longest water distance is 600 miles. Other deep sea cables between Sardinia, Malta, and Corfu, and one from the mouth of the Red Sea to India were laid shortly after and they failed. A committee of the most eminent electricians was organized by the English Chamber of Commerce and the Transatlantic Company to study the subject, and after eighteen months of labor they issued an elaborate report in 1863. Without waiting for their report a cable between Malta and Alexandria had been successfully laid, in 1861, and in the year succeeding their report, the Persian Gulf cable, about 1,330 miles long, was successfully laid. This was the major part of the work done prior to the laying of the Atlantic cable in 1866. Sir Wm. Thomson (Lord Kelvin) was identified from its earliest days with the cable laying art, and in his works may be found many graphic accounts of difficulties encountered and how they were surmounted. His instruments were used in the earliest days for the transmission of signals. It was found that with a line of such high capacity, worked with ordinary apparatus, endless difficulties were experienced, but Sir Wm. Thomson overcame them at an early period. His reflecting galvanometer was made to give visual signals by movement of its spot of light upon the scale, and when it was desired to have permanent signals, the siphon recorder traced, by means of ink from a capillary orifice, a zigzag line upon a strip of paper and solved the problem, the great scientist recurring to Morse's original written code produced by his old pendulum apparatus.

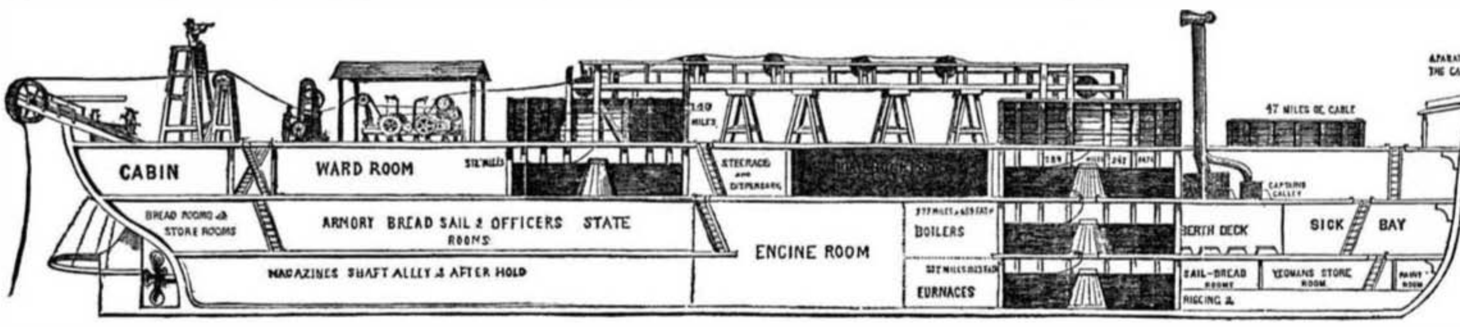
Fleeming Jenkin, the Edinburgh professor (whose life has been so charmingly written by Robert Louis Stevenson, a part of whose interest consists in the reflection of the author's own character, as he was registered as a student under Prof. Jenkin at the University of Edinburgh) gives an excellent account of the difficulties experienced by the early cable layers, in which expeditions Jenkin, great sufferer from seasickness as he was, appeared as an enthusiastic worker. To-day all is changed. There are a whole fleet of cable ships used for cable laying and for repairs, and appliances and methods have become systematized to the last degree. Cables are turned out from the factories in lengths of thousands of miles without imperfection, and the world is almost girdled by electric wire, the great Pacific forming practically the only break in its complete circuit, a break soon to be closed.

We have reproduced for our readers, with the kind assistance of the Postal Telegraph Company, the map of the world on Mercator's projection, on which are drawn the many lines of cable now existing. This map is thoroughly up to date, and shows in a most interesting way the amount of work accomplished. One of the most impressive features is the number of lines across the Atlantic Ocean between Europe and America. Hardly less impressive are the remote lines to New Zealand, Australia, Madagascar, and the Mauritius, while in the opposite sense the great Pacific, as yet uncrossed, marks the present limit of man's achievements. There is at present, however, a plan under way for laying a line across the Pacific from Vancouver to Japan, and the full plans were recently placed before Congress, but up to the present writing the necessary co-operation has not been obtained.

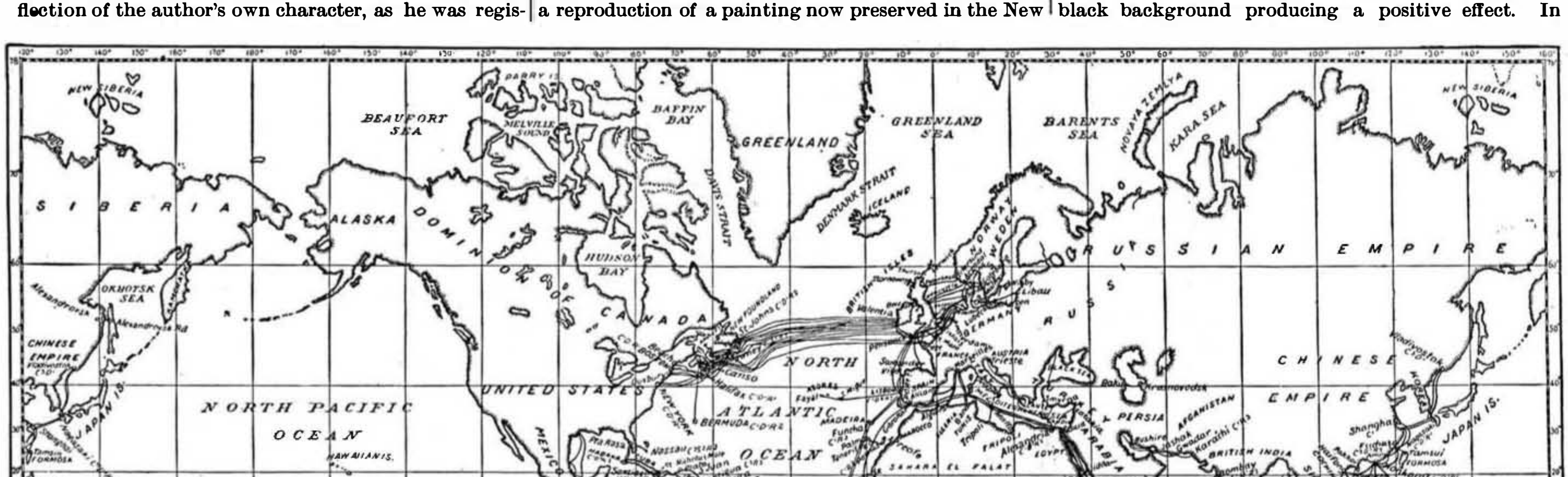
In the electrical outfit of the cable system, the principal progress has been in the adoption of a more delicate type of instruments for the transmission and reception of messages. The cables are generally worked on the condenser system, there being no through metallic circuit. The Thomson and Varley transmission apparatus increased the old speed eight fold. Thomson's siphon recorder quadrupled the speed of the systems used before its advent.

The cuts accompanying this article are of special value. The section of the Niagara is reproduced from a contemporaneous wood cut which appeared in the SCIENTIFIC AMERICAN in 1858. The portrait group is a reproduction of a painting now preserved in the New York Chamber of Commerce, and represents the incorporators of the Atlantic cable of 1858 assembled in the library of Cyrus W. Field, the philanthropist-inventor Peter Cooper presiding. In the background the artist, the great American portrait painter, Daniel Huntington, has introduced his own portrait. The cost of the painting alone was $20,000, and a long list of donors subscribed for its production.

Finally, the map gives the authoritative presentation of the world's network of cables corrected up to date specially for the SCIENTIFIC AMERICAN.



SECTION OF THE STEAMSHIP NIAGARA ARRANGED FOR LAYING THE TRANSATLANTIC CABLE OF 1858.



SUBMARINE CABLES OF THE WORLD, WITH THE PRINCIPAL CONNECTING LAND LINES, ALSO COALING, DOCKING AND REPAIRING STATIONS.

FIFTY YEARS OF PHOTOGRAPHY.

In the entire range of invention and discovery nothing shows a more brilliant series of successes than the art of photography.

A hundred and fifty years ago, copies of writing had been made by the action of light on sensitive paper. Giambattista Porta had invented the camera obscura; and more recently Niepce and Daguerre by different methods had succeeded in making sun pictures; and Fox Talbot had invented the calotype or talbotype; Herschel had given to the impression made from the object the name "negative" and to the print from the negative the name "positive."

Fifty years ago, in 1846, Schonbein discovered gun cotton, and soon after collodion was produced by making a solution of gun cotton in alcohol and ether. It was almost immediately adopted by Archer for a film in lieu of albumen and gelatine. Pictures produced on the sensitive film having collodion as the basis superseded the calotype and daguerreotype, and were made almost exclusively after this discovery up to within fifteen or sixteen years. This film is still used by many photographers for special purposes, but more particularly in photo-engraving, and for transparencies and lantern slides. The collodion film was used for making negatives as well as positives; some of the best photographic pictures ever produced were made by means of wet plate collodion film negatives, albumenized paper being used in making the positive prints. Prior to the use of albumenized paper sensitized with the silver salts, glass positives, called ambrotypes, were introduced by making a very thin negative image and backing the plate with asphaltum varnish or black velvet, the black background producing a positive effect. In some cases they were bleached by means of a solution of mercuric chloride. Collodion positives are still made upon thin japanned iron, commonly called tintypes.

After a great many experiments the modern dry plate was produced, not in its present state of perfection, but in a way which indicated its capabilities. The gelatine dry plate could not be made in perfection until after the gelatine itself had been improved so as to render it suitable for this purpose. It is to the perfection of the extremely sensitive dry plate that the great popularity of photography is to be attributed.

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 $\frac{1}{1000}$ 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 contempora-