tablishment was enlarged to include a water front of about half the length occupied by the present yard, and from that date to the present the growth has been a steady one, the present yard covering a little over 31 acres, and employing an army of 5,600 men, whose wages alone amount to $54,000 a week.

An excellent idea of this large establishment, and of some of the notable ships to which it has given birth, may be gathered from the accompanying bird's eye view. The buildings are mainly of brick, or of steel frames covered with corrugated iron. The most notable structure is a large building 1,164 feet long by 72 feet wide, and from two to three stories high, in which are included joiner and pattern shops, machine and erecting shops and two mould lofts. The iron foundry is 415 feet long by 264 feet wide, and the boiler shop—the largest of its kind in America—is 387 feet long by 112 feet wide, and it is furnished with two electric traveling cranes capable of handling 70 and 90 ton boilers with ease. There are five large building slips 600 feet long by 75 feet wide, and five wet docks from 600 to 1,000 feet in length, together with a dry dock 462 feet by 70 feet, with a sill depth of 22 feet. In the center of the picture, alongside of the armored cruiser New York, is seen the celebrated floating derrick, known as the Atlas, the largest of its kind in the world. It has a lift of 60 feet, and a radius of 35 feet, for a load of 125 tons.

The yard has a complete pneumatic, hydraulic and electric plant, and in addition to its ship and engine building facilities, it boasts of an ordnance plant for the manufacture of rapid-fire guns up to 4 inches caliber.

The total output of ships from this yard to date is nearly 300, and includes the Morning Light of the days of the clipper; the New Ironsides, an early broadside ironclad; the four fine ships Indiana, Illinois, Pennsylvania and Ohio, built for the American Steamship Company in 1872; and a veritable fleet of ships for the new navy, in which is included such famous creations as the armored cruisers New York and Brooklyn, the commerce destroyers Minneapolis and Columbia, and the battleships Indiana, Massachusetts and Iowa.

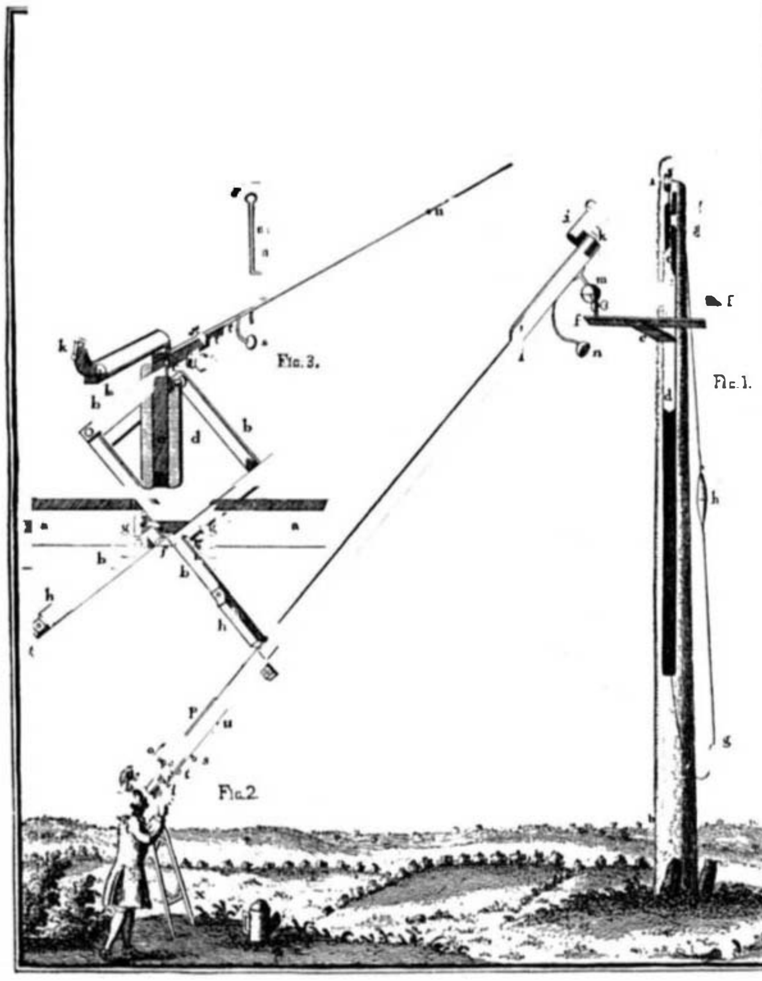
Last, and perhaps most brilliant achievement of all, was the construction of the two great transatlantic steamships, St. Louis and St. Paul, of 11,629 tons displacement, and 20 to 21 knots sustained sea speed. The advent of these twin ships to the transatlantic route may be taken as an earnest of the fact that the United States are determined to win back something of the old time prestige, which was hers when her clipper ships were the fleetest that crossed the seas.

DEVELOPMENT OF THE ASTRONOMICAL TELESCOPE IN FIFTY YEARS.

Like almost every great invention dating back a century or more, it is very difficult to obtain data of a positive character regarding its early history. It will be useless in an article of this nature to speculate on the indirect evidence that may be gathered from the writings of Greek and Latin authors, but from such writers as Roger Bacon we are able to obtain information of a very satisfactory nature regarding the properties of lenses.

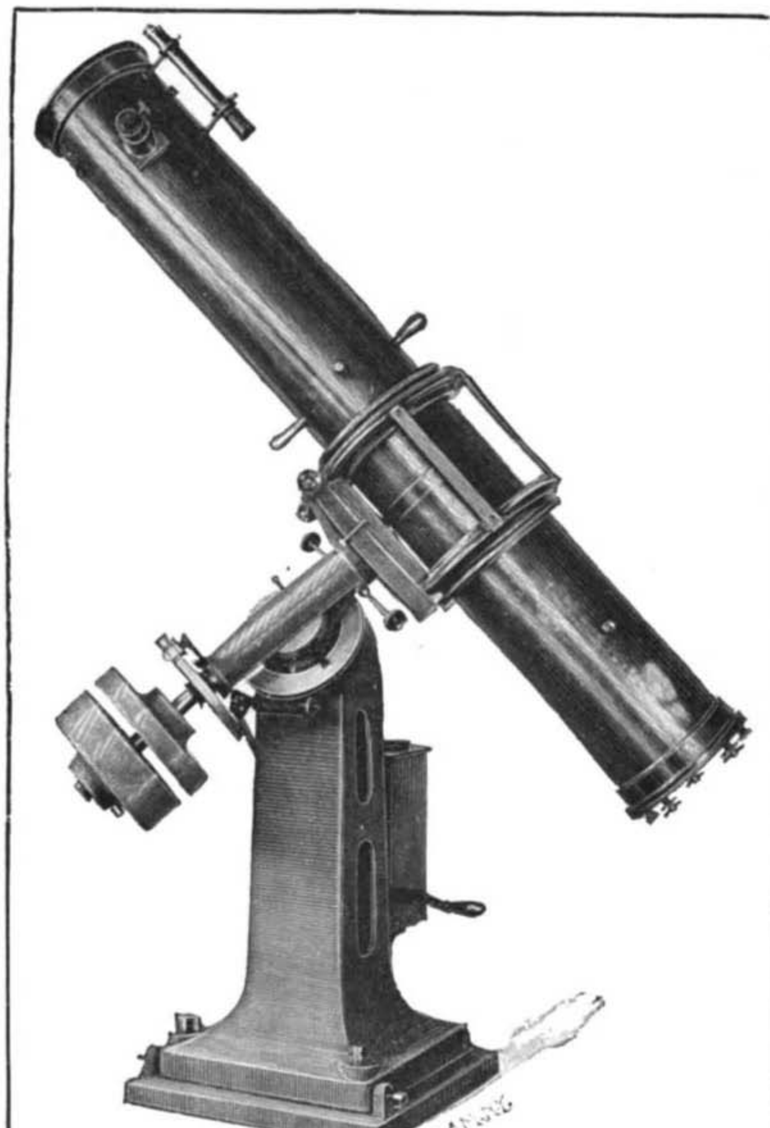
Mention is made of the use of lenses in "Pantometria," by Thomas Diggs, in the sixteenth century. Dee's preface to an edition of Euclid, published by him in 1570, has some remarkable passages on the use of lenses. Batista Porta, in a work published by him in 1561, describes a combination of concave and convex lenses. Henry Lippershey, about 1607, seems to have the best evidence on his side as the inventor of the telescope. In 1609 Harriot made observations on celestial phenomena with an instrument probably made in England, and Sir William Lower, a Welshman, asked Harriot to procure a cylinder (telescope) for him. Galileo, in the same year, learning that the telescope had been invented, made one. Afterward he made a larger one, with which the greatest astronomical discoveries ever recorded were made. Kepler improved the instrument by substituting a convex for a concave eye lens. Huygens made a telescope in 1655 having a focal length of 12 feet, with which he discovered Titan, Saturn's largest moon. His brother made telescopes 107 and 210 feet focal length. About the same time Campani, at Bologna, and Divini, at Rome, were making fine lenses of 90 to 130 feet focal length.

The reflecting telescope was invented by Gregory, in the middle of the seventeenth century. Newton invented his telescope in 1666, and in 1672 Cassegra improved the Gregorian telescope by making the secondary or small mirror with a convex surface, so as to intercept the rays from the great mirror before they came to a focus.



HUYGENS' AERIAL TELESCOPE, 1655.

In 1732 James Short, a young Scotchman, made glass reflectors, silvered on the back; but he soon substituted speculum metal for glass. About forty years later Sir William Herschel commenced his wonderful career as an astronomical telescope maker, producing beautiful mirrors of speculum metal from 6 to 48 inches in diameter. Contemporaneously Schroeter, in Germany, made some excellent reflecting telescopes, and, like Herschel, made many interesting observations with instruments of his own construction.


REFLECTING TELESCOPE.

Having done thus much in the way of a hasty review of the early history of the telescope, we will state a little more in detail what has been done in the way of development of the astronomical telescope within the last fifty years.

From 1840 to 1845 Lord Rosse designed and constructed several large and powerful reflecting telescopes, one of which was six feet diameter and fifty-four feet focal length. The work of this telescope upon nebulæ and star clusters has become historic.

In 1861 Lassell erected his great reflecting telescope on the island of Malta, and Dr. De la Rue constructed several fine reflecting telescopes which he used in photographing the moon, etc.

In 1868 Mr. Thomas Grubb finished the great Melbourne reflecting telescope. For this telescope two 48 inch mirrors of speculum metal were furnished. In almost all reflecting telescopes used up to 1854 speculum metal was employed. This is composed of sixteen parts pure copper, fifty-eight parts pure tin, with slight modifications by various makers.

About the year 1850 Liebeg discovered a method of depositing pure silver on a glass surface. In 1856 Steinheil took advantage of this fact and was perhaps the first to make the now well known silver on glass specula, in which the silver is deposited on the first surface, which has been accurately polished and corrected before the silver is deposited upon it. A year later Leon Foucault described his method of making silver on glass mirrors, and made with his own hands many beautiful surfaces. By this method M. Eichens made the 48 inch mirror for the Paris Observatory, and a few years later Dr. Henry Draper made the 15 inch silver on glass telescope with which he obtained such beautiful results in lunar photography. Later on he constructed a silver on glass telescope of 28 inch aperture, by which he photographed the spectra of stars for the first time. These telescopes are now mounted at Harvard College Observatory. Dr. Draper published a most valuable monograph on the silvered glass telescope in 1864, and by its aid hundreds of amateurs have made very creditable reflecting telescopes.

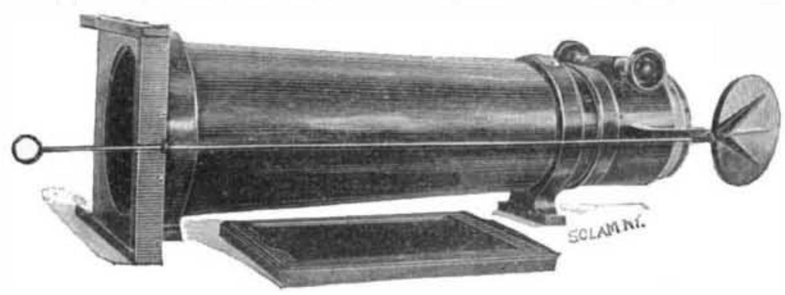
But we must go back to the middle of last century to record what proved to be the greatest invention of the age in the way of developing the refracting telescope. Notwithstanding Newton's dictum that it was useless to try to improve it, owing to the impossibility of producing refraction without dispersion, Euler read a paper before the Berlin Academy in 1747 proving mathematically the possibility of correcting both the spherical and chromatic aberration of an object glass; and curious to say, the very man who published an adverse criticism of Euler's paper was no less a person than the celebrated John Dollond, who is recognized as the father of the achromatic telescope, for upon reading Klingenstierna's paper corroborating Euler's views, Dollond made a series of most valuable experiments which led him to the solution of the problem of the achromatic object glass; namely, that by properly combining two kinds of glass, flint and crown, he could unite the colored rays fairly well and still have refraction to unite the incident rays to form an image. Here we could fill a column with many interesting items of Dollond's work, but lack of space forbids. It is true that when Dollond applied for a patent to protect his discovery, it was claimed that Chester Hall had invented the achromatic objective as far back as 1829; but Lord Mansfield, who tried the case, remarked, "It was not the person who locked his invention in his scrutoire that ought to profit for such invention, but he who brought it forth for the benefit of the public."

Dollond's work soon became famous. He was surely master of it and had a clear field for many years, but he labored under great difficulties in procuring glass suitable for telescopes of any diameter. The writer has read an original letter from Dollond to Prof. Loomis, of Yale, in which he asked three years for the completion of a five inch telescope. Fortunately a genius had taken hold of this problem in the person of Guinand, a Swiss watchmaker, the story of whose life work is as charming as that of Palissy the Potter. After long experimenting, Guinand solved the problem of making fine disks of optical glass, and having associated himself with the celebrated Fraunhofer, in 1805 successfully made optical glass disks up to fifteen inches aperture. To Fraunhofer we owe many of the most important discoveries in the theory of the achromatic objective, and it is sad to record that his brilliant career was cut off by his death at the age of thirty-nine. Foucault died at the same age, but both men during their short lives added to the world's records an immense fund of invaluable data in mathematical and practical optics.

The then great telescopes of Cambridge, Mass., and Pulkova, Russia, were made by Merz and Mahler, the successors of Fraunhofer. Contemporary with the progress of practical optics, mathematicians were developing theories of a critical nature, and the names of Gauss, Littrow and others must always be associated with this great work. In France Lerebours and Cauchoix were making excellent achromatic objectives. In England, Simms; in Ireland, Thomas Grubb, were taking an active part in the charming work; while in America, the Clarks had commenced their great work; first on reflecting and afterward on refracting telescopes. Every American has a personal pride in the work of the Clarks, and their objectives soon became famous in every part of the world for their accuracy of figure and fine definition. But one of this firm is now living, Mr. Alvan G. Clark, who has recently finished the great objective of the Yerkes Observatory, the largest objective yet constructed. There are but two firms in the world who have attempted to furnish the glass disks for these great telescopes—Mr. Mantois, of Paris, successor to M. Feil, and Dr. Schott & Company, of Jena, in Germany; but Macbeth & Company, of Pittsburg, Pa., have lately succeeded in making optical glass up to 20 inches diameter, of very excellent quality. To-day we have in France the eminent opticians the Henry Brothers, who have made many large and fine objectives; Secreton & Bardou, who have constructed many excellent telescopes of smaller size. In Germany Merz still sends out some good objectives, while Steinheil & Son are making objectives of the highest type. In England Messrs. Cooke & Company are doing splendid work, while in Ireland Sir Howard Grubb is turning out many fine telescopes of large size. In America Mr. Alvan G. Clark, of Cambridge, Mass., is the successor of the firm of Alvan Clark & Sons. Mr. Henry Fitz made a large number of the older glasses and the Spencers have contributed several large objectives to American observatories. Mr. Clacey, of Washington, has also made a few excellent objectives of good size. Indeed, there have been quite a number of objectives made by American amateur workers that have proved to be worthy of the makers. In Allegheny, Pa., John A. Brashear has been engaged in the development of the achromatic objective from new and valuable formula devised by Dr. Charles S. Hastings, of Yale University.

In the mounting of great telescopes, engineering problems of a difficult nature have had to be met, and to the mechanician we must accord a place of honor in the development of the telescope; for, when it is taken into consideration that such a telescope as the 36 inch at the Lick Observatory weighs forty-five tons, and the 40 inch of the Yerkes Observatory weighs nearly seventy-five tons, and that the great tubes of these instruments must move with the utmost precision, aye "keep time with the stars," it is easy to comprehend that the engineering problems are intricate and difficult of solution. But our astronomical engineers have been equal to the task, and have brought the mounting of the telescope to the highest perfection. In France we have Gautier; in Germany, the Repsolds; in England, Cooke; in Ireland, Sir Howard Grubb; in America, Messrs. Warner & Swasey, of Cleveland, O., and Mr. Saegmuller, of Washington. The largest instrument mounted by Mr. Saegmuller is the 20 inch of the Denver University. Messrs. Warner & Swasey constructed the 36 inch (an illustration of which appeared in our issue of June 16, 1888) Lick telescope mounting, the 40 inch of the Yerkes Observatory, and many of the larger telescopes that have been constructed of late years. Constant efforts have been made to lessen the work of the observer in handling the "magic tube," and perhaps no better type has yet been constructed than the new mounting for the 26 inch equatorial of the United States Naval Observatory, an illustration of which is here given. This mounting is what the engineer would call "clean," as it has no useless appendages, but has everything needed for use of the observer. This mounting has been constructed recently by Messrs. Warner & Swasey, of Cleveland, O.

A new type of telescope has of late years come into prominence as an "astronomical weapon," i. e., the photographic telescope. There are two general forms; one as adopted by the Photographic Congress for small but accurate fields of stars, which is to be used to obtain a photographic chart of the entire sky, the other for wide field "picture" photography. The eye at the telescope receives an impression from the light coming from a star and dismisses it, so that by long gazing we see no more stars than by a brief glance. Not so with the photographic plate. Every tiny ray sticks to the plate, and if the astronomical camera is held long enough upon the stars in the field, the images become imprinted by thousands—images of stars no telescope will ever show to the eye. The writer has seen on a plate 14 × 17 inches not far from fifty thousand stars photographed by Dr. Gill, of the Cape Observatory. Prof. Barnard, when at the Lick Observatory, used the photographic telescope in most valuable studies of comets and star clusters, while Dr. Max Wolf, of the Heidelberg Observatory, has discovered many new asteroids by the aid of this wonderful tool of the modern astronomer.



ASTRONOMICAL PHOTOGRAPHIC CAMERA, WITH DOUBLE OBJECTIVE, FOR WIDE FIELD PHOTOGRAPHY.

To Dr. Lewis Rutherfurd we owe the principle of the refracting telescope as applied to purely photographic purposes, and the instrument made by his own hands is typical of all that have followed in this line. The reflector had already been used for photography and still holds an important place for this kind of astronomical work.

The spectroscopic discoveries of Wollaston and Fraunhofer, as well as those of Herschel, Fox-Talbot and Brewster, were made several years previous to the period we have under consideration. After 1849, however, through the efforts of Foucault, Kirchhoff and others, the coincidence of the absorption bands and bright lines of the spectrum was established, and upon this discovery was based the star spectroscope, by means of which so many brilliant astronomical discoveries have been made. This instrument, as improved by Kirchhoff, Bunsen, Huggins and others, has been the means not only of revealing the constitution of the sun, stars, comets and nebulæ, but the condition of matter of which these bodies are composed.

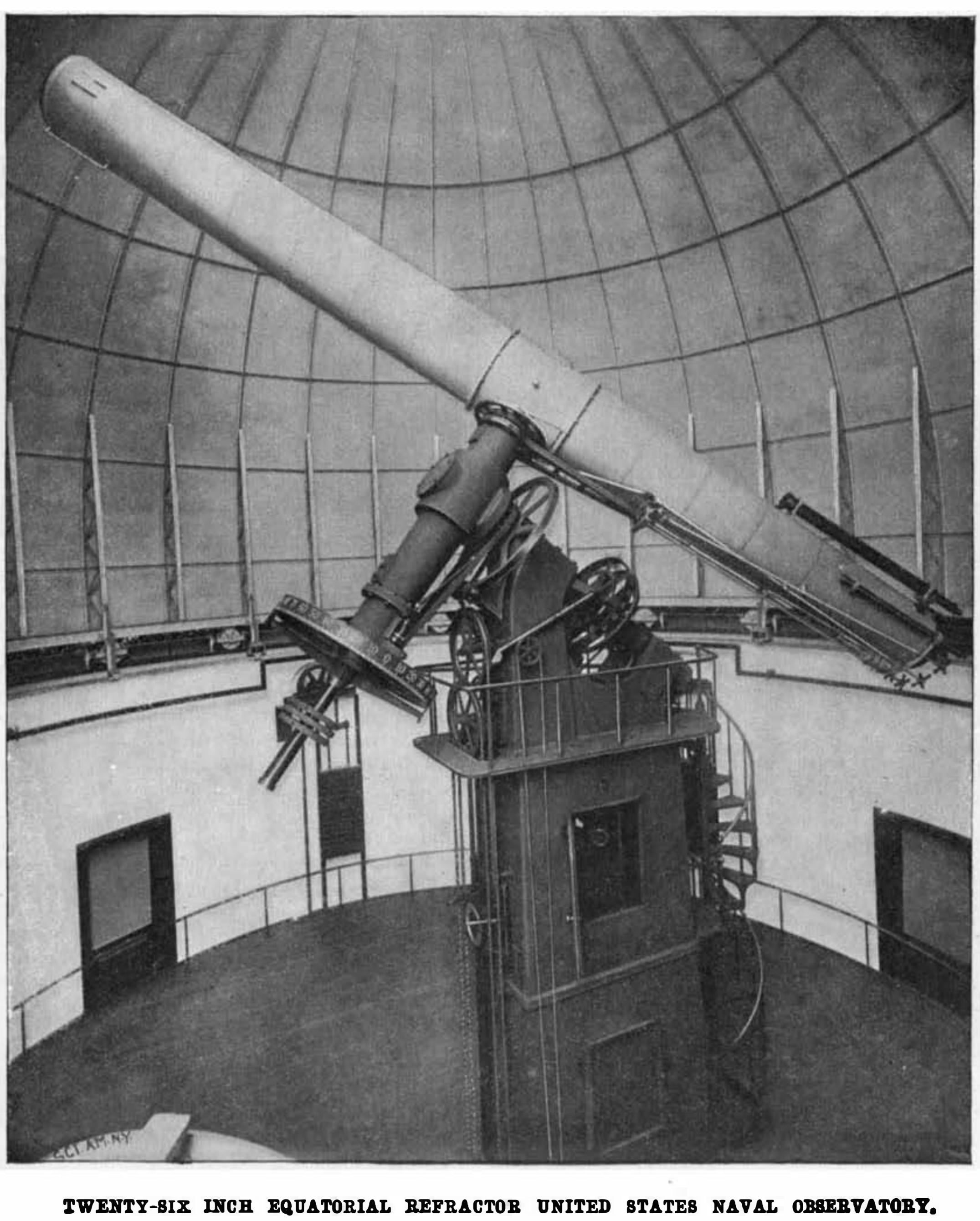
Spectroscopic observations of the motions of the stars in the line of sight yield results of the highest importance. By a single observation it can be determined whether the star is approaching or receding, and with what velocity. By the union of this method with the ordinary telescopic method, even though the path of the stars should cross the field of vision at any angle, the velocity of the star and the direction of its movement can be determined, provided the distance of the star is known. The spectroscopic method of measuring the velocity of stars has only recently been put in practice.

By the use of the photographic plate in connection with the spectroscope, extremely close binary systems have been discovered which would certainly never have been known if the ordinary telescope alone were available.

But the half has not been told. When we compare the little telescope of Galileo with the majestic 36 inch of the Lick Observatory, we think of the mighty step from one to the other, but it has all come along slowly through the years of the past until further progress would seem to be limited by our environment. The writer is not willing to say that we have reached this limit, either in optical or engineering problems, as master minds still look and hope, and are now working for new discoveries in the realms of optical science.

THE TELEPHONE.

In the early days of the telephone no one seems to have conceived of the possibility of transmitting speech by electricity. Natural as the idea might seem, it apparently transcended any one's imagination up to a comparatively recent period. Page had discovered, in 1837, that an iron bar magnetized and demagnetized emitted sounds, and he went no further. Over twenty years later, about 1860, Philip Reis, a German school teacher, was experimenting on a telephone which, in his hands, took various shapes, always, however, having a different construction of the receiver and of the transmitter. His receiver had a diaphragm bearing at the center a contact piece. The diaphragm was caused to vibrate when acted on by the voice, and Reis relied on the effect on the contact to cause vibrations in the current, the latter being produced by a battery. In the same circuit was placed his receiver, one typical form being a knitting needle wound with a coil of wire and mounted on a sounding box. The apparatus was first shown at a seance of the Physical Society of Frankfurt, in 1861. Reis believed that his instrument could transmit words, and he is reported to have said that he had shown the world a road to a great discovery, but left it to others to follow it up. He died in 1874. All that was wanted to make his telephone a success was the substitution of carbon for one or both of the metallic contact points which he employed. Numerous variations of his construction may be found, but what has been said about



TWENTY-SIX INCH EQUATORIAL REFRACTOR UNITED STATES NAVAL OBSERVATORY.