Barring the bicycle, probably no craze was ever so widespread as that of modern photography. Methods of manipulation and improvements in lenses and apparatus have kept pace with improvements in the art itself, and the large demand for apparatus and material effected a corresponding reduction in prices. Lenses have been devised for every use, and the very recent improvements in optical glass have rendered it possible to produce lenses which are marvels of perfection.

It is needless to mention the improvements in cameras and portable apparatus, for we think it would be almost a rarity to find a family of which some member is not practically interested in photography. A great impetus was given to modern photography by the invention of the hand camera and more particularly that of the magazine hand camera. Magazine cameras in great variety have been brought out. Most of them have been fitted for the use of roll films or cut films, but a small proportion are arranged for receiving glass plates. Such cameras have been made as large as 8 by 10. The beautiful modern folding camera, being very light and portable, has become a great favorite with both professionals and amateurs. It is even more portable than the magazine camera.

From the ordinary side window as a source of illumination, the daguerreotypist turned to the skylight, and special skylights, some of them of large size, were constructed and used to great advantage in the production of pictures which have never been surpassed in soft, delicate shading.

After the invention of highly sensitive plates it was possible to make a good picture with a smaller skylight, also with a good sidelight, when suitable screens were provided. With sensitive plates came the use of artificial lighting and flash lights for instantaneous work in the night, and in caves and dark places.

Since the development of the electric light many photographic establishments have been fitted out with electric lighting apparatus, permitting of taking portraits at night and in cloudy weather. An additional advantage in the use of artificial light is that of carrying on the work on the first floor, thus saving stair climbing or traveling in the elevator. With proper management the amateur photographer may procure flashlight pictures at home in the evening which compare favorably with daylight work.

Early in the history of photography it was noticed that true color values were not rendered in any photographic pictures. Yellow, red, and green always appeared darker in the picture than in the object, while blue and violet appeared lighter. To correct this defect in photographic pictures the plates were made color sensitive by coloring them with applied dyes, or by incorporating the dyes with the emulsion used in coating the plate. The difference between pictures taken with orthochromatic plates and those taken on ordinary plates is very noticeable. Colored screens have been used in connection with ordinary rapid plates for securing similar results, and in copying paintings, tapestries, and other works of art depending upon color value for effect. Both the yellow screen and the orthochromatic plates have been applied simultaneously.

Very early in the history of photography, in fact before Daguerre's discovery, the workers in this line conceived the idea of making pictures in the colors of nature, or as they are shown on the ground glass or screen of the camera obscura. Fugitive colored pictures were made which could be examined by weak light, but they were quickly destroyed when exposed to strong light. No means was ever found for fixing these colored images. Experiments looking forward to the discovery of some means of fixing and preserving the images have been carried forward without much success since the days of Daguerre.

Tricolor photography is not a strictly modern invention, but it has been perfected to a great extent within ten years, and very pleasing pictures can be produced by this process, although they do not present the ideal colored picture. Such pictures are produced by using three separate plates and taking the pictures through three separate color screens, red, green, and blue; a positive made from a negative taken through a red screen is transparent through all places where pure red is seen in the subject represented, also more or less in parts representing purple or violet and orange. A positive taken through the green screen will be transparent in the parts that are green in the subject. It will be transparent also in the parts representing yellow. In a similar way a picture taken through a blue screen is transparent to the parts representing the blue portions of the subject.

According to one method, the prints from the negative are made upon sensitized gelatine, the gelatine carrying the color which is required to build up the portion of the picture demanding that color. When these three prints are made and superposed, they reproduce approximately the colors of the scenes represented.

A modification of this method which results in truer colors is accomplished by making three positive black and white prints representing the three colors and projecting them on a screen, where they are superposed, suitable colored screens being placed in front of each positive. Some very beautiful effects are produced by this method.

Lippman, of Paris, not long since discovered a very simple and interesting method of producing photographs in color. He first produces a suitable negative, prints a positive from the negative and backs up the positive with a film of mercury. The image is seen by reflected light, and the colors are produced by interference of light in a manner similar to Newton's rings.

Among other developments in photography within very recent years may be mentioned several methods of reproducing photographic pictures in black and white, and other tints by lithography, photogravure, collotype, half-tone and line etching. The collotype is a simple style of photographic reproduction. In making the collotype, the glass which is to support the film is finely ground and a solution of albumen and silicate of soda and water poured over it to form a foundation for the film. Upon this foundation is poured a solution of ammonium bichromate and gelatine in water. When the plate is dry it is exposed to the light through a negative and immersed for a time in cool water, after which it is dried in a bath of glycerine and water, and coated with printing ink. The plate is then printed according to the method of the lithographic printer.

In photogravure the shadows are depressed in the plate, and the printing is done on practically the same principle as that of steel or copper plate printing.

In making a photogravure, a transparency or positive is taken from a negative by any of the well-known methods, and a copper plate larger than the print to be made is cleaned and dried and then coated with a solution of gelatine and potassium bichromate in water. The plate is then dried, placed in a printing frame, and exposed through the transparency or positive, after which the surface of the film is dusted, etched and cleaned, when the plate is printed from, after inking and wiping off, either in the same manner as a copper or steel plate engraving, or as an etching, leaving a thin film of color in different positions on the high lights to modify the effects.

In the half-tone process the sensitive plate is exposed in the camera through a grating, which leaves a texture on the negative, which, when printed through on the bichromatized metallic plate, produces lines or dots, which are etched, and which, in printing, leave high lights and carry the ink, which produces the shadows. When three plates are made through three colored screens and three impressions are produced from the plate with appropriate colors, very good pictures approximating the tints of nature are produced. This is now the most popular method of illustrating with colors. Recently improvements in the shape of apertures in the screen have been made.

With the improvements in photography, the projection lantern has been rendered very efficient, so that either colored or black and white pictures may now be projected upon a screen twenty-five feet square, producing very satisfactory results. In fact, some of the most popular entertainments of the day are on this order. With improvements in lenses, plates, and developers the speed of photography has been increased to such an extent as to produce a distinct image in the space of $\frac{1}{10000}$ of a second. This renders it possible to catch images of insects, birds and other animals and even projectiles in their successive positions. By reversing the process these images are reproduced in such rapid succession as to give the pictures all of the movements of life, without any apparent break in continuity. This is in brief the principle of the kinetoscope.

Photography has proved itself to be of incalculable value to other sciences. In surgery it has been employed for differentiating tissues. It has been employed for detecting stains invisible to the eye. It is a faithful recorder of physical phenomena, and has been made by Roentgen, in connection with the X ray, to show interior portions of the body, and make other disclosures of a startling nature.

In addition to these, photography has been used for grasping celestial objects beyond the power of the eye and telescope, for mapping the heavens, measuring and recording spectra, showing the structure of the sun, revealing the extent of nebulæ, picturing comets, and making records of eclipses and other phenomena. It has also revealed things beyond the power of vision and the microscope.

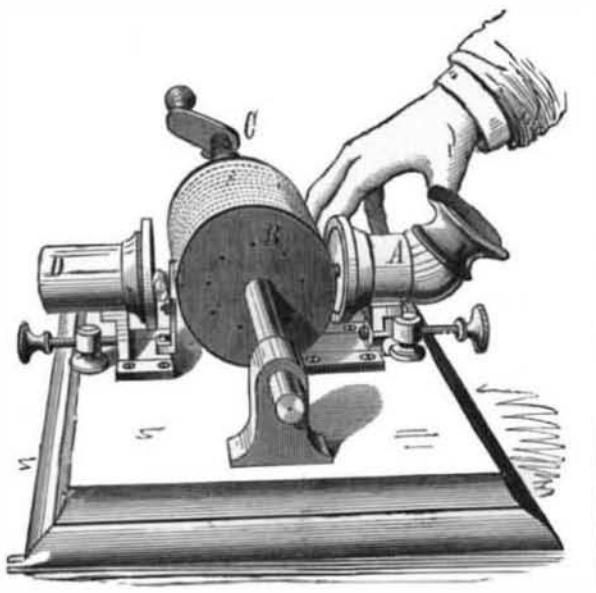
CHEMISTRY.

An attempt to review the progress of chemistry during the last fifty years requires more space than this entire issue would put at our disposal. Fifty years ago chemistry and physics were both established on a firm basis. Chemistry had had nearly three-quarters of a century in which to develop its theory and had become formulated into an exact science in which the results were attested by the balance and in which exact analyses were applied by some of the most brilliant minds that the world has ever seen. At that time and for many years subsequent the old binary or dual system of Berzelius was still employed by chemists, and those who graduated from the polytechnic schools and colleges up to 1870 studied chemistry under what is known as the old system. Dumas opposed the Berzelius system, and, supported by those constituting the French school of chemists, obtained a victory about 1832. Nevertheless, for forty years after that period the old system held sway, though of course to a greatly diminished extent. To-day some of the old time chemists who have been unable or indisposed to drop the old system and have not changed it for the new still write sulphuric acid HO,SO_3 instead of H_2SO_4, and so for other compounds. Those who, like the writer, studied chemistry under the old system and had to change it for the new realize how much is involved in it; how great an improvement the new is over the old, and yet how unwillingly they dropped the system of their student days. The new system carried out Dalton's atomic theory to its logical extent, and chemistry took on a more systematic aspect, and the consequences of the acceptance of Dalton's and Avogadro's law appeared in the monumental work of Mendeleeff. The indefatigable scientist of Siberia, who, it is worth noting, is a seventeenth son, in a paper read before the Russian Chemical Society in 1889, at one bold stroke made his great announcement of the periodicity of the properties of the elements. In a halting way his predecessors had noted some slight relations between the atomic weights, especially of the four haloids, but Mendeleeff applied his system to the entire scheme of elements, drew up his famous table, showed how in accordance with it the elements ought to occur, and at once established one of the greatest triumphs of science, one that led to some of its most remarkable achievements. This table was filled with blank spaces where, in order to carry out the complete series, elements ought to exist. Almost immediately some of the spaces began to be filled by newly discovered elements, so that it was recognized that Mendeleeff's law was, to a certain extent, prophetic and might point out the existence of elements yet unknown to us. It also led to a more accurate censorship of the atomic weights and of their other properties. Thus uranium, whose atomic weight was formerly taken as 120 and then 180, required for the Mendeleeff law 240, a value confirmed by independent experiments of other chemists. Uranium is the element which marks one end of the Mendeleeff scale. Gold, tellurium, and titanium refused to come into the law under their old atomic valuations, but new determinations of atomic weights have brought them into the law with the others.

A good indication of the work of chemistry is in the discovery of new elements. Upon looking at the dates of the discovery of the different elements it is most surprising to see how many had been discovered prior to 1846 and how few have been discovered since that period. Robert Bunsen in 1860 discovered rubidium and cæsium; Crookes, in 1862, thallium; Reich and Richter, in 1863, indium; Boisbaudran, in 1875, gallium; Marignac, in 1878, ytterbium; Boisbaudran, in 1879, samarium; and in the same year Nilson, scandium, and Cleve, thulium; Welsbach, in 1885, neodymium and praseodymium; Marignac, in 1886, gadolinium; Winkler, in 1886, germanium; Ramsay and Rayleigh, in 1894, argon; Ramsay and others, helium, 1888 to 1895. Many of these elements have been discovered by spectrum analysis. In the early part of this century the laws of the production of a spectrum by permitting light to pass through the prism had been seriously studied and the properties of the spectrum so produced examined. Kirchhoff, in 1859, studied the subject as a physicist and soon attracted the attention of Bunsen. The latter's unequaled genius for solving the most difficult problems of chemistry brought about the construction of a new instrument of chemical research based upon the use of the prism, and the spectroscope was invented. This was about 1860, and at once, for qualitative analysis and for the discovery of new elements, an unequaled instrument was put into the chemist's hands. The work of Bunsen and Kirchhoff filled the world with amazement and led to the most brilliant results in chemistry. By its more recent application to astronomy, double stars have been discovered and the determination of the composition of incandescent celestial bodies has been effected, and the substitution of ruled gratings for the prism has led to some of its most interesting developments.

Woehler's classic synthesis of urea marked the beginning of advanced synthetical chemistry. The mere catalogue of what has been done in organic synthesis would fill a volume. Coal tar has proved one of the great bases for synthetical work. Perkin, in 1858, patented a dye stuff, aniline violet, and that dye marks the beginning of an enormous chemical industry, the production of coal tar colors. Color after color was discovered, and the very existence of the great madder fields of Europe was threatened by the discovery of coal tar alizarine. In analytical chemistry constant improvement was effected. Bunsen brought gas analysis to a wonderful degree of perfection. His methods, unequaled for accuracy and precision, were gradually supplanted in the technical world by simpler ones. The chemists' balance was improved largely by the labors of Becker and other world-famous manufacturers. The first edition of Fresenius' works on analytical chemistry goes back fifty years; the great master of two generations of chemists in his role of master of the world of analytical chemists being almost contemporaneous with the beginnings of the SCIENTIFIC AMERICAN.

New methods of attack have been applied. The electric furnace, in the hands of M. Moissan, has yielded remarkable results. Fluorine, the element which for so many decades resisted isolation, was isolated by him. By the utilization of electricity, rare metallic elements were also reduced from their compounds, and the electric current was applied by Classen with much success to the problems of analysis by electrolysis of aqueous solutions of the double oxalates. The synthesis of carbon and hydrogen has been effected on the large scale by the electric furnace, in which carbides decomposable



THE FIRST PHONOGRAPH.

by water are first produced. The decomposition of these by water gives acetylene gas, a veritable triumph of synthesis.

The every-day appliances of the laboratory have been improved beyond the dreams of old time chemists. Now special apparatus is procurable for all purposes. Rapid filtration, introduced originally by Bunsen, is really one of the notable improvements of the period we treat of, and in the hands of Gooch and others has been greatly developed and improved.

It may seem that the chemist's work is done, but it is not. The discovery of metallic carbonyls is an illustration of how great recent discovery may be. It was found by Mond that carbon monoxide gas had the wonderful power of combining with nickel, and also less freely with iron at ordinary temperatures, and could carry them off in the state of gas. This dates back only a few years. Had the discovery yielded the fruits expected, it would have fairly revolutionized some industries. The same is to be said for calcium carbide and acetylene gas, already alluded to.

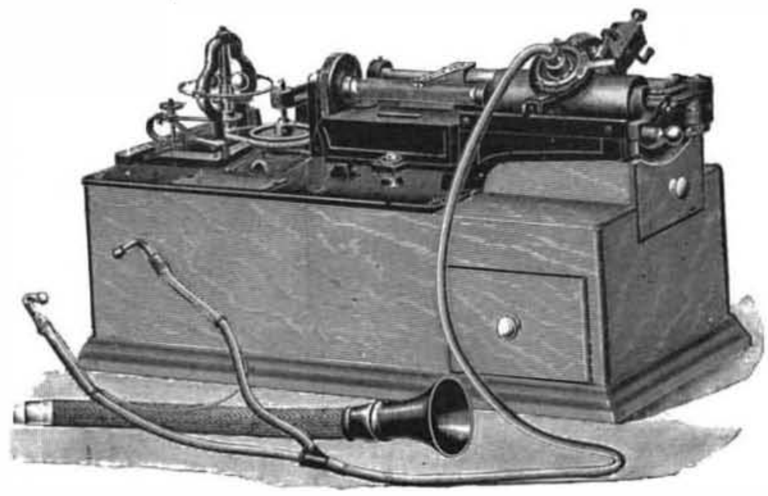
THE PHONOGRAPH.

In December, 1877, a young man came into the office of the SCIENTIFIC AMERICAN, and placed before the editors a small, simple machine about which very few preliminary remarks were offered. The visitor without any ceremony whatever turned the crank, and to the astonishment of all present the machine said: "Good morning. How do you do? How do you like the phonograph?" The machine thus spoke for itself, and made known the fact that it was the phonograph, an instrument about which much was said and written, although little was known.

The young man was Edison, and the phonograph was his latest invention. The editors and employes of the SCIENTIFIC AMERICAN formed the first public audience to which it addressed itself. Edison, even then, was a well known and successful inventor. The invention was novel, original, and apparently destined to find immediate application to hundreds of uses. Every one wanted to hear the wonderful talking machine, and at once a modified form of the original phonograph was brought out and shown everywhere, amusing thousands upon thousands; but it did not by any means fulfill the requirements of the inventor. It was scarcely more than a scientific curiosity or an amusing toy. Edison, however, recognized the fact that it contained the elements of a successful talking machine, and thoroughly believed it was destined to become far more useful than curious or amusing. He contended that it would be a faithful stenographer, reproducing not only the words of the speaker, but the quality and inflections of his voice; and that letters, instead of being written, would be talked. He believed that the words of great statesmen and divines would be handed down to future generations; that the voices of the world's prima donnas would be stored and preserved, so that, long after they had passed away, their songs could be heard. These and many other things were expected of the phonograph. It was, however, doomed to a period of silence. It remained a toy and nothing more for years.

The original instrument consists of three principal parts—the mouthpiece, into which speech is uttered; the spirally grooved cylinder, carrying a sheet of tinfoil which receives the record of the movements of the diaphragm in the mouthpiece; and a second mouthpiece, by which the speech recorded on the cylinder is reproduced. In this instrument the shaft of the cylinder is provided with a thread of the same pitch as the spiral on the surface of the cylinder, so that the needle of the receiving mouthpiece is enabled to traverse the surface of the tinfoil opposite the groove of the cylinder. By careful adjustment this instrument was made to reproduce familiar words and sentences, so that they would be recognized and understood by the listener; but, in general, in the early phonographs, it was necessary that the listener should hear the sounds uttered into the receiving mouthpiece of the phonograph to positively understand the words uttered by the instrument.

In later instruments exhibited throughout the country and the world, the same difficulty obtained, and

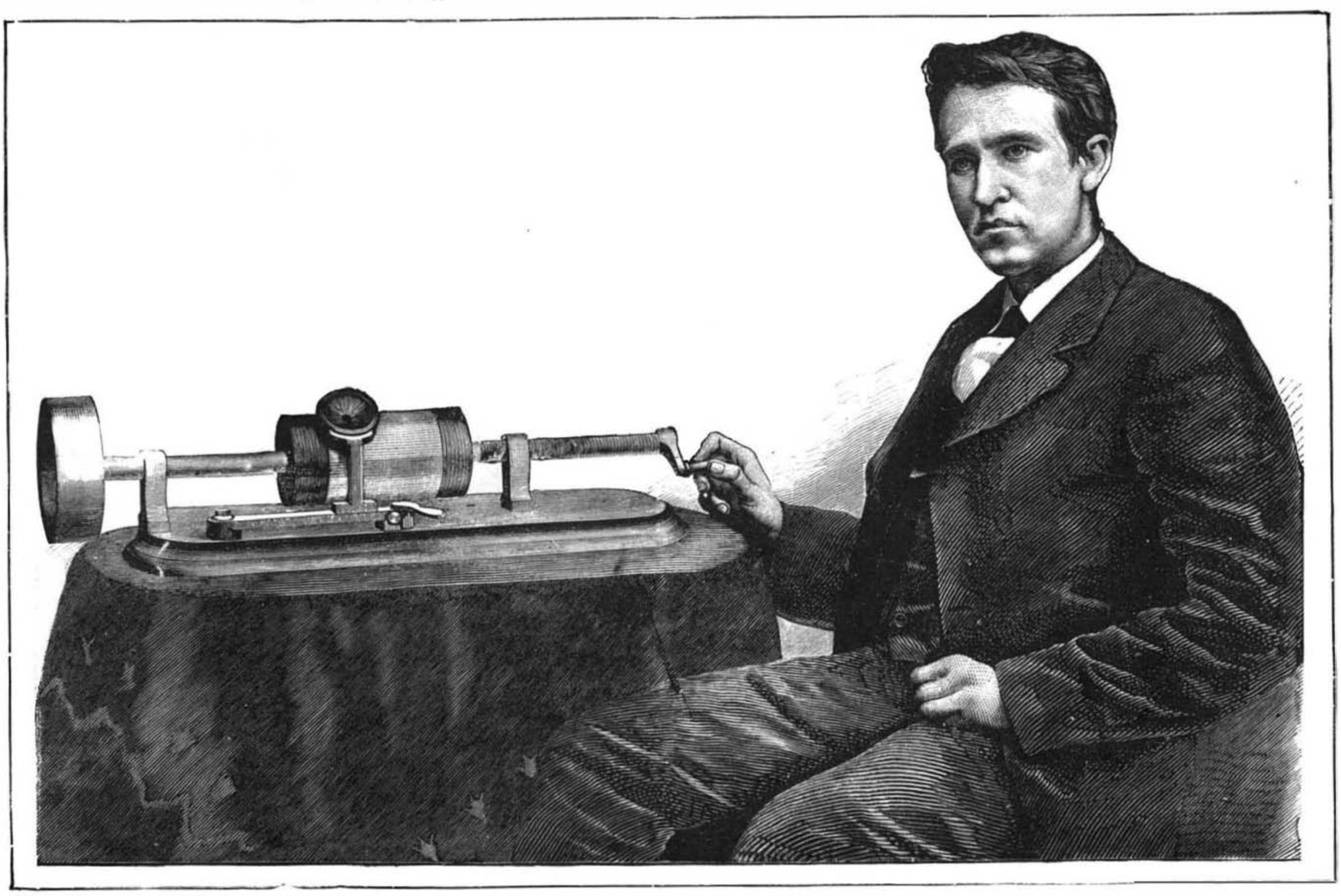


IMPROVED RECORDING AND REPRODUCING PHONOGRAPH OF 1896.

perfection of articulation was sacrificed to volume of sound. This was necessary, as the instruments were exhibited before large audiences, where, it goes without saying, the instrument, to be entertaining, had to be heard. These instruments had each one mouthpiece and one diaphragm, which answered the double purpose of receiving the sound and of giving it out again.

Finally it was made known to the public that the ideal phonograph had been constructed; that it was unmistakably a good talker; and that the machine, which most people believed to have reached its growth, had after all been refined and improved until it was capable of faithfully reproducing every word, syllable, vowel, consonant, aspirate and sounds of every kind.

During the dormancy of the phonograph, its inventor secured both world-wide fame and a colossal fortune by means of his electric light and other well known inventions. He devoted much time to the phonograph, and not only perfected the instrument



EDISON AND THE FIRST PERFECTED PHONOGRAPH.