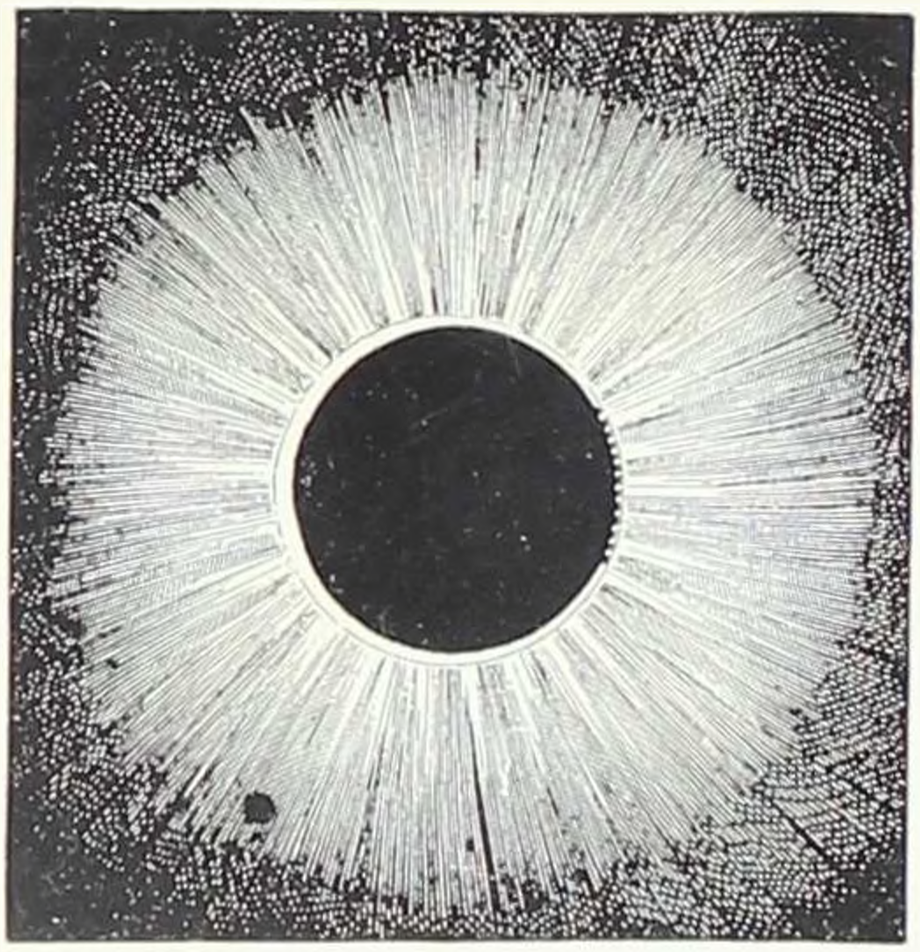
Track of the Moon's Shadow, Eclipse of July 29, 1878.

Velocity of the Shadow

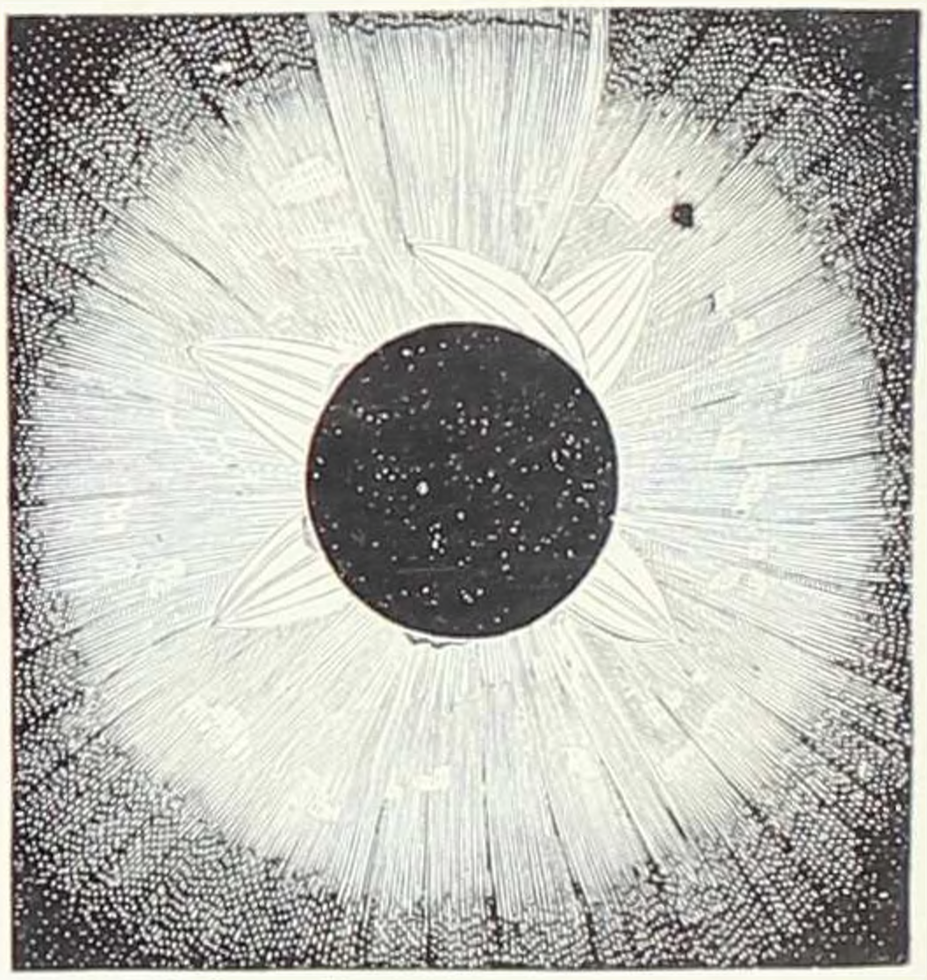
The moon advances along its orbit very nearly 2,100 miles an hour, and were it not for the earth's rotation, this is the rate at which the shadow would pass the observer. The earth, however, is rotating towards the east in the same general direction as that in which the shadow moves, and its surface moves at the rate of about 1,040 miles an hour at the equator.



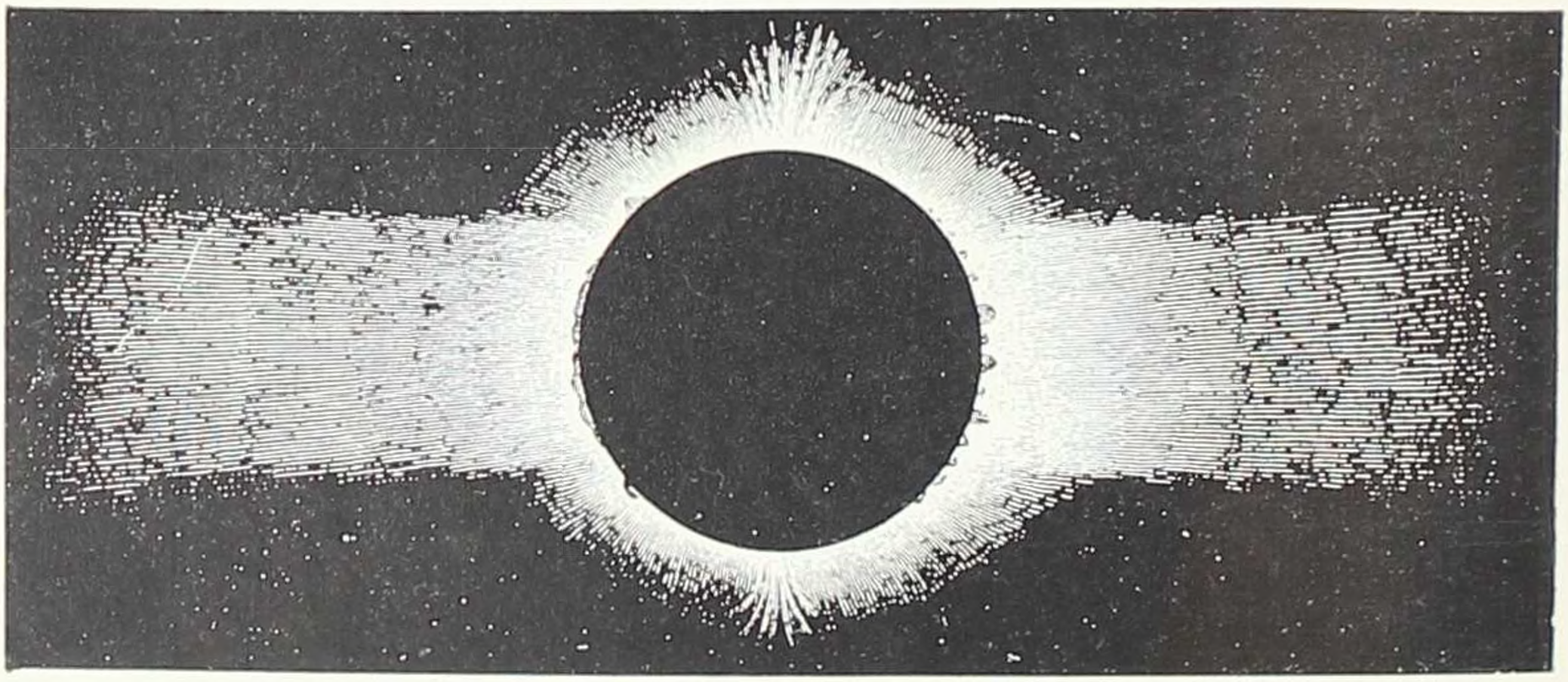
The Ptolemaic System was for fourteen centuries the authoritative "Scripture of Astronomy." It supposed that all planets moved around the circumference of a circle with the earth as the center.



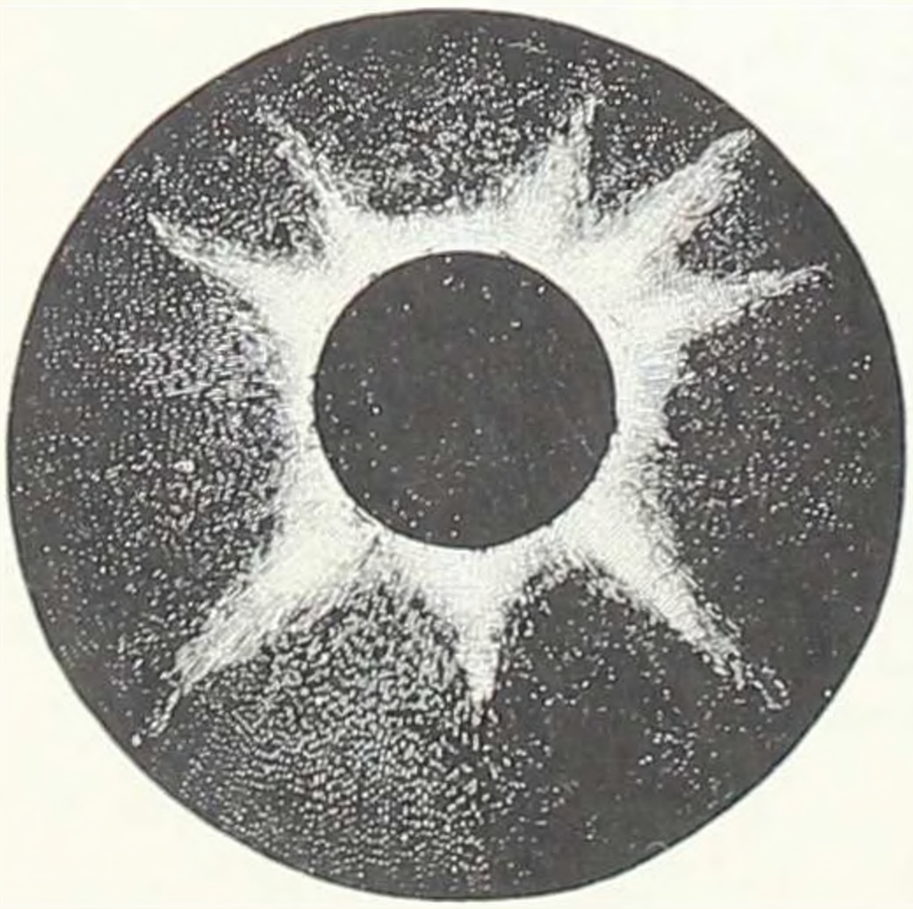
Annular Eclipse of 1835



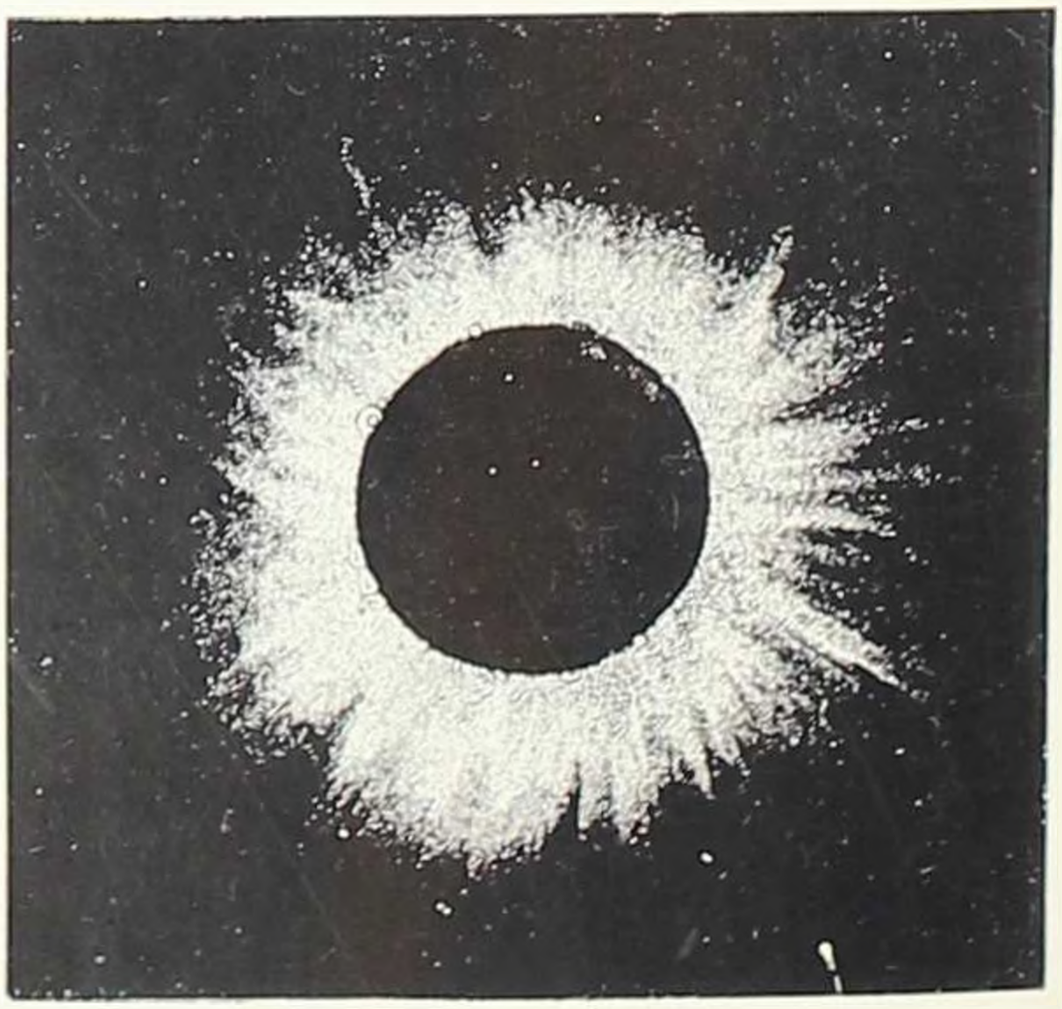
Eclipse of 1858



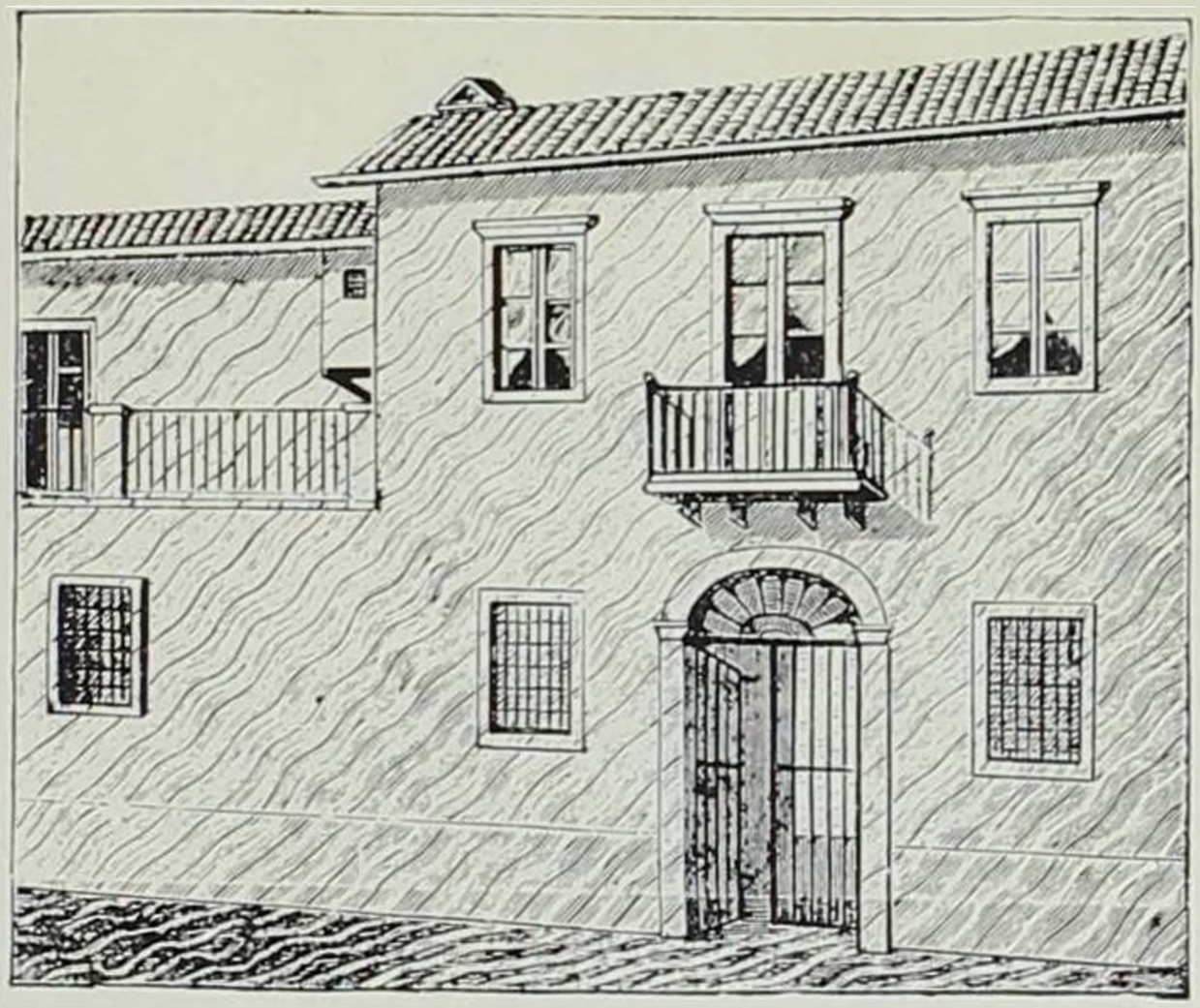
Corona of 1867



Corona of 1871



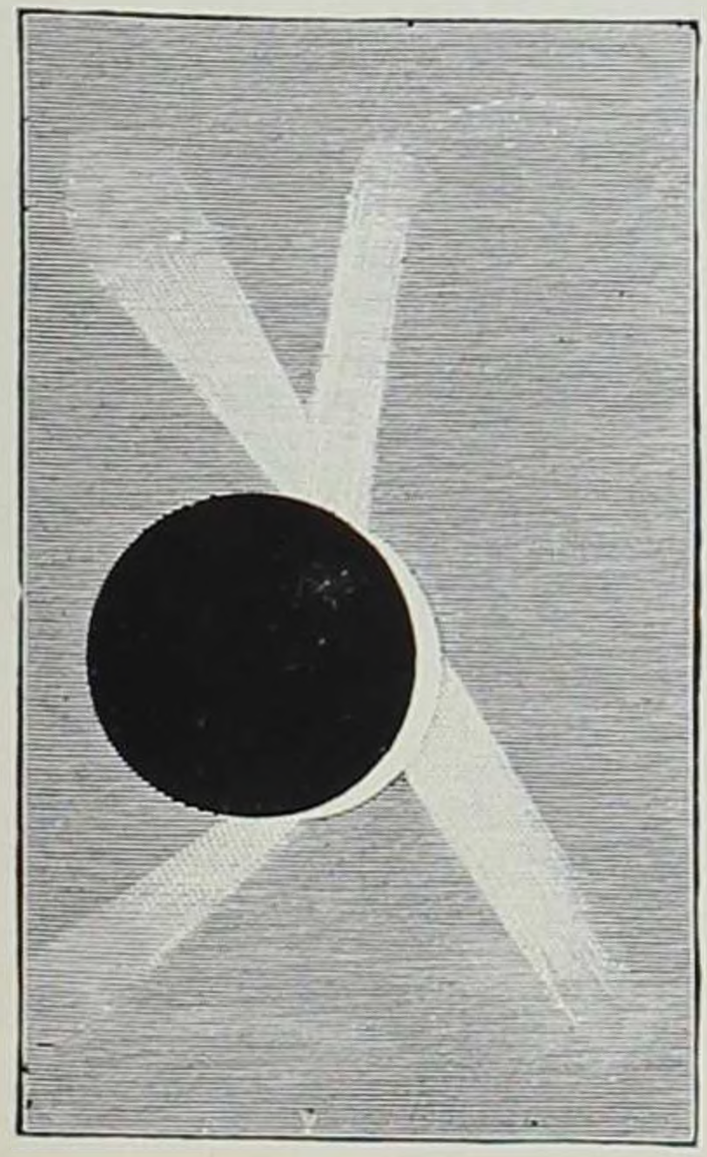
Corona of 1882



Shadow Bands

Let us suppose that we have a chance of observing a total eclipse of the Sun; have completed all our preliminary preparations; have taken note of everything which needs to be noted or suggests itself for that purpose up till nearly the grand climax; and that the clock tells us that we are within, say five minutes of totality. Somewhere about this time perhaps we shall be able to detect, dancing across the landscape, singular wavy lines of light and shade. These are the "Shadow Bands," as they are called. The phrase is curiously inexplicit, but seemingly cannot be improved upon at present because the philosophy of these appearances—their origin and the laws which regulate their visibility—are unknown, perhaps because amid the multitude of other things to think about sufficient attention has hitherto not been paid to the study of them. These shadow bands are most striking if a high plastered wall, such as the front of a stone or stuccoed house, is in their track as a screen to receive them. The shadow bands seem to vary both in breadth and distance apart at different eclipses, and also in the speed with which they pass along. Though, as already stated, little is known of their origin yet they may be conceived to be due to irregularities in the atmospheric refraction of the slender beam of light coming from the waning or the waxing crescent of the Sun, for be it understood they may be visible after totality as well as before it. It is to be remarked that they have never been photographed.

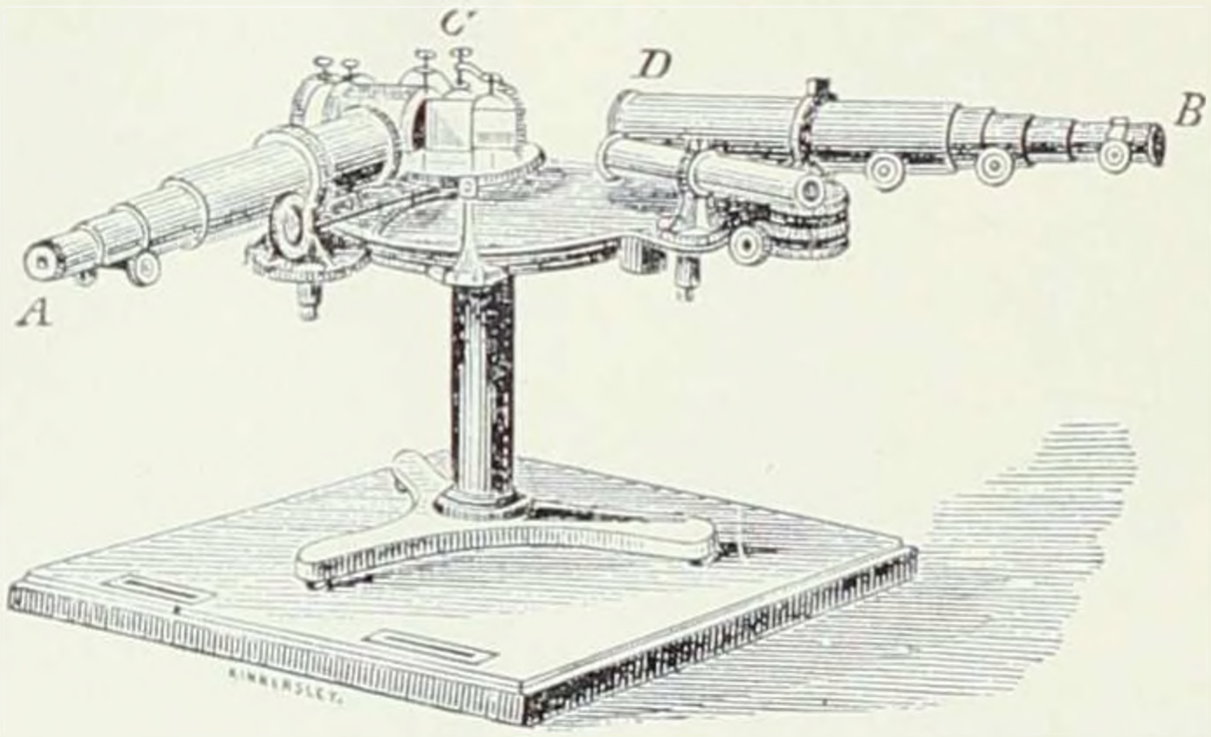
George F. Chambers, *The Story of Eclipses.*



Limbs of the Sun's Crescent

There are instances on record of the limbs of the Sun's crescent appearing to undulate violently on the approach of totality. These undulations were noticed by Airy in 1842 about 6 minutes before totality. Blake, in America in 1869, observed the same phenomenon 8 minutes before totality. In other cases the interval would seem to have been very much shorter—a mere matter of seconds.

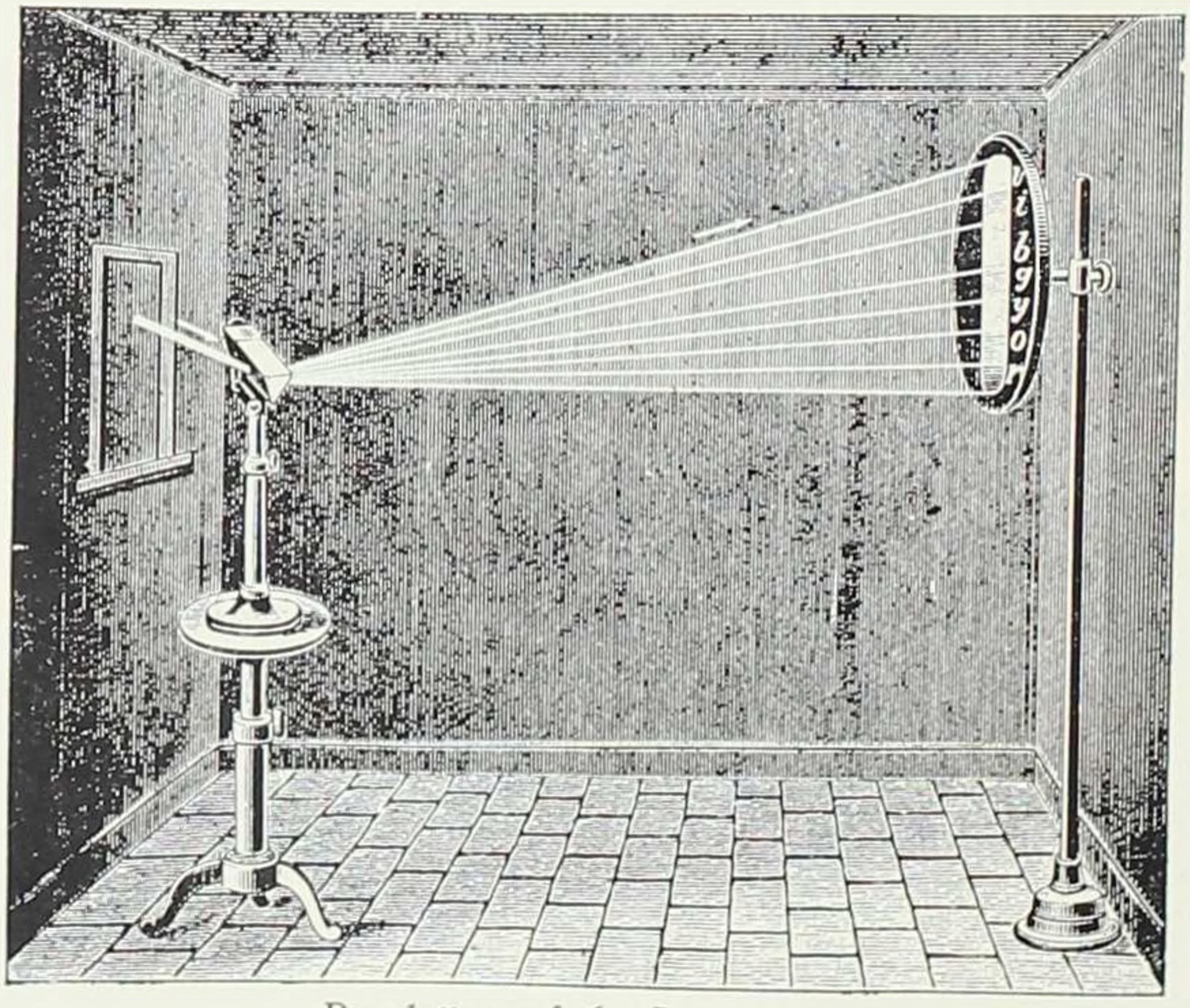
George F. Chambers, *The Story of Eclipses.*



The Spectroscope

This instrument consists of two small telescopes, with a prism mounted between their object-glasses (Fig. 106). The rays of light enter through a narrow slit at A, and are rendered parallel by the object-glass. They then pass through the prisms at C, are separated into the different colors, and, entering the second telescope at D, fall upon the eye at B. A third telescope is sometimes attached, which contains a minutely-accurate scale for measuring the distances of the lines. In addition, a mirror may throw in at one side of the slit a ray of sunlight or starlight, and so we can compare the spectrum of the sunbeam with that of any flame we desire.

Steele, *New Descriptive Astronomy.*



Revelations of the Spectroscope

The Spectrum of the sunbeam is not continuous, but is crossed by a large number of dark lines, called, from their discoverer, Fraunhofer's lines. It is therefore concluded that the sun's light is of the third class just named, and that it is produced by the vivid light of a highly heated body shining through a flame full of volatilized substances.

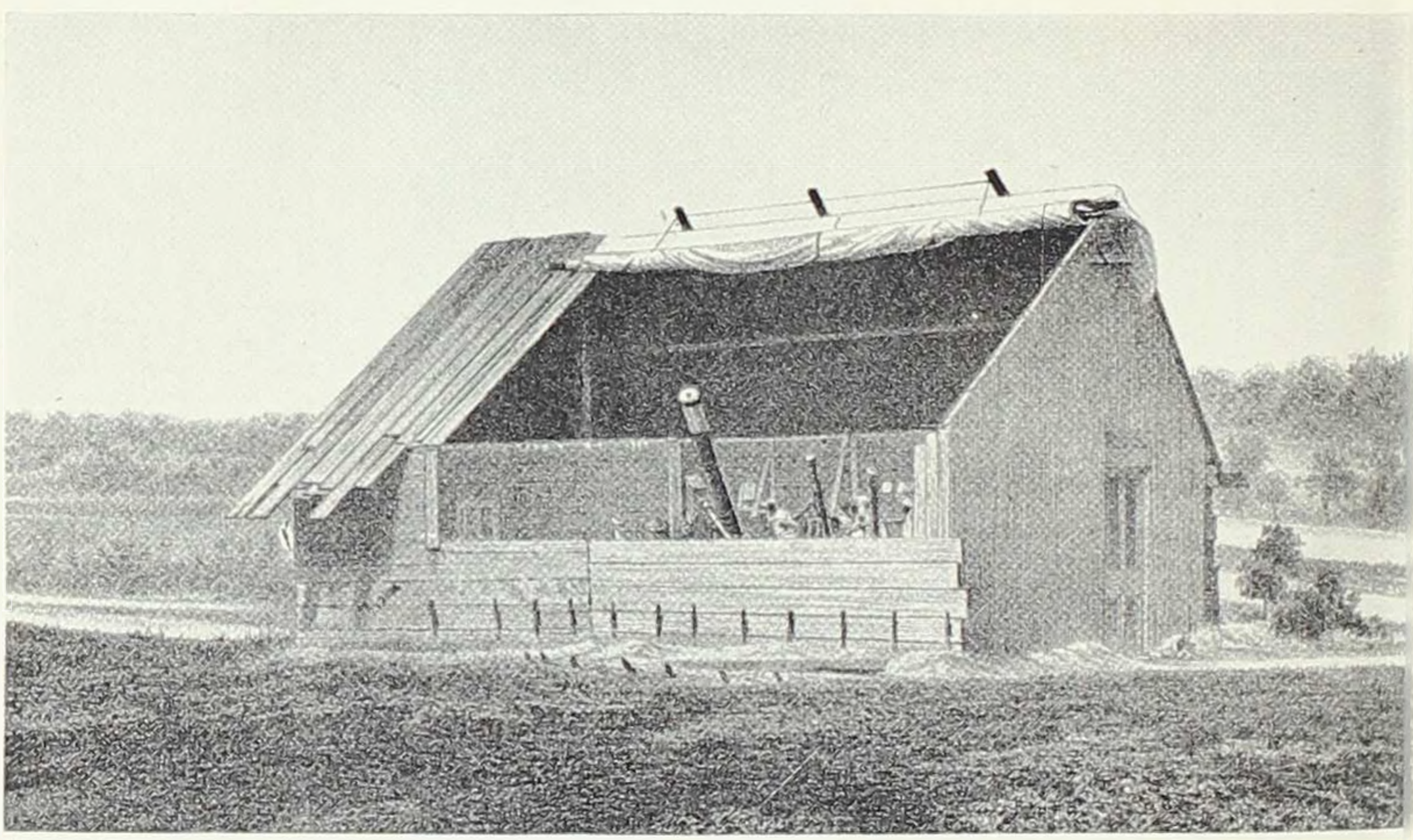
Steele, *New Descriptive Astronomy.*

Ideal Landscape on the Moon

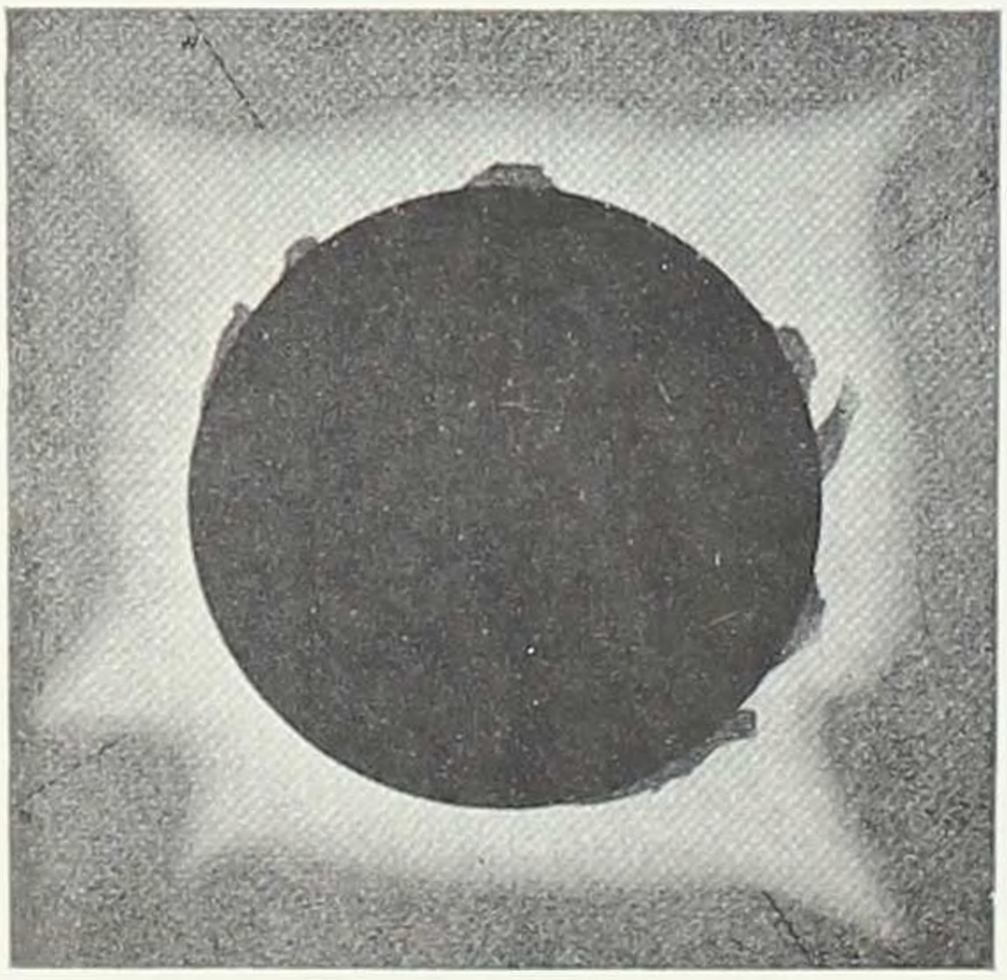
How strange the lunar appearance would be to us! The disk of the sun seems sharp and distinct. The sky is black and overspread with stars even at midday. There is no twilight, for the sun bursts instantly into day, and after a fortnight's glare, as suddenly gives place to night; no air to conduct sound; no clouds; no winds; no rainbow; no blue sky; no gorgeous tinting of the heavens at sunrise and sunset; no delicate shading; no soft blending of colors, but only sharp outlines of sun and shade.*

*The moon is a fossil world, an ancient cinder, a ruined habitation perpetuated only to admonish the earth of her own impending fate, and to teach her occupants that another home must be provided, which frost and decay can never invade. The moon was once the seat of all the varied and intense activities that now characterize the surface of our earth. At one time its physical condition was like that of the parent earth from which it had just been separated: but, being smaller, it cooled faster, and its geologic periods were correspondingly shorter. Its life-age was perhaps reached while the earth was yet glowing.—Read Winchell's Geology of the Stars.

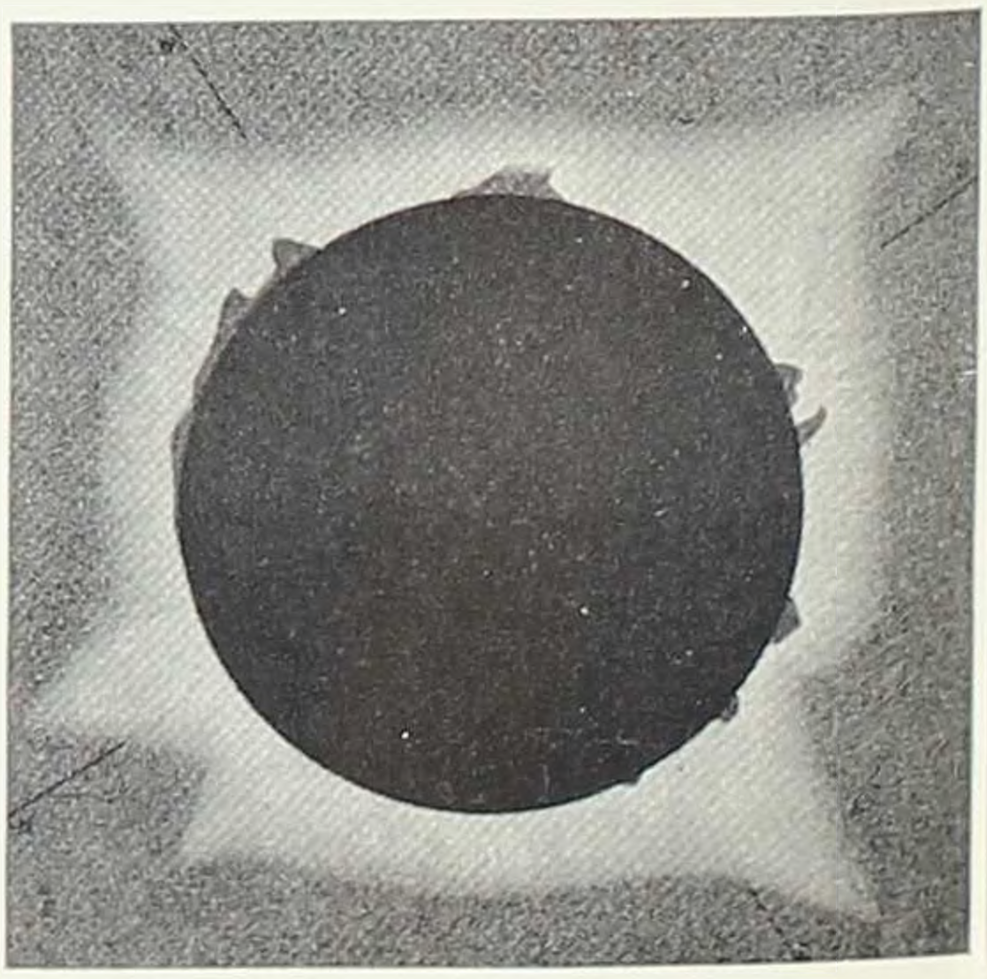
Steele, *New Descriptive Astronomy.*



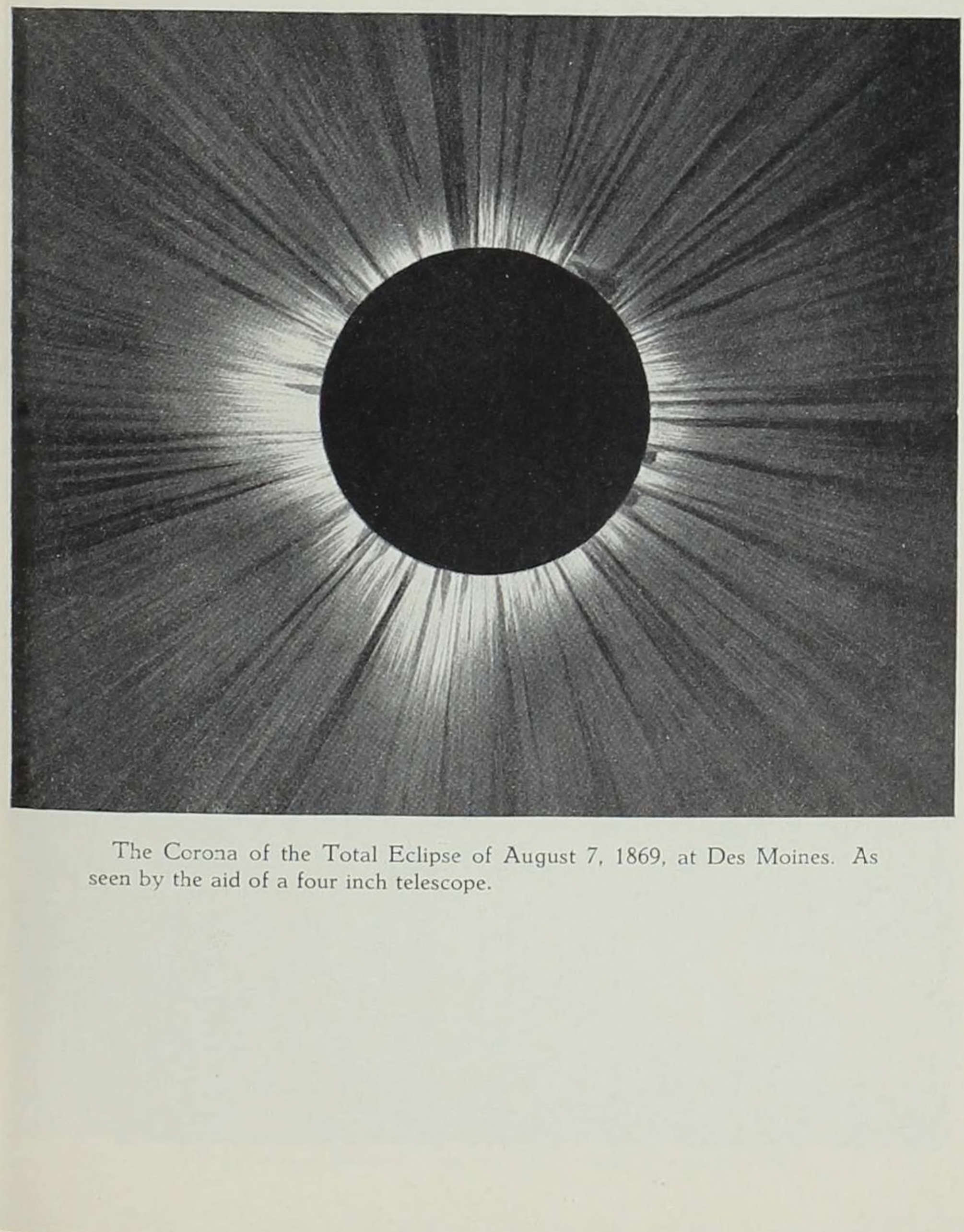
U. S. Eclipse Observatory, with four inch telescope set up at Des Moines, Iowa, for observation of the total eclipse of August 7, 1869.



Appearance of Corona and Protuberances immediately after the beginning of totality.



Appearance of Corona and Protuberances just before the end of totality.



The Corona of the Total Eclipse of August 7, 1869, at Des Moines. As seen by the aid of a four inch telescope.

HARPER'S WEEKLY.

A JOURNAL OF CIVILIZATION

VOL. XXII.—No. 1130.] NEW YORK, SATURDAY, AUGUST 24, 1878. [WITH A SUPPLEMENT. PRICE TEN CENTS.

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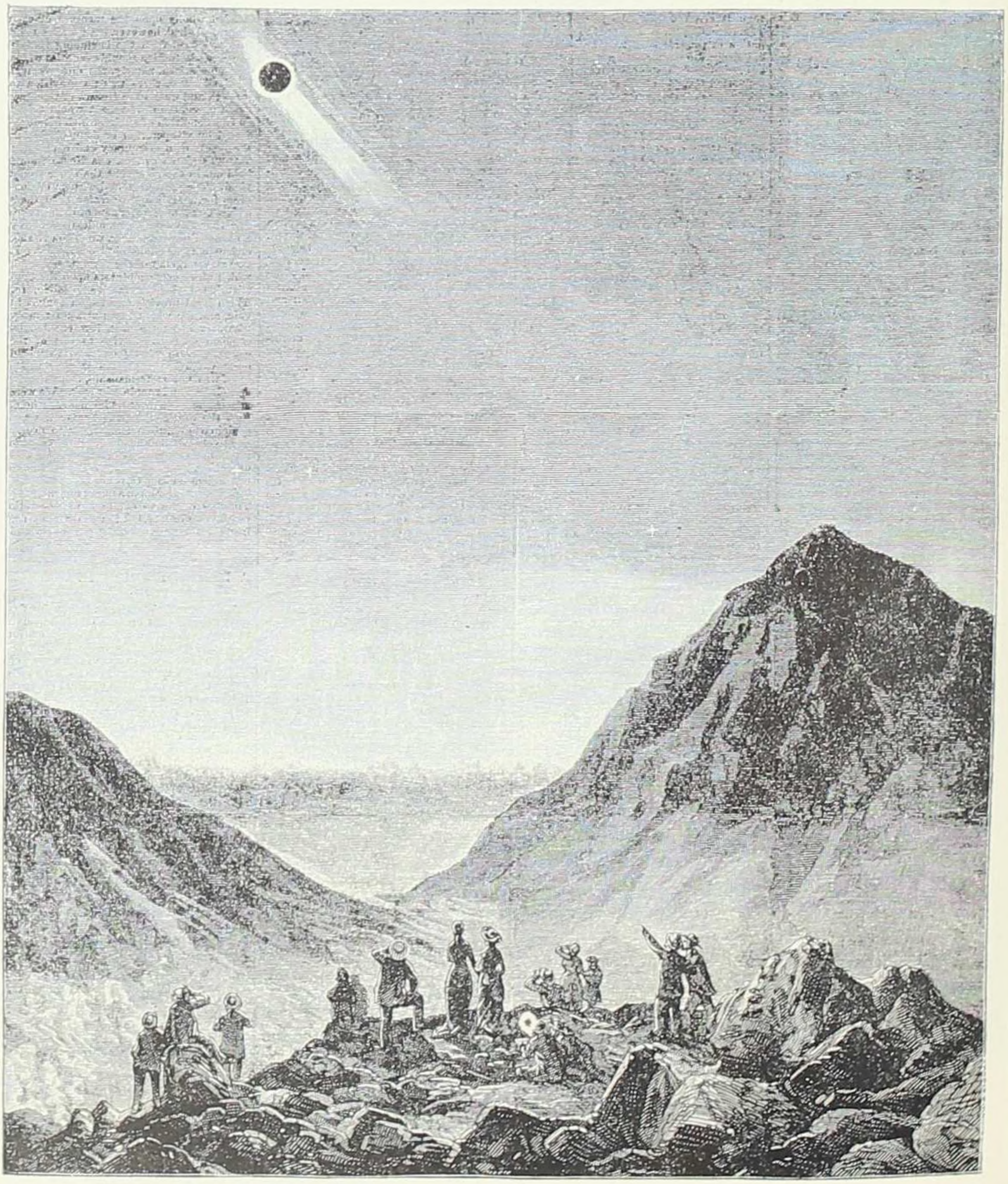

THE GREAT SOLAR ECLIPSE.—SKETCHED AT SNAKE RIVER PASS, COLORADO, BY ST. GEORGE STANLEY.—[SEE PAGE 675.]

Newton were giants in the field of astronomy who laid the foundation for our present-day knowledge of the universe.

It is with this brief historical introduction that we turn to the great eclipse of August 7, 1869, the only eclipse that occurred in totality over Iowa since the beginnings of permanent white settlement. Giant strides had been made in the improvement of astronomical equipment, particularly photography, and it was hoped much would be learned from the eclipse in Iowa. Little wonder that scores of leading astronomers were bound for Iowa in 1869 for the big show.

That Iowa was extremely fortunate in the caliber of men who elected to study the eclipse is attested by their national and international standing. Thus, prior to the eclipse a feature story appeared in several Iowa newspapers calling attention to the contributions of Americans in discovering new planets. Only six planets had been recognized and identified up to 1781 when Sir William Herschel "burst through the heavenly enclosures" and discovered the remote planet Uranus. From that time until 1868 the "unwearied industry of astronomers and the powerful aid of the telescope" had added 107 planets to the list. Nearly one-fifth of these telescopic planets, or 23 in number, were discovered by Americans, 8 by Christian Henry Frederick Peters and 9 by James Craig Watson. These discoveries were made be-

tween 1854 and 1868, eight of them in the latter year. Peters led the scientific group which came to Des Moines in 1869 while Watson was a key man in the delegation at Mount Pleasant.

Christian Peters was born in Schleswig, Germany, in 1813, and received his Ph.D. degree from the University of Berlin in 1836. Two years later, in 1838, he was a member of the expedition to survey Mount Etna in Sicily. Peters spent ten years in Sicily on scientific work. In 1854 he came to the United States and was identified with the U. S. Coast Survey for four years. He was director of the Hamilton College astronomical survey in Clinton, New York, from 1858 to 1867. In the latter year he was named director of the Litchfield Observatory at Clinton, serving until his death in 1890.

The excellent reports of the eclipse at Des Moines by Dr. Peters led to his selection to lead the U.S. expedition to New Zealand to observe the transit of Venus in 1874. Among his many contributions, he discovered 48 new asteroids and 2 comets. He revised Ptolemy's *Almagest*—the accepted catalogue of the position of the stars. Peters was named to almost all the leading scientific societies and published widely in his field. In Des Moines he used the spectroscope, and confirmed the theory that the protuberances on the sun were in great part composed of hydrogen.

Another outstanding astronomer who came to

Iowa in 1869 was James Craig Watson, a Canadian-born scholar who won signal honors at the Universities of Leipzig, Yale, and Columbia. Watson published 15 astronomical papers before the age of 21 and promptly became professor of astronomy at the University of Michigan. It was while in charge of the Ann Arbor observatory that Watson vied with Peters in the discovery of new planets. He was credited with 22 discoveries. In addition to the Iowa expedition, Watson was on an astronomical expedition to Sicily in 1870, China in 1874, and Wyoming in 1878. He was named director of the Washburn Observatory at the University of Wisconsin in 1879. Before his death in 1880 he had won many national and international awards. During the eclipse of 1869, Watson confined his observations to the Mount Pleasant area.

Astronomer John H. C. Coffin was a professor with the United States Navy before his association with the U.S. Naval Observatory in Washington from 1843 to 1853. From 1853 to 1866 he was a professor of mathematics, astronomy, and navigation at the Naval Academy. He then became chief editor of the *Nautical Almanac* from 1866 to 1877. A student of astronomy for many years, Coffin directed the astronomers assigned to Burlington and designated other strategic locations in Iowa to late arrivals.

When Professor James McClune and President Samuel J. Gummere of Haverford College, Penn-

sylvania, arrived in Burlington they found that city well-provided with scientists, photographers, and volunteer help. After consulting with Professor J. H. C. Coffin they were assigned to Oskaloosa (an Iowa town that had not been pre-empted by astronomers) as the best place to set up their base. A "natural elevation" north of the main street of Oskaloosa was selected and all were at their telescopes before the beginning of the eclipse.

Professor McClune has left us a good description with a colored picture, reproduced on the front cover of this issue of *The Palimpsest*. According to McClune:

> The most interesting objects which present themselves during a total eclipse of the sun, are the corona or halo which appears around the dark body of the moon when the sun is entirely obscured, ruby-colored or flame-like protuberances of irregular shape, seemingly in immediate contact with the margin of the lunar disc, and luminous streamers or radiations from the brightest parts of the corona. These, and other phenomena observed while the total phase continued, are shown in the annexed drawing [front cover] sketched before the end of the eclipse.
>
> A, brightest part of the corona. At B, the radiation was less luminous than at A, but it extended farther and was interspersed with parallel orange-colored rays. At C, several streaks of orange-colored light were observed. At D, the extension was brighter than in the corona proper, but it was not so bright as at A, B and C. At E, a large rose-colored protuberance appeared, resembling somewhat a balloon or inverted bell pear. Its height was, at least, one-twentieth of the disc, or upwards of forty thousand

miles. At F, a circular ruby-colored protuberance, not so large as the one on the lower limb, was visible the entire period of totality. During some seconds, pink-colored flames spread along the limb on each side of this protuberance, and then faded away. Pink-colored flames were also observed at the part of the limb opposite G, but they soon became invisible. H, point of first contact. I, point of last contact. J, K, L, M, dark body of the moon which appeared, through the telescope, like an immense globe suspended in the heavens.

The luminous streamers or radiations from the corona, arranged themselves nearly opposite, and gave it an appearance not unlike a St. Andrew's Cross. The remaining portions of the corona were by no means uniform in brightness, even for short distances, *lighter* and *darker* portions intermingled.

The breadth of the corona proper, instead of being everywhere the same, as commonly represented, was very unequal. While in some places it reached more than two hundred thousand miles; in other places, and those generally where the rose-colored flames appeared, it did not extend to half that distance.

Professor McClune noted that the "clamor" of the Oskaloosa boys who had gathered to "watch our operations" was "hushed" and a "death-like paleness gradually diffused itself over the countenances of all . . . when the solar rays reappeared" a shout of joy burst from those who had gazed in "mute astonishment; the glow of health overspread the pallid features; . . . and inactivity and dreariness instantly gave place to light, animation and beauty."

Professor McClune was careful to note the reactions of birds and animals to the eclipse:

> In consequence of the short duration of the total phase, a little less than three minutes, it could not be expected that the effect on the lower animals would be as manifest as it has been in some eclipses of the sun, in which the total obscuration lasted much longer, nevertheless it was distinctly seen. Bees returned in swarms to the hives, swallows sought their places of nightly abode, fowls ascended the roost, and cattle either huddled together in the fields or hastened to their usual places of shelter.

Upon his return to Philadelphia, Professor McClune made a report to the Controller of the Public Schools on the Solar Eclipse of August 7, 1869, a copy of which is in the possession of the State Historical Society of Iowa.

Of far greater stature was Benjamin A. Gould, a Harvard graduate who was born in Boston in 1824. Gould established and conducted the *Astronomical Journal* (1849-1851) which was reestablished in 1886. Associated with the U. S. Coast Survey from 1852-67, Gould built and directed several observatories. He gauged the difference in longitude between Europe and America by the aid of the submarine cable. He was the first astronomer to use the telegraph in geodetic work, making 15 determinations before the method was introduced in Europe. He did his greatest work in observation of the stars of the Southern Hemisphere. His most important work (for the

Argentine National Observatory) contained zone catalogues giving the position of 73,160 stars and a general catalogue of 32,448 stars in the Southern Hemisphere. He died at Cambridge in 1896.

One should not overlook the name of Charles Augustus Young, to whom must be credited many of the illustrations appearing in this issue. Born in Hanover, New Hampshire, in 1834, Young graduated from Dartmouth in 1853 and gained his Ph.D. from the University of Pennsylvania. He served four months as a captain of the 85th Regiment of Ohio volunteers. He was a professor of astronomy at Western Reserve from 1857 to 1866; at Dartmouth from 1866-77; and then at Princeton until he resigned in 1905. His books on *The Sun* (1882), *a General Astronomy* (1889), *Elements of Astronomy* (1890), and *Lessons in Astronomy* (1891).

The only woman astronomer was Professor Maria Mitchell, who had discovered a new comet in October of 1847. She was the first woman elected to the American Academy of Arts and Sciences. Born on Nantucket Island in 1818, she also was the first professor of Astronomy at Vassar College—1865-1888. Professor Mitchell arrived in Burlington with eight of her lovely students, bedecked with hoop skirts and small parasols. According to the Burlington editor:

> The beaux at Des Moines who plumed themselves on

their supposed brilliant prospects of captivating these young lady astronomers, must, as soon as possible, pack their carpet bags and make their appearance in Burlington or miss their opportunity. Of course, a lot of sprightly and handsome young ladies, coming "out west" wanted to go to a handsome town, with handsome scenery adjoining, and handsome young men by the score, and of course came to Burlington. Des Moines may have an old observer or two, but the wide awake and handsome ones of both sexes are all in this city, we judge.

While much was said of the reaction of birds and animals to the complete eclipse, the fright of a person, unaware of the sudden advent of a total eclipse, could be so terrifying as to prove fatal. On August 24, 1869, the *Lansing Mirror* carried the following:

DEATH FROM FRIGHT AT THE ECLIPSE.—A Mrs. Gifford, residing in the north part of Marion county, in this State died from fright from seeing the eclipse. She was not aware of its coming, and being alone with her little child, was so terrified at the sight that she fled with her child to a neighbor's where she lingered in an unconscious state until death relieved her on Saturday.

Death from fright seems almost impossible, considering the widespread publicity that had preceded the eclipse of 1869. Apparently Mrs. Gifford had neither read, nor been told, about the eclipse by others. Thus, the *Iowa City Republican* on July 28 carried the following widely disseminated report by Professor Charles A. White, who was with the astronomers located at Des Moines.

The sun will rise eclipsed in the interior of Siberia, on the morning of August 7, 1869, whence the shadow will move in a northeasterly direction, then turning eastwardly and southeastwardly, will pass over Behring's strait and northern Alaska about noon local time. Thence, moving across part of British North America, it will enter the United States in Montana; between two and three P.M., local time. Moving thence across western Nebraska, it will pass diagonally through Iowa—passing over Sioux City, Des Moines and Keokuk about 5 o'clock. Thence it will pass still to the southeast, over Jacksonville, Illinois, across southern Indiana, central Kentucky, eastern Tenn., into and across North Carolina, and will touch the sea-coast at Pamlico sound; and will finally leave the earth not far from the Bermudas. It will be visible in all parts of the United States, and total over one hundred miles wide along the line just indicated, the sun being hid more than four minutes.

The many comments by Iowans, and by the eminent scientists who came to Iowa, form a valuable record for students of this astronomical phenomenon. Writing briefly in his *Eclipses of the Sun* almost a century later, Samuel Alfred Mitchell declared:

> The eclipse of August 7, 1869, crossed America diagonally from Alaska to North Carolina, and fortunately clear skies greeted the observing parties. Little of the important work accomplished will be noted in detail here. Spectroscopically, the most valuable discovery was that the spectrum of the corona was continuous but was traversed by a single green ray. This green line was detected independently by both Harkness and Young, the latter identifying its position as coinciding with the line

numbered 1474 on Kirchhoff's scale. But since this line 1474 is due to iron, it was surprising and perplexing in the highest degree to find it present in the corona and reaching such great heights above the sun's surface. In spite of the apparent coincidence, it was evident that the substance causing the green line was not iron. To it the name *coronium* was given.

The discovery of the above mentioned spectrum led to concentrated research by astronomers in the decade following 1869. And Charles A. Young was a leading astronomer in studying the mystery of the corona which could now be attacked by four methods: the telescope, photography, the polariscope, and the spectroscope. But while new discoveries were made, and new theories were advanced, new problems arose following each successive probe. Thus, the Eclipse of 1878 was considered to have only one-tenth the brightness of the Eclipse of 1871, but it threw out coronal streamers to the incredible length of ten million miles! Why? Truly, the generation of 1869 had many memories to carry with them, memories that, though awesome, brought joy and understanding to their children and grandchildren.

WILLIAM J. PETERSEN