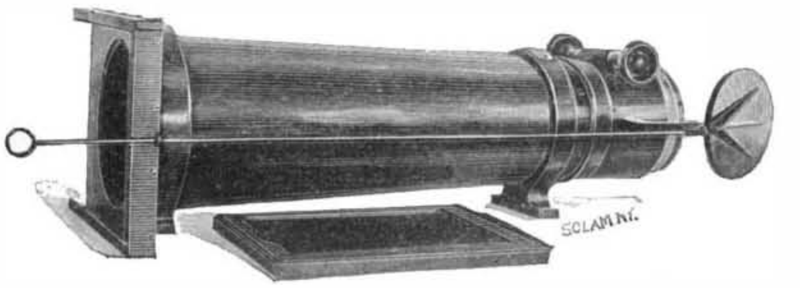
inches aperture. To Fraunhofer we owe many of the most important discoveries in the theory of the achromatic objective, and it is sad to record that his brilliant career was cut off by his death at the age of thirty-nine. Foucault died at the same age, but both men during their short lives added to the 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.

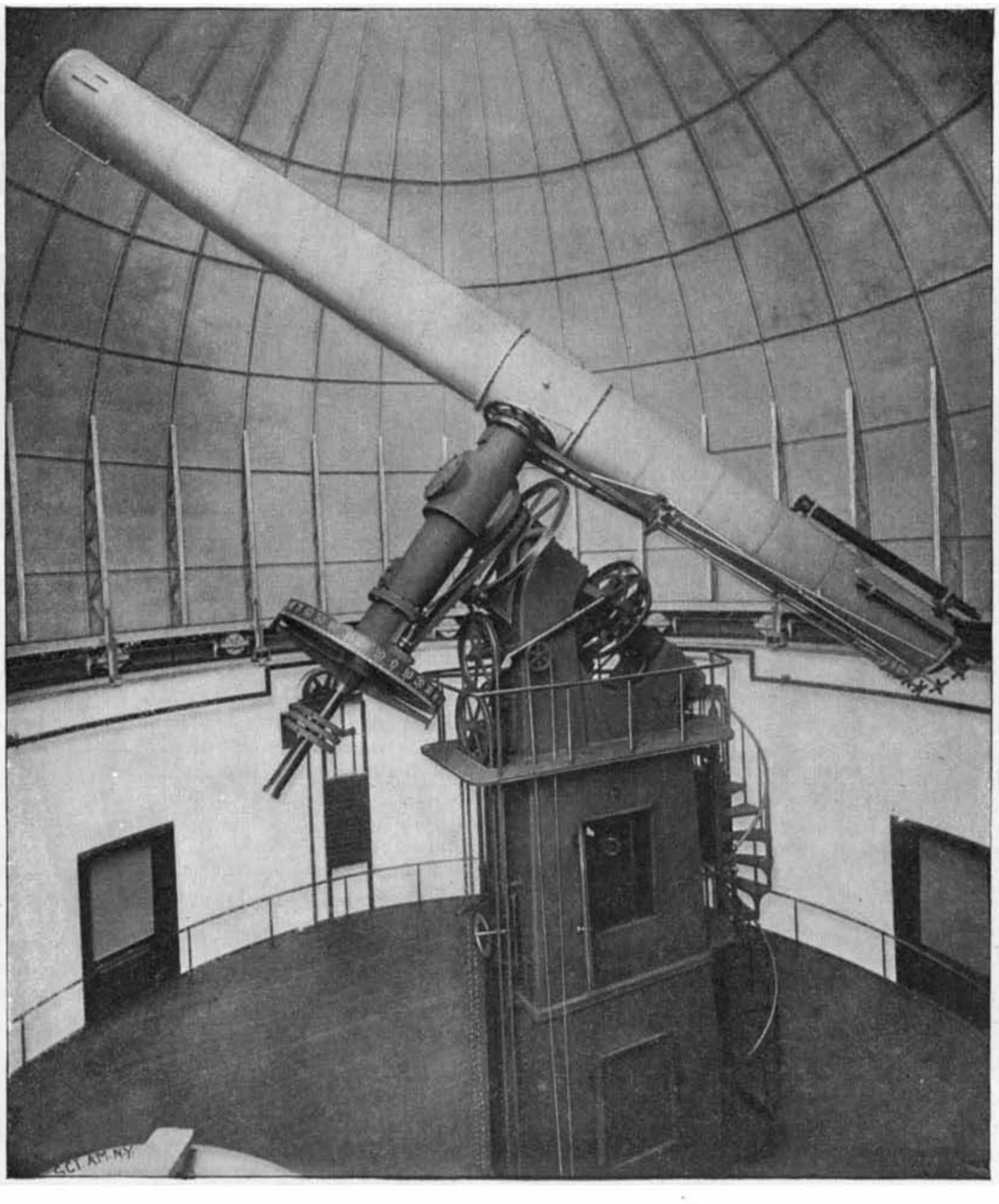
Spectroscopic observations of the motions of the stars in the line of sight yield results of the highest importance. By a single observation it can be determined whether the star is approaching or receding, and with what velocity. By the union of this method with the ordinary telescopic method, even 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.

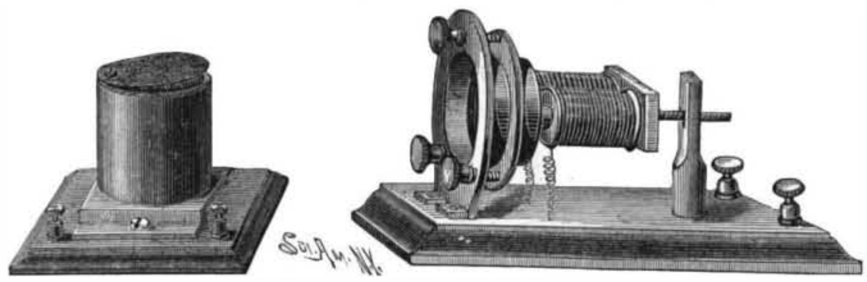
In the early days of the telephone no one seems to have conceived of the possibility of transmitting speech by electricity. Natural as the idea might seem, it apparently transcended any one's imagination up to a comparatively recent period. Page had discovered, in 1837, that an iron bar magnetized and 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



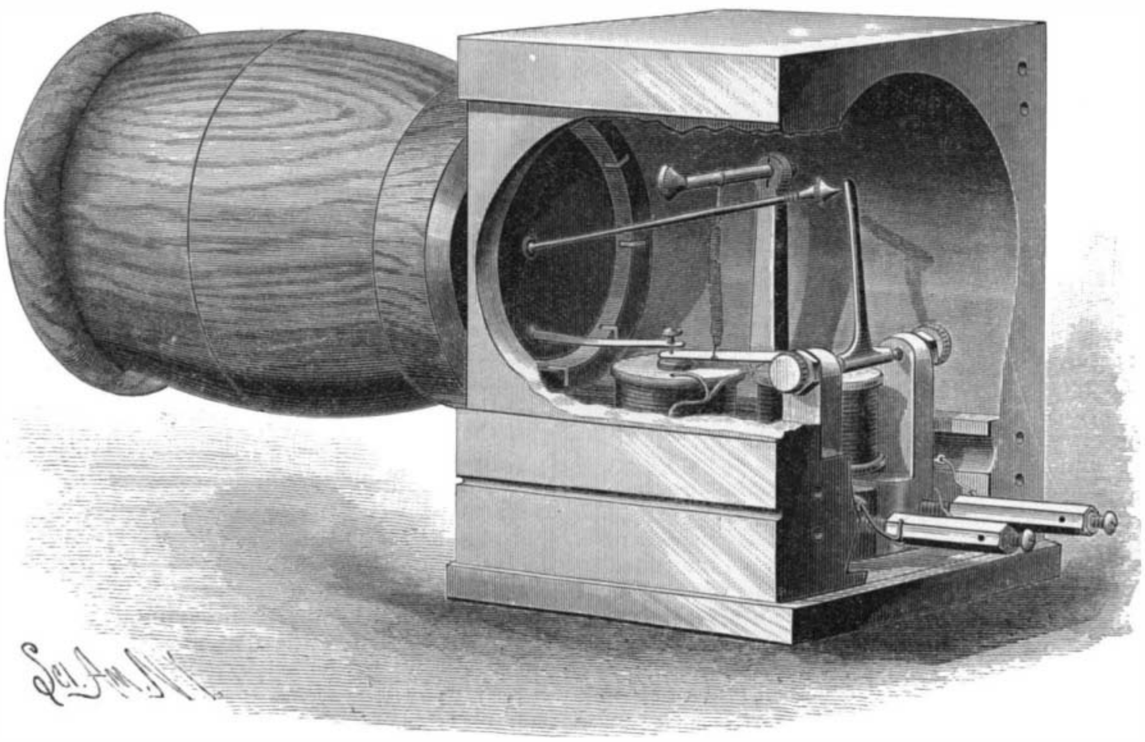
TWENTY-SIX INCH EQUATORIAL REFRACTOR UNITED STATES NAVAL OBSERVATORY.

it gives the general idea. Many other investigators experimented with his telephone.

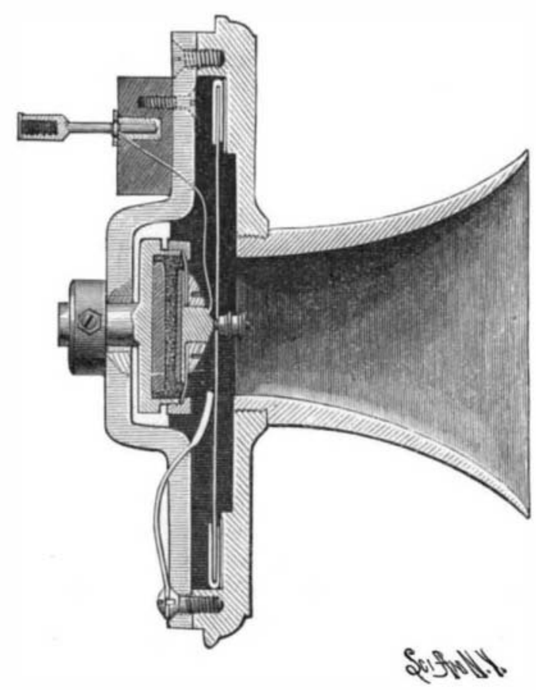
About 1868 Royal C. House, an American inventor whose printing telegraph had awakened universal interest, invented what he termed an electro-phonetic receiver for his telegraph. His idea was to produce an instrument which, precisely like the modern telephone, would produce an audible sound upon receiving a weak current of electricity. It consisted of a box closed with a diaphragm, against which two rods were pressed endwise by the rocking or pivoted armature of an electromagnet, so that in its motions the armature would alternately push against one or the other rod. The electromagnet was actuated by weak currents, and an ear placed opposite an ear piece leading to the diaphragm received the sound. This instrument is a telephone far superior to Bell's original invention, although its inventor had not the least idea of its capabilities for the transmission of articulate speech.



BELL'S EARLY TELEPHONE.

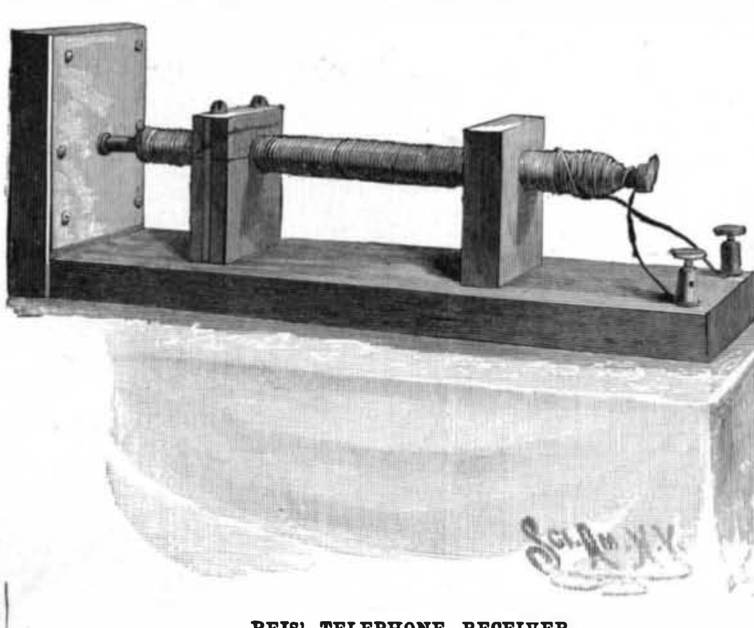


THE HOUSE TELEPHONE.

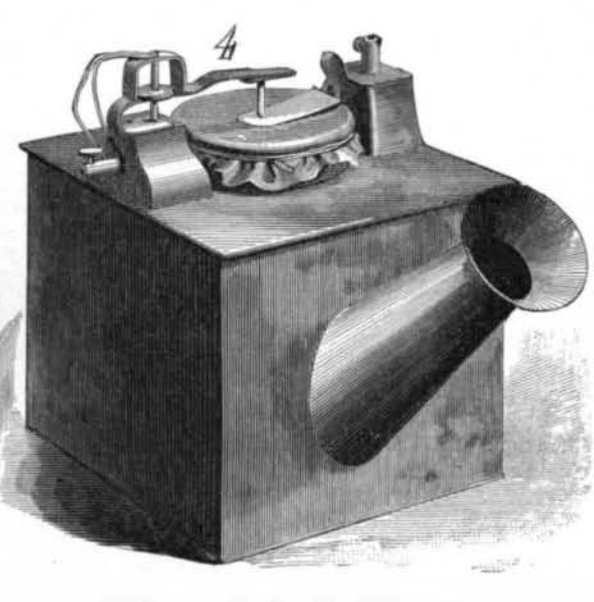


MODERN CARBON OR MICROPHONE TRANSMITTER.

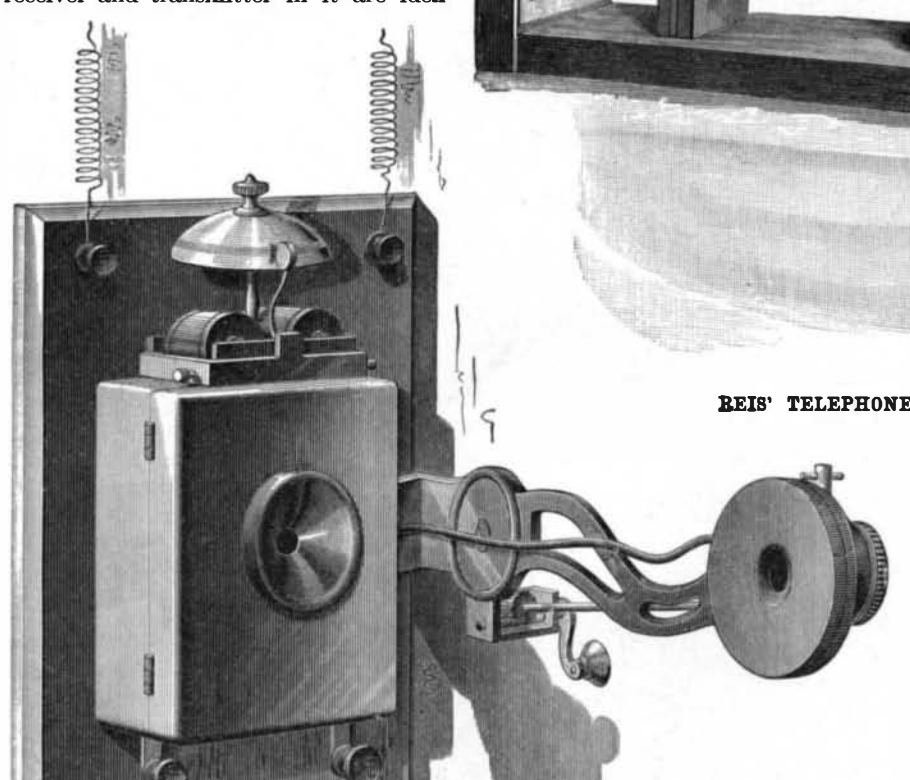
Eight years later, Elisha Gray, of Chicago, and Graham Bell, of Boston, were working on the problem of the transmission of sound by electricity, and on the 14th of January, 1876, Bell took out his patent for his first instrument. The receiver and transmitter in it are identical in their essential features, each consisting of an ear or mouth piece, over whose end a diaphragm is stretched, which diaphragm is made of gold beater's skin. By means of a little rod it is connected to the oscillating armature of an electromagnet, and a battery is included in the circuit. The assumption was that if one of these instruments was spoken into the diaphragm would vibrate, causing the armature of the magnet also to vibrate, thereby introducing variations in the current so as to reproduce the vibrations from the diaphragm into the receiving instrument. In the summer of 1876 Bell exhibited his telephone at the Centennial Exposition in Philadelphia. It varied somewhat from the instrument of his patent. The transmitter was a vertical electromagnet with a plate armature, which was spoken against by the person sending the message. It worked with the utmost difficulty, but speech was transmitted. The next improvement took the shape of omitting the battery and substituting permanent magnets therefor. It was found that identical instruments could be used for receiving and sending, each consisting of a permanent magnet wound with a coil of wire, near the poles of which magnet a thin diaphragm of iron was held. By speaking against one of the diaphragms it was caused to vibrate, thereby inducing currents in the line connecting the two coils and causing the second diaphragm to repeat the sound uttered in the first. Almost at the same time with Bell, Gray had worked upon the telephone system, using a varying liquid contact, made to vary by the vibrations of a diaphragm and thereby producing the speaking current.



REIS' TELEPHONE RECEIVER.



REIS' TELEPHONE TRANSMITTER.



EDISON'S CHEMICAL RECEIVER AND CARBON TRANSMITTER.

In 1856, Du Moncel had discovered that when two conductors are in contact the electrical conductivity of their contact varies with the change of pressure therein. The Bell telephone, in which the gold beater's skin for a diaphragm was early abandoned, and a plate of iron substituted therefor, was astonishingly sensitive to minute variations in sound when used as a receiver; when used as a transmitter, the agitation of the plate by the voice produced such minute changes that the system embracing a Bell telephone at each end was very imperfect and was regarded as not much better than a scientific curiosity. The Du Moncel principle was now applied to telephony, Edison and Hughes being among the earliest experimenters. The telephone system took a new shape. A transmitter based upon the use of a carbon contact was used. The receiver was a Bell telephone. As a carbon contact, however, much agitated, generated no current, a battery was also put into the circuit and at once the telephone system was completed; talking in an ordinary tone of voice into the microphone, the telephone miles distant repeated the sound. The rest was detail. The most extraordinary results were produced by some of the early transmitters. Edison adopted a carbon button which was held against a contact piece by a diaphragm. This proved astonishingly sensitive to the voice. It was only one of a whole series of changes which were rung upon the microphone. Carbon balls, powder, and rods in every conceivable relation were adopted. The microphone made the telephone a success.

It was rapidly introduced in commerce. One of the curiosities of the telephone was Edison's loud-speaking or chemical telephone. This receiver was based on a chemical principle. Directly back of a micro-diaphragm was a cylinder of plaster of Paris moistened with a chemical solution. A strip of platinum bore, spring fashion, against the surface of the cylinder, the other end being attached firmly to the center of the diaphragm. The instrument was placed in a circuit, one wire connecting with the spring and the other with the cylinder. When the cylinder was turned, it pulled upon the diaphragm evenly and no sound was produced. If a current from the transmitter were passing, its action on the chemical solution caused the mechanical resistance or the friction between the cylinder and the spring to vary, and thereby the diaphragm was vibrated in exact accordance with the original motions of the diaphragm of the transmitter. In this way the message was very loud and could be heard over the whole room. The telephone at once went into extensive use and was introduced everywhere. Enormously expensive law suits were instituted to determine the proprietorship in the basic inventions, which were decided in favor of the owners of the Bell patent, who have succeeded in maintaining a monopoly of the business for many years.

As now used, the telephone operating with a microphone transmitter and a Bell telephone receiver uses the secondary or induced current. To put subscribers in communication with each other what are known as switch boards are operated in the central exchanges. Some of these switch boards are enormous pieces of work representing thousands of dollars in value and embodying in their construction hundreds of miles of wire. Gradually the instruments have taken a single type of construction and the telephone industry has become one of the greatest electrical interests of the day. By the use of more perfect instruments and heavy copper wire the area covered by the telephone has been greatly extended and long distance lines have been established between the leading cities of the world.

STATISTICS OF THE TELEPHONE BUSINESS OF THE UNITED STATES FOR 1895.

Number of exchanges	927
" " branch offices	686
" " instruments in hands of subscribers	674,976
Miles of wire on poles	260,324
" " " buildings	12,861
" " " underground	184,515
" " " submarine	172
Total employes	11,930
Total stations	281,695
Estimated daily exchange connections	2,351,420
Average cost of connection to the subscriber, from 1 cent to $10\frac{2}{10}$ cents.	
Miles of underground wire in New York	38,986
" " " " " Chicago	20,352
" " " " " Boston	15,687
" " " " " Philadelphia	10,999

FIFTY YEARS OF THE SCIENTIFIC AMERICAN.

The present issue is published in the form of an historical review of the progress of science and mechanical industries during the past fifty years, and as it is commemorative of the fiftieth anniversary of the publication of the SCIENTIFIC AMERICAN by the present owners, it will, we feel sure, not be considered amiss if we give some account of the early beginnings and struggles through which the journal passed before it had made for itself a position of authority in the particular field to which it is devoted. The early numbers of the paper are rarely attainable, and cannot generally be reached even in our large public libraries. We have reproduced some pages of the first issues, in order to give our readers some idea of the character of the paper at its inception, and we give below some account of its peculiarities and characteristics.

The size of the paper was more like that of the present daily newspaper. It had four pages. All the matter was printed on both sides of one large sheet and folded in the center so as to make a folio 19 × 13¼ inches.

Across the engraved heading, on which were shown steamboats, waterfalls, windmills, factories and a temple, as may be seen by examining the facsimiles of these early issues published on the front page, was printed the name, "SCIENTIFIC AMERICAN," in large letters.

PATENT DEPARTMENT OF MUNN & COMPANY, 1849.
From a contemporary print.

To those interested in studying the progress of science in this country, the first volume is instructive in showing the gradual, yet rapid development that has taken place. The proprietor, then, Mr. Rufus Porter, was a versatile genius. Finding the world of science too small, he branched out in several directions; included poetry, temperance and religion among the subjects for discussions and essays. Temperance combined with science was uppermost in his mind, and gave the journal a high moral tone.

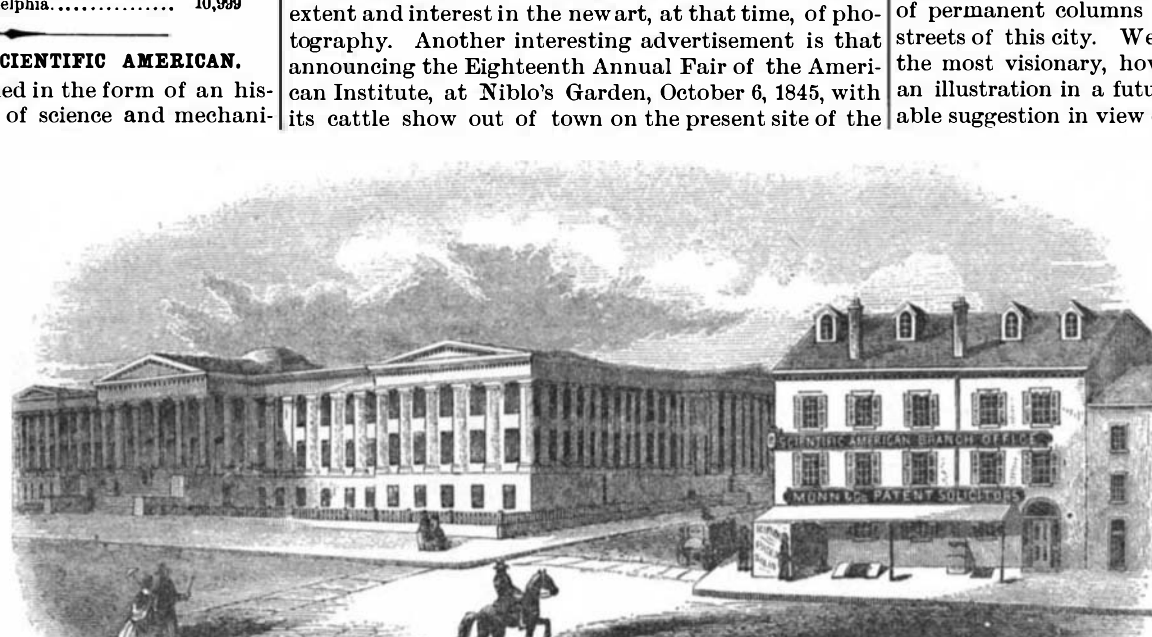
An examination of the business columns of the new paper will reveal many curious advertisements, and in them will be found some names well known to-day. There appears the advertisement of Daniel Davis' journal "Electrical Apparatus," a review of his famous book, "Manual of Magnetism," ranking as the modern "Gilbertus de Magnete." Adams & Company's Express advertise largely, stating that it sends daily iron chests to Pittsburg for the transportation of valuables. "The Pioneer and Express Line" takes goods to Philadelphia in three and a half days, in perfect order. Advertisements of daguerreotypes and supplies show the extent and interest in the new art, at that time, of photography. Another interesting advertisement is that announcing the Eighteenth Annual Fair of the American Institute, at Niblo's Garden, October 6, 1845, with its cattle show out of town on the present site of the Fifth Avenue Hotel, opposite to what is now Madison Square Park. In the issue of October 9 is a short description of the fair. Among the 1,300 entries is Hoe's printing press, Colt's repeating pistol, and Gurney's daguerreotypes, all of them time honored.

It was quite difficult to get up good illustrations then. The engravings were crude, yet they enhanced the popularity of the paper in the eyes of subscribers and readers. The illustrations covered several different subjects. On the front page of the second issue is shown a self-regulating windmill; in the next number is a rotary steam engine, and in the succeeding number appears a picture of a traveling balloon, which may be accounted for by the fact that Mr. Rufus Porter was a strong believer in the possibilities of aerial navigation. In later issues may be found as front page embellishments illustrations of a semaphoric telegraph, a steam carriage for common roads, Brown's dovetailing machine, a combination trunk lock, and an improved tubular boiler.

On October 20, 1845, the office was destroyed by fire, which caused an omission of two issues of the publication. In the November 13 issue, the first published after the fire, is a very characteristic editorial giving interesting details. The loss is placed at seven hundred dollars; not insured. In the same number as many as eight vessels are spoken of as being engaged in commerce on Lake Superior, while more vessels are building. It also mentions that a line of telegraph is being laid from New York to Pittsburg and that one between New York, Philadelphia and Baltimore will soon be completed.

Another item describes the steamship Great Britain, one of the earliest screw vessels, and attacks the practicability of screw propulsion. Railroad progress is given a prominent place. One item tells its own story: "Norris, of Philadelphia, has sent two more of his splendid locomotives to Russia." It demonstrates at how early a date the American locomotive was appreciated abroad, and is prophetic as regards the adoption of American machinery by Russia. It has been recently stated that an immense locomotive plant will be established in Russia, based on American ideas, as carried out by the Baldwin Locomotive Works, of Philadelphia, for the equipment of the great Siberian Trans-Continental Railway, which was at that time projected, but which is not yet completed. Another item alludes to a great work that is being done in the grading of thirty miles of roadbed, expecting it would be completed during the winter. The Baltimore and Ohio road has 177 miles finished. Most extraordinary of all, in the issue of December 11, 1845, is found the statement that "the last project we have heard on this subject is that for the construction of railroads elevated on rows of permanent columns to be erected in the principal streets of this city. We believe this project to be not the most visionary, however, and shall probably give an illustration in a future number." Quite a remarkable suggestion in view of the fact that it was not actually carried out until twenty or more years later, and may be said to be the foreshadowing of our present elevated railroad system.

Captain Eads' proposed ship railroad, across the Isthmus of Panama, attracted considerable attention, because of the ingenious application of hydraulic power to sustaining the strains on ships. But in the first volume of the SCIENTIFIC AMERICAN is to be found a ship railroad which solves the problem at once. It is proposed to mount a great tank upon wheels, to float the ships into it, then to close its ends like a lock, and carry the whole across the land,



THE FIRST WASHINGTON OFFICES OF MUNN & COMPANY.
United States Patent Office at left.