SCIENTIFIC AMERICAN SUPPLEMENT. No 1483

Entered at the Post Office of New York, N. Y., as Second Class Matter. Copyright, 1904, by Munn & Co.

Scientific American, established 1845.
Scientific American Supplement, Vol. LVII., No. 1483.

NEW YORK, JUNE 4, 1904.

Scientific American Supplement, $5 a year.
Scientific American and Supplement $7 a year.

THE ELIZABETH BRIDGE, BUDA-PEST.

A SUSPENSION bridge presenting various novel engineering features has been opened at Budapest. We propose to illustrate and describe this bridge. But in the first place, it is well to explain how it came to be erected. We are indebted to Mr. Charles Peter Dubez, engineer to the Buda-Pest Electric Railway Company, for the following historical sketch.

The necessity for erecting and opening the Elizabeth Bridge was like the necessity for erecting and opening the famous Suspension Bridge, Margaret Bridge, Railway-Connecting Bridge, New Pest Bridge, and Francis Joseph Bridge, due to the very rapid development of the capital, Buda-Pest. Before the erection of the first permanent bridge, Buda-Pest was not yet called by the present name, "Buda-Pest"; there was a separate town called "Buda" on the right-hand side of the river Danube, and a separate town "Pest," on the left. The traffic between the two towns, however, soon required a roadway leading from one town into the other. Thus a pontoon bridge was made. However, the trade and commerce between the two towns soon led the City Board of Trade to the conviction that so primitive a bridge was quite unfit for carrying and conveying the constantly increasing traffic. The Board of Trade therefore urged the government to have built a permanent bridge of more suitable dimensions and construction.

Thus it was decided to erect the very first permanent bridge over the waterway, and for this purpose Mr. William Clark's designs were accepted, and he was at the same time also intrusted with carrying out the work. The bridge itself was to be called after its type "Lánczhid." However, Mr. William Clark died while the bridge was being made, and so his brother, Mr. Adam Clark, was appointed to take his place, and put in absolute charge of the construction. Mr. Adam Clark succeeded in completing the work, so that the bridge was ready to be opened on November 20, 1849.

In those days, when the Hungarian art of bridge-building was not on its present level, Budapest had to look and search very far abroad for experts, engineers, and even workmen, as also for the necessary ironwork, castings, fittings, and materials, that were required for building and completing bridges. Mr. Dubez's late grandfather, Mr. C. Frommhold, who was the leading physician, as also the only English-speaking gentleman at that time in Pest, and who was also appointed doctor of the whole English bridge-building colony, could not speak highly enough of the superior quality of the English working class.

So the "Lánczhid" was erected between 1840 and 1849, and is still nowadays quite unequaled—it is unique of its kind, decorating this delightful city. The length of its main span is 664.41 feet, while the two land approaches have a length of 286.6 feet each, thus giving the entire suspension bridge a total length of fully 1,233.65 feet between the two abutments.

This bridge on the one hand is a fine example of English art and bridge building, and on the other hand permanently remains as an ideal bridge for closely connecting together the friendliest feelings of the two great nations.

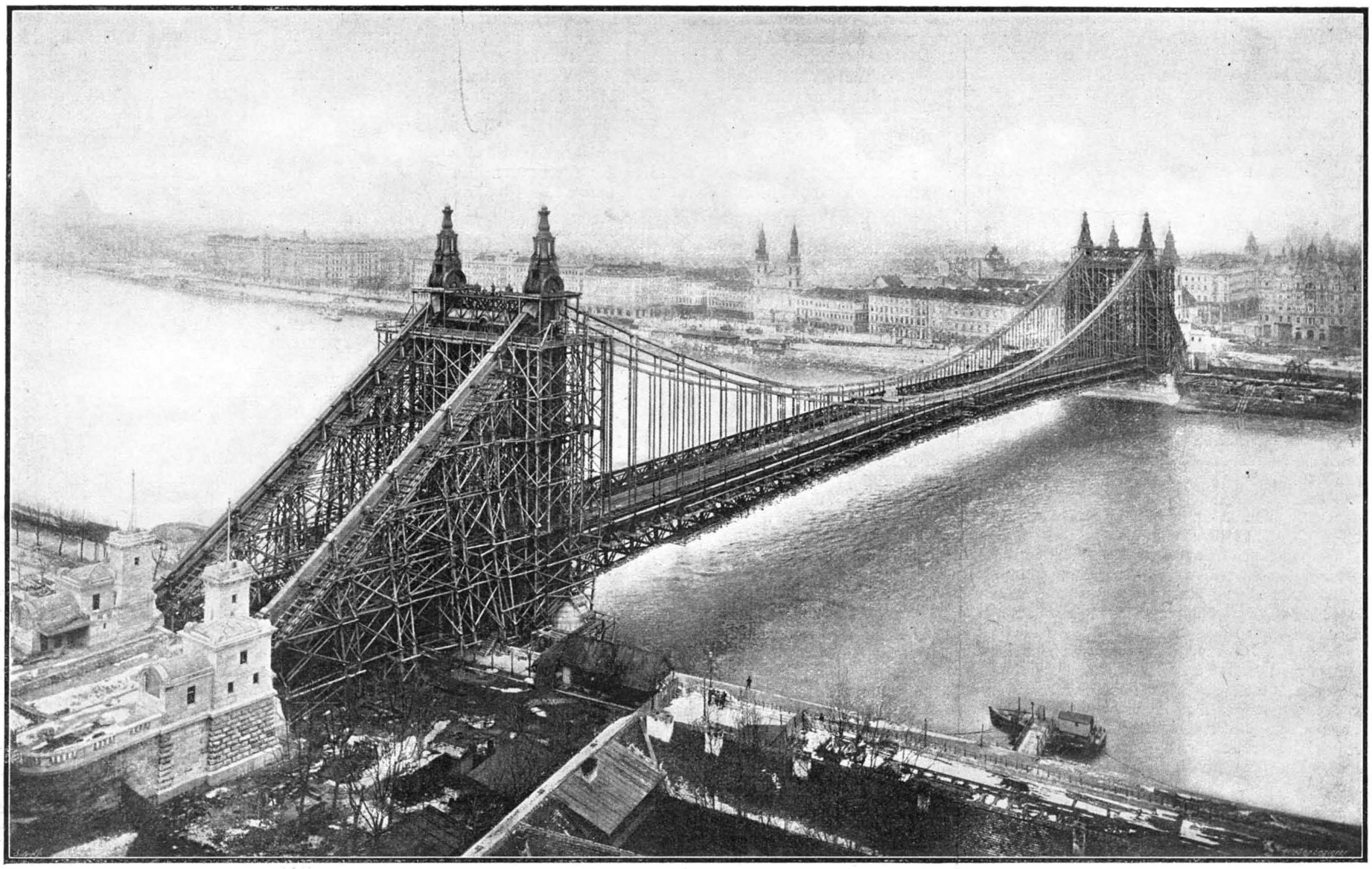
The rapid growth of population, however, soon led the government to the conviction that this "Lánczhid" would not prove sufficient in regard to traffic in the very next decades. The government was not mistaken in this supposition in the least, as about twenty-five years later it proved to be urgently necessary to erect a second permanent bridge over the river Danube, between Buda and Pest. It was the "Margit hid" (Margaret Bridge) that was made, which has a total length of 1,884.73 feet, including the two land approaches 72.18 feet long each. This bridge was opened on April 30, 1876.

However, the further rapid growth and development of Budapest rendered necessary in the next twenty-seven years not fewer than four more bridges. They were the "Osszeltötö vasuti hid" (railway connecting bridge), the "Ujpesti hid" (New Pest Bridge), the "Ferencz József hid" (Francis Joseph Bridge), and the "Erzsébet hid" (Elizabeth Bridge).

Judging from the present development of this city, it is safe to say that in the course of about ten to twenty years, two more bridges are likely to be erected over the river Danube at Budapest; the one will be the "O'Budai hid" (Old Buda Bridge), the other the "Borárostéri hid" (Boráros-Square Bridge).

It was on October 10, 1903, at 11 A. M., that the Elizabeth Bridge was opened. Although it is now the sixth permanent bridge over the river Danube in the territory of Budapest, still it comes first, not merely at Budapest, but also in Hungary, as to its huge structure and in respect of the length of its main span. It is unquestionably a grand work of modern engineering, evidencing the uninterrupted increase of traffic and population. The opening of the bridge was performed in the presence of Archduke Joseph, who represented his Majesty, Francis Joseph, the King of Hungary. By consent of his Majesty the bridge is called "Elizabeth Bridge" in commemoration of the late Queen Elizabeth.

The actual history of the Elizabeth Bridge dates back to as early as 1893, when the Board of Trade, seeing that the bridges already in use at Budapest were not able to fulfill the traffic requirements properly, urged the government to have two more bridges erected. One of them was the Francis Joseph Bridge, erected according to the designs of Mr. John Feketcházy, at that time chief engineer to the Hungarian Royal State Railways, and thrown open to traffic on the 4th of October, 1896; the other one the Elizabeth Bridge. The principal difference between the Elizabeth Bridge and the others is that the Elizabeth Bridge has only one span over the river Danube, and two piers, one on each side of the river, built on substantial ground. Its clear span over the river Danube is 951½ feet. There are two land approaches, one on each side of the river, each having a length of 40 meters, thus giving the entire bridge a total length of fully 3,014 feet. The two piers, one on each side of the river Danube, have a total height of 212 feet each over the zero level of the water. Both of them are made of steel and rest upon granite foundations. The highest point at the center of the bridge is 59 feet from the zero level of the river Danube. The principal constituent parts of the whole bridge are such that the two lattice-typed main girders have the four chains, two on each side. The dip or versed sine of the chain curve is 95 feet, thus being one-tenth of the length of the main span. Therefore the chains are supported by the piers at a height of 95 feet from their lowest points, and are anchored down into the masonry of the abutments. The chains themselves carry by means of suspension rods the cross-girders of



THE ELIZABETH SUSPENSION BRIDGE AT BUDA-PEST.

the structure, while the lattice-type main girders serve merely for stiffening purposes. The bridge has a total width of fully 59 feet, 36 feet of which is carriageway, and 11½ feet for each of the two footways. The footways are raised above the carriageway by one step, thus being separated from the latter. Great stiffness and rigidity against any external power or pressure have been obtained by latticing in the vertical as well as in the horizontal plane. The former adds much stiffness and rigidity to the structure against any external vertical force, such, for instance, as the dead load resulting from the weight of the structure itself, and the working load resulting from the weights of pedestrians, omnibuses, vehicles of every sort, and electric cars; the latter resists lateral force, such as wind pressure. Great care was taken by experts in making the most correct mechanical and graphostatical calculations and investigations in order to settle the exact numerical value in length of the greatest permissible deflections at different parts, points, and cross-sections of the bridge, resulting partly from the expansion or contraction due to changes of temperature, partly from the downward action caused by the dead load of the structure and the constantly altering working loads.

In testing the bridge, the results obtained proved to be satisfactory beyond expectation, as it was found that the temporary as well as the permanent distortions of the structure caused by internal stresses in the material itself, resulting partly from expansion by heat, partly from contraction by cold, and, finally, partly from combined downward action of dead and working load, were altogether much smaller than any of those that were ascertained by mechanical and graphostatical calculations. To illustrate this it should be mentioned here that while the bridge was under full load, the vertical downward total deflection—the arithmetical sum of the permanent and temporary distortions—was only 230 millimeters, while it was expected by the aforesaid calculations that it would reach fully 282 millimeters. Of this total deflection, 52 millimeters were computed to remain as a distortion of permanent character, while accurate measurements made on the spot showed that this did not exceed 26 millimeters.

It may be said, on the whole, that the construction gives the greatest strength and efficiency in proportion to the weight of the material that was employed.

The work of erecting the bridge proper was started in 1898, when the masonry of the abutments was completed. Next to this came the steel work, which was started three years later, in 1901, at each end simultaneously.

The Elizabeth Bridge has been erected in accordance with the designs of the engineers of the Bridge Building Department of the Hungarian Royal Ministry of Commerce, under the charge of Ministerial Councilor Aurel Czelkelinsz, while the architectural works of both the Francis Joseph and the Elizabeth Bridge were designed by Technical Councilor Virgil Nagy.

This bridge is a work of Hungarian engineering only, and from top to bottom a product of entirely Hungarian industry. It is claimed by the inhabitants of Budapest that it will remain as a permanent reminder of the highly scientific level in bridge building reached by modern Hungarian art, and that is able to compete in every respect with any bridge on the globe.

This bridge, after a period of six years taken up in its construction and erection, was finally opened to traffic in October last. It spans the Danube, and connects "Kossuth Lajosutcza"—a prolongation of "Kerepesi-út," the chief street of the city—with the embankment promenade on the opposite or Pest side of the river. The main span is only 951 feet 5 inches, which is little enough for a modern structure of this type; but the choice of the design is attributable to æsthetic reasons, having regard to the splendid panoramic view of the Danube at Budapest. It may be here remarked that there are five city bridges crossing this river, but the two bridges by which the new one is flanked are either suspension, or imitate the lines of suspension bridges, and consequently uniformity of appearance was preserved by a repetition of the type. The Lancz Bridge on one side is a chain bridge, but of an old type, with stone towers in the stream, and with very shallow stiffening girders in its platform, while the Ferencz-Jozsef Bridge is of cantilever type with upper chords and pier towers having the outlines of a suspension bridge. The other two bridges are of rigid girder type, but are too far distant to destroy the general architectural scheme of the bridges named.

The new bridge is the first to cross the river in one span. Its stiffening trusses are continuous from end to end of the structure, and the cantilever ends, or connecting spans, are so short (42.2 meters) that they have not required support by suspenders from the anchor cables.

The towers are pivoted at their bases, and consequently there are no cradles, chain saddles, rollers, or such like arrangements for temperature movement, and both the lower suspension chains have fixed points in the tower heads. The 19½-inch pins through which the whole weight of the entire bridge is transmitted to the piers, insure the passage of that pressure through the center line of the masonry, thus eliminating possible variations of pressure under the pier footings, and in the longitudinal direction of the bridge, as when rigid towers are considered. Especial provision has been made to allow for longitudinal form changes in the cable and stiffening trusses, due to varying magnitudes in live loads and in temperature movements. Dilation of the main structure is permitted by long rocker-arms, by which the trusses are suspended between the tower posts, and by long funicular hinges in the anchorage piers or abutments, the extent of molecular change allowed for being a total of 260 millimeters, with a temperature variation of 60 deg. Cent. The rocking of the towers is also allowed for below the lower ends of the mantles—6 meters wide—which mask the tower posts, and above the tops of the pier cappings, by a vertical clearance of 30 millimeters on either side. Side pressure from wind force is stayed by lateral abutments, built in the middle of the anchorage pier, the thrust there being taken up by a transverse beam, having spherical ends or slides, and connected direct to the wind bracing of the lower chords.

The whole design, considering that the bridge is only intended for ordinary street traffic, comprising a double track for electric tram cars, compares, as regards strength, with that of other bridges of much larger span and built for much heavier loads. The calculations, strain sheets, and all plans for its construction were prepared by the Danube Bridges Constructional Department in the Hungarian Ministry of Commerce, of which department Mr. Aurelius Czelkelinsz, consulting engineer to the Ministry, is the chief. The structural materials were all manufactured, and the bridge constructed and erected, by the works of the Hungarian State Railways, Budapest—Magyar Kiralyi Allamyasutak Gepgyara—the bulk of the materials being produced at the steel works of the State at Diósgyör, near Miskolcz. The erection was supervised by the Danube Bridges Department already mentioned, and only the wood, asphalt concrete, promenade railings, lamps, and the ornamental bridgework were provided by private firms.

Manufacture of the Eye-Bars.—The principal work, which necessitated considerable care in the processes of manufacture, and which may be mentioned at once, was that in connection with the eye-bar cables. For the machining of these members a special plant was laid down and new buildings erected at Diósgyör. This work was begun early in 1889, five months before the commencement of the chain erection at the bridge site, and the chains were finished at the end of 1900, twenty-one months from the date of their commencement at Diósgyör, and about eight months previous to the completion of the chain work on the bridge. This facility for the manufacture in many portions, and far from the bridge site, is the chief recognized advantage of chains over wire cables, when the suspension trusses are to be of great size.

The steel employed for the chain plates is carefully rolled Siemens. It has a fairly high tenacity, the minimum ultimate tensile strength being 5,000 to 5,500 kilos per square centimeter in the direction of the rolling, say 31 tons per square inch. The test pieces cut from the plates, 200 centimeters long, with a sectional area of 5 square centimeters, gave, at the limits quoted, a minimum elongation of 20 per cent, and, with pieces of greater section, 1 per cent additional stretch for each increase of one centimeter in the area of the cross-section. In the preparation of the plates neither punching nor shearing was allowed, and the treatment of the plates in their machining appears to have been such as to render annealing superfluous. The machines principally employed in this work comprised exceptionally long planers, boring mills having vertical axes, and horizontal bores—all special types for the plates to be manufactured—and made by Vulkan, of Budapest, and of Becs (Austria), and operated entirely by electric motors. In the rolling of the plates each web was required to be finished perfectly straight and true, with a smooth clean surface, and on account of the large number of plates to be packed to each joint or knuckle (38 to 44) each plate had to be accurately to gage (1 inch) so as to insure the maintenance throughout of the specified sectional area of the finished links or eye-bars. To this end, and to reduce to a minimum the error possible by temperature influences, the gages, templates, shapes, etc., were made from the material of the plates themselves. As soon as the plates were planished, they were coated with a tough varnish to protect their surfaces from the corrosion incidental to the cooling water employed all through the machining operations. Care was taken to prevent deformation or buckling of the plates from their handling in the various departments, they being lifted by means of long girders provided with numerous grab-hooks, which uniformly supported the plate throughout its length. The finished chain-plates have lengths of up to 49 feet (14.605 meters) weighing over 1½ tons (1,642 kilos). Having regard to the length of these plates, the maximum deviation from templates permitted in the distance between eye centers was three millimeters at a temperature of 10 deg. Cent., half-millimeter in the eyes themselves, or a total of 40 millimeters in the half-span of the suspended chain.

The eyes were required to be geometrically central in the head and on the center line of the plate. This was assured mechanically both by the jigs used and by the fixing of the pairs of machines, which worked simultaneously at opposite extremities of the same plate. The method of procedure in the machining was to cut the plate approximately to shape, and afterward to finish it absolutely to template in a second operation. The first work was to cut out the necks of the links upon a vertical boring and profiling mill, and then to bore the eye while on the same machine. This operation was effected simultaneously at both extremities of the plates by machines suitably placed in groups of two. The plates were next transferred to milling machines, also grouped in pairs, for the finishing of the heads, and they were then passed on to the planing machines, which were extra long machines with return-cutting tool carriers. In these the strips between the two necks were removed, so forming the body, both sides of the link being planed together. The plates were next assembled, and the complete numbers for each eye-bar were temporarily bolted together at one end and rigidly clamped up throughout the rest of their length with their center lines in exact correspondence. The eye at the free end was then reamed accurately at one operation, and as nearly as possible at the same temperature, this process being followed subsequently by the similar boring of the opposite head, and also upon the horizontal borer.

The various machines for the work were arranged as much as practicable in such manner that the plates could be passed along from machine to machine upon fixed rollers. While in the shop the links were again made up into bars of from three to five plates and verified as to their exact conformity to specification details; any subsequent work upon them being done in packets of from three to four previous to the reassemblage and transfer of the plates to the store, from which latter they were ultimately removed for the preliminary construction of the chain in sections.

The material cut from the sides of the links to form the waist or body is sufficient in every case to render the heads of the links the strongest part of the chain. In the middle of the suspension span—at joints No. 38—the plates have a depth in the body of 400 millimeters (15¾ inches), and are 720 millimeters (28⅜ inches) deep in the heads, these depths increasing as the chains approach the curve of greatest deflexion in the catenary line. On the other side of the towers the deepest plates of the anchor cable extend from the anchor up to mid-length of the chain. The various sectional areas of the chains employed may be obtained from the succeeding particulars. The anchor heads or plates—at eye No. 1—have a depth at their bearing on the anchorage beams of 1,200 millimeters by a width of 975 millimeters. The first or lower links are 530 millimeters deep in the body and 950 millimeters deep in the head. Between joints Nos. 2 and 3 the plates are 500 millimeters deep in the body, and 910 millimeters deep in their heads. Between joints 3 and 4 they are 490 millimeters deep in the body, and the two sets of heads interleaved upon the same pins at joint No. 4 have heads first 900 millimeters and then 800 millimeters deep, and so on, the head being always proportionate to the bodies, which decrease successively in depth as they rise—485 millimeters, 475 millimeters, 460 millimeters, and 455 millimeters. In width these same anchor chains increase in size in proceeding from the anchor to the towers, and this by reason of a forking of the eye-bars which commences at the joint No. 6. There are nineteen plates packed in the first eye-bars with the width practically constant at 975 millimeters up to joint 5, where it increases to 1,055 millimeters, and at the next joint—No. 6—one middle plate is omitted, and at every succeeding joint two plates of 25 millimeters thickness are omitted in each eye-bar, so that at the fixed tower links the interval of the split between the chains amounts to 175 millimeters, while the total width across the two divisions of the chain is 725 millimeters (28½ inches). The separation mentioned allows of the introduction of a central diaphragm bearing in the head of the towers for supporting the middle of the suspension pin. In a like manner the main suspension chain is also divided in starting from the joints—Nos. 21 and 55—on either side of the span, and advancing upward to the towers, from which points one plate is first omitted, to be followed by two plates in each of the following links, the separation so produced in the bars amounting to 225 millimeters at the fixed tower links. The chain at mid-span—joint 38—has a width equal to that at the anchorage—i. e., 975 millimeters—and which width is practically continuous up to the joint 19, the number of 25-millimeter plates in each bar being twenty, but with alternate links composed of only nineteen plates of 25 millimeters, and with two outside cover plates of 15 millimeters. The increase in the thickness of the main suspension truss begins therefore after the commencement of the separation, while in the anchor chain it commences in advance. The longest bars in the main chain are situated in the first four links at the greatest inclination of the catenary—joints 12 to 15—these being between centers—13.128 meters in the lower chain and 12.766 meters in the upper chain, the numbers of plates to each joint being $22 \times 2 = 44$.

Some amount of flexibility by the sagging of the upper anchor cables is introduced by short links of 6.564 meters between joints 3 and 4 within the anchorage gallery, and of 4.626 meters in the lower cable between joints 9 and 10 next to the tower arms. These arms, or short-fixed links, are narrowed in width at their lower ends. Those for the upper anchor chains are 3.197 meters long between pin centers, and 1,320 meters and 1.125 meters deep in the heads; those for the lower chains are 2.255 meters long between centers, and 1.200 meters and 1.095 meters deep in the heads. The arms of the upper suspension chains are 2.422 meters long between centers, and 1.080 meters and 1.035 meters deep in the heads, and those for the lower chains 1.821 meters long between centers, and 1.095 meters and 1.020 meters deep in the heads. The upper arm of the anchor chain is not a regular taper, but it is cut out in the body to a depth of only 810 millimeters, which gives the necessary clearance space for the knuckle of the lower main-chain arms below. Each of these arms is maintained parallel in respect to each other by means of stretchers or yokes 375 millimeters in depth, and prolonged down to bracket plates on the towers and there pinned with 60-millimeter (2⅜-inch) bolts. This connection of the slots in these arms to

the eye-bar links by means of double rolling bolts will be mentioned in the description of the chain erection.

The pins for the chains were forged from steel of the same quality and of the same tenacity as that already described for the links. Their diameters vary —for example, 330 millimeters diameter for the anchor eyes, and 330 millimeters diameter for eyes No. 2, and 320 millimeters for the rest of the eyes up to the yoked arms of the towers. For the main chains, and commencing at the towers, the pins have successive diameters of 310 millimeters, 330 millimeters, 320 millimeters, and 310 millimeters, and for the succeeding joints, wherein the plates are packed solid in a single eye-bar section, the diameter is decreased to 270 millimeters up to joint No. 27; and for the remainder of the pins up to mid-span, where the shearing forces decrease with the feeble inclination of the chain, their diameter is only 260 millimeters. The length of the pins varies in proportion with the different thicknesses of eye-bars previously given.

The screwed length at each extremity of the pin is 110 millimeters long, and turned down to a diameter of 280 millimeters uniformly for all pins, and then cut with a pitch of two threads to the inch, and 9 millimeters deep. A shoulder, 15 millimeters to 25 millimeters in depth, is so formed on the pins, and thus becomes a stop or limit to the extent to which the plates forming the eye-bars may be bound together. The line of the screw thread being below the pin shank, the thread is not damaged in driving the pin through the plates, for which operation thimbles, or pilot nuts, do not appear to have been employed. The nuts were turned and milled from cast steel, and have cup ends. Cast steel is also employed for all other nuts of visible bolts. The entire length of the unsuspended chain in the upper or longest line between the anchor eyes is 520.5 meters (1,708 feet), and is made up of a total of 4,094 plates. Their manufacture during twenty-one months required manual labor amounting to 571,000 work-days of ten hours each, or nearly fourteen days' labor for each plate, the rate of production being 195 plates per month.—London Engineer.

CONTEMPORARY ELECTRICAL SCIENCE.*

INFLUENCE OF ELECTRONS ON COLLOIDAL SOLUTIONS.—W. B. Hardy describes a remarkable effect of radium rays in producing a colloid substance. Specially purified globulin from blood was dissolved (*a*) in a trace of acetic acid, (*b*) in a trace of sodium hydrate. In presence of acetic acid the globulin was found to move in an electric field from anode to cathode; in presence of alkali, it moved from cathode to anode. In the former case, therefore, the globulin particles carried a positive charge, in the latter a negative charge. These two solutions were exposed to the radiations from radium bromide, and it was found that the electro-negative solution of globulin was turned into an opaque jelly in three minutes, while the electro-positive solution became more mobile and less opalescent.—W. B. Hardy, Proc. Camb. Phil. Soc., October 21, 1903.

INDUCED THORIUM ACTIVITY.—F. von Lerch has made a series of experiments to determine the chemical behavior of the induced radio-activity shown by metals exposed for some hours to Rutherford's thorium emanation. He works on Rutherford's hypothesis, assuming that thorium gives rise to thorium X, the latter to thorium emanation, and this again to induced thorium activity, by a series of sub-atomic transformations. The author finds that all metals activated by thorium emanation show the same index of decline. Palladium appears to absorb the emanation. When metals after exposure to the emanation are dissolved in acids, the radio-activity acquired remains attached to them, and reappears on precipitating them from solution. It may, however, be detached from the metals by electrolysis and made to precipitate on the cathode. The author believes that the induced activity is a new element or series of elements, the main constituent having a position between copper and lead in the voltaic series.—E. von Lerch, Ann. der Physik., No. 12, 1903.

CHARGE BY ION ABSORPTION.—Of the numerous theories framed to account for the permanent negative charge on the earth's surface none has been so generally accepted by geo-physicists as that due to Elster and Geitel, which ascribes the phenomenon to a charging of the surface through absorption of ions from the surrounding atmosphere. G. C. Simpson, however, points out that it rests upon an experiment by Zeleny which had a different result when repeated by Villari. He therefore undertook a series of experiments to find the conditions under which a conductor can become charged, and to what extent, in consequence of ion absorption. He proved first of all that Villari's explanation of the better absorption of negative ions by metals as depending upon the friction of the gas against the metal is erroneous, and that Zeleny's results are best accounted for by ascribing a higher rate of diffusion to the negative ions. He demonstrated this higher rate of diffusion by the novel expedient of sending out vortex rings from a box in which the air had been highly ionized by means of Röntgen rays. When the rings impinged on a cage 20 centimeters away and connected with an electrometer, a positive charge was indicated, owing to the negative charge having been diffused on the way. But in naturally ionized air, no "absorption of negative ions" can be detected such as is supposed to account for the earth's permanent charge. All charges apparently produced in that manner are really due to the Volta effect.—G. C. Simpson, Phil. Mag., November, 1903.

* Compiled by E. E. Fournier d'Albe in the Electrician.

ABSORPTION OF CATHODE RAYS.—P. Lenard gives a very interesting tabulation of the absorption of cathode rays possessing various velocities, ranging from that of light to 1-270 of light. The experiments were carried out in hydrogen, argon, and carbonic acid. In all these bodies, the absorption increased on reducing the velocity, and more rapidly than the reduction of the velocity. On reducing the velocity from that of light to 1-100 that of light, the absorption is increased a millionfold. But this rapid increase of the absorption is not indefinitely maintained. At low velocities there is a turning point, after which the absorption tends toward a limiting value. The lower the velocity, the more does the individual character of the gas come into play. At the high velocities the mass alone seems to determine the absorption, whereas at low velocities it is more the number of molecules per unit volume which determines it. An exact correspondence between absorption and velocity cannot be established anywhere between half the velocity of light and zero velocity. The author proceeds to formulate a new theory of the constitution of matter based upon these observations. The ultimate constituent of the atom he calls the *dynamid*, on account of its electric field, which deflects and arrests the electron in its passage. The dynamid may be regarded as an electric doublet, whose moment may vary from one atom to the other. The atoms of the different elements are made up of different numbers of dynamids in exact proportion to their atomic weights. Every dynamid throughout the universe has the same mass, but the actual volume of the dynamids constituting a cubic meter of solid platinum is barely a cubic millimeter.—P. Lenard, Ann. der Physik., No. 12, 1903.

WATER RADIO-ACTIVITY.—E. P. Adams has studied the nature of the radio-active gas found in Cambridge tap-water by J. J. Thomson, and has found that it possesses properties remarkably similar to the emanation of radium. The value obtained for the rate of decay is in sufficiently good agreement with that of radium emanation to make it very probable that the radio-activity of the gas is actually due to radium emanation. The conductivity produced in air by bubbling through tap-water is probably due to the same cause as the conductivity of the dissolved gases in water. Contrary to the opinion of Rutherford, the author succeeded in showing conclusively that a small amount of radium emanation can be absorbed by water. But this can be entirely got rid of by boiling, whereas tap-water behaves as if, in addition to dissolved emanation, it contained an extremely minute quantity of a radium salt in solution. All attempts to evaporate a large quantity of water to dryness, and to find any radio-activity in the solid residue, have so far failed. But the evidence for the presence of the radio-active salt is indirect. If a flask of tap-water is closed up air-tight and allowed to stand for several days, it is found that the rate of decay of its radio-activity is considerably less than that of the gas driven out of it. In fact, on one or two occasions the radio-activity actually increased on standing.—E. P. Adams, Phil. Mag., November, 1903.

IONIZATION BY POSITIVE IONS.—In the Electrician of April 3, 1903, J. S. Townsend gave an outline of a method by which some properties of positive ions may be investigated. He now gives a fuller account of the theory of the genesis of ions by positive ions and its application to experiments which have been made with air and hydrogen. The theory is founded on the determination of the conductivity produced between parallel plate-electrodes when ultra-violet light falls on the negative plate. The investigations show how the potential required to produce a continuous discharge may be found by this theory, assuming that all the ionization is produced by collisions of positive and negative ions with neutral molecules in a uniform field of force. There is a very accurate agreement between the potentials thus calculated and the sparking potentials determined experimentally. It requires much larger forces to develop new ions by the motion of positive ions in air than in hydrogen. If the positive ion be regarded as being approximately the same size as the molecule of the gas in which it is generated, the free paths of a positive ion in hydrogen would be 1.85 times as long as the free paths of a positive ion in air at the same pressure, this number being the ratio of the mean free paths of molecules in hydrogen and air. For a force of 370 volts per centimeter there are about nine times the number of ions produced in hydrogen as in air for the same number of collisions and the same falls of potential between the collisions.—J. S. Townsend, Phil. Mag., November, 1903.

COAL CUTTING BY ELECTRICITY.

AT a recent ordinary monthly meeting of the Manchester Geological Society, Mr. Alfred J. Tonge read a paper on "Coal Cutting by Electricity," in which he gave useful and very interesting details respecting the results obtained by the introduction of electrically driven coal-cutters at the Hulton collieries, near Manchester. He said one of the reasons which had induced them to introduce these coal-cutters was the scarcity of thin seam colliers and the desire to keep abreast of the times. After visiting various collieries and inspecting a few kinds of electric cutters at work, they chose a Jeffrey disk longwall cutter as the most suitable of the electric machines for their purpose. They had now six electric cutters working day after day, and had others ready to be again put to work in other districts. They had four types of cutters at their collieries, each make they had tried having some special feature which suited their mine. The "Jeffrey" was their first choice, because it seemed best at that time for thin seams—running on one rail, cutting on the floor level, being very compact, light, and low. It was put in in the Half-Yard Seam (the Diamond machines at that time were not driven by electricity). This machine they afterward transferred to the 1-foot 8-inch seam, and a second one was purchased. The next type of machine tried was the "Diamond" longwall cutter. This they got for a thicker seam, a deeper undercut, and to cut above floor level. The "Diamond" was also put in a fourth seam, although, by this time, they had returned to a shallower cut, and to cutting on the floor level. The "Morgan-Gardner" chain machine was obtained chiefly for the purpose of dispensing with the use of rails in thin seams, and for its compactness. And, lastly, a "Hurd" three-phase bar cutter, and a "Diamond" three-phase cutter had been purchased to work at their new pits. The choice of three-phase cutters was very limited, so they chose all the types. There were three generating stations of 150, 60, and 600 kilowatts capacity respectively. The first-named, situated at their Nos. 1 and 2 Chequerbent pits, was the first one installed, but originally consisted of a 50-kilowatt plant. Subsequent extensions had been made. The plant now consisted of two 500-volt multipolar generators, each of 75 kilowatts capacity, belt driven by two horizontal engines, 18 inches cylinder and 3 feet stroke, making 120 revolutions per minute; steam pressure, 80 pounds. There were five cutters driven from this plant, but they also fed three electric haulage engines and two pumps, and also lighted the surface and underground. The second-named plant of 60 kilowatts capacity was turbo driven, with a voltage of 500. The turbine revolutions were 3,200 per minute, and a fan was also direct driven from the same turbine. The generator supplied current for the cutter, the pump, and lights for general surface work. The third-named plant, situated at their new main, Nos. 3 and 4 pits, consisted of two "Parsons" three-phase turbo alternators, which were each of 300 kilowatts normal capacity—voltage, 465. Many classes of work were being fed by these, but coal-cutting had not yet been added. The total amount of coal cut by their machines in 1902 was 41,850 tons, and as the total amount cut by machinery, as given by Mr. Gerrard in his report for the Manchester district, was only 80,056 tons, they thus participated in one-half of the output. At the present time they were cutting at the rate of 100,000 tons for the year, and last year they had cut 70,568 tons. The question of the advantage or disadvantage of a coal-cutter, as against hand labor, was largely dependent in their experience upon the average tonnage rate previously paid to the collier for hand labor. In the case of the 1-foot 8-inch seam, he ought to say that they had the cutter working a district in which a shilling per ton extra was paid to the collier for "hard coal," and he had not included the extra shilling in the hand-got coal in his comparison of cost.

The stores also varied with the hardness of the cutting. Their experience led them to say that a machine cutter could not take out holing dirt that was much harder than could be got by hand. An extra degree of hardness added considerably to the stores and cutting cost. The amount of coal filled per man after the cutter was about twice the amount filled by hand holing, or 14.8 to 7.2, and the cost per ton for filling was 2s. 0½d., as against 3s. 2¾d. In other words, for a 100 per cent increase in amount of coal filled there had only been 37 per cent reduction instead of 50 per cent in price paid. This had gone to increase the wages per man, but the "size" and expense of the men employed had risen. Instead of a collier and light drawer they now had a collier and two more highly-paid drawers. The crux of the saving really lay in that particular of filling and drawing, and he had maintained at other times and places the great probability that the collier, as such, must really cease to exist if coal-cutting was to find its true level. The higher wages in coal mining, as in other trades, would eventually be paid to the most intelligent workman, and not simply because a man worked on the faces as distinct from the roadways. The quality of coal obtained was certainly changed by the cutter. On the whole, the slack had not improved, but had depreciated. The rise in quantity of cutter coal had been coincident with the call of the consumer for more dust to be taken out of the slack which, in itself, was suggestive. In one seam, the Half-Yard, although the percentage of round was improved, the whole of the slack was rendered useless, because of a 1-inch band of dirt on the floor which the cutter persisted in holing in. In hand labor they could keep on the top of this dirt and have good slack. But just as the slack was often of less value, the round coal was more often improved. In three out of the four mines under consideration, the quality of round coal had certainly been improved. He could not say exactly what the increase was, but might safely put it at 10 per cent. The size and quality of the round coal were improved at the same time. In the Three Feet Mine the coal stuck very hard to the roof and much chopping was necessary. They had found a 4-foot 6-inch cut the most suitable. This was about the minimum cut which would allow of timbers being set under the new roof, still leaving room for the cutter to pass between them and the coal. They preferred also to cut a floor level, finding that the wheel kept its position better between the partings, and the floor did not need to be afterward leveled. They had generally adopted the "backward and forward along the face" method of cutting as preferable in the shorter lengths of face, which they were only able to work, but the "Jeffrey" cutters in the 1-foot 8-inch seam were cutting in a unidirection, and

were "flitted" from end to end. An important desideratum was the shortening to as fine a point as possible of the wagoning of the coal from the face to the haulage rope. In conclusion, he might safely claim that they had attained such definite objects as: (1) More output per man employed; (2) coal economically worked which previously had been unworkable to a profit by hand; (3) more systematic working; (4) better round coal in three out of four mines; (5) greater area exposed in same time in two out of four seams; (6) premium per ton for risk of life reduced by one-third. It was scarcely possible to say how far the effect of coal-cutting reached. The official had to keep better vigilance than before, not only as regards safety, but also to keep the machine "forging ahead," as the next day's output depended largely upon it. The collier had been disturbed in his nest at the face. He now met the mechanic and the electrician on his own private preserve, and no doubt considered them interlopers; work of a higher class, such as the mechanical and electrical, was displacing, say, 33 per cent of the colliers' work, and that the most laborious. Therefore, having installed the coal-cutters, the Hulton Colliery would certainly consider that a return to the hand labor would be a step back into the older and darker times.

THE TRANSMISSION OF ELECTRIC ENERGY WITHOUT WIRES.*

By NIKOLA TESLA.

TOWARD the close of 1898 a systematic research, carried on for a number of years with the object of perfecting a method of transmission of electrical energy through the natural medium, led me to recognize three important necessities: First, to develop a transmitter of great power; second, to perfect means for individualizing and isolating the energy transmitted; and, third, to ascertain the laws of propagation of currents through the earth and the atmosphere. Various reasons, not the least of which was the help proffered by my friend Leonard E. Curtis and the Colorado Springs Electric Company, determined me to select for my experimental investigations the large plateau, two thousand meters above sea level, in the vicinity of that delightful resort, which I reached late in May, 1899. I had been there but a few days when I congratulated myself on the happy choice, and I began the task for which I had long trained myself, with a grateful sense and full of inspiring hope. The perfect purity of the air, the unequaled beauty of the sky, the imposing sight of a high mountain range, the quiet and restfulness of the place—all around contributed to make the conditions for scientific observation ideal. To this was added the exhilarating influence of a glorious climate and a singular sharpening of the senses. In those regions the organs undergo perceptible physical changes. The eyes assume an extraordinary limpidity, improving vision; the ears dry out and become more susceptible to sound. Objects can be clearly distinguished there at distances such that I prefer to have them told by someone else, and I have heard—this I can venture to vouch for—the claps of thunder seven and eight hundred kilometers away. I might have done better still, had it not been tedious to wait for the sounds to arrive, in definite intervals, as heralded precisely by an electrical indicating apparatus—nearly an hour before.

In the middle of June, while preparations for other work were going on, I arranged one of my receiving transformers with the view of determining in a novel manner, experimentally, the electric potential of the globe and studying its periodic and casual fluctuations. This formed part of a plan carefully mapped out in advance. A highly sensitive, self-restorative device, controlling a recording instrument, was included in the secondary circuit, while the primary was connected to the ground and an elevated terminal of adjustable capacity. The variations of potential gave rise to electric surgings in the primary; these generated secondary currents, which in turn affected the sensitive device and recorder in proportion to their intensity. The earth was found to be, literally, alive with electrical vibrations, and soon I was deeply absorbed in this interesting investigation. No better opportunities for such observations as I intended to make could be found anywhere. Colorado is a country famous for the natural displays of electric force. In that dry and rarefied atmosphere the sun's rays beat the objects with fierce intensity. I raised steam, to a dangerous pressure, in barrels filled with concentrated salt solution, and the tinfoil coatings of some of my elevated terminals shriveled up in the fiery blaze. An experimental high-tension transformer, carelessly exposed to the rays of the setting sun, had most of its insulating compound melted out and was rendered useless. Aided by the dryness and rarefaction of the air, the water evaporates as in a boiler, and static electricity is developed in abundance. Lightning discharges are, accordingly, very frequent and sometimes of inconceivable violence. On one occasion approximately twelve thousand discharges occurred in two hours, and all in a radius of certainly less than fifty kilometers from the laboratory. Many of them resembled gigantic trees of fire with the trunks up or down. I never saw fire balls, but as a compensation for my disappointment I succeeded later in determining the mode of their formation and producing them artificially.

In the latter part of the same month I noticed several times that my instruments were affected stronger by discharges taking place at great distances than by those near by. This puzzled me very much. What was the cause? A number of observations proved that it could not be due to the differences in the intensity of the individual discharges, and I readily ascertained that the phenomenon was not the result of a varying relation between the periods of my receiving circuits and those of the terrestrial disturbances. One night, as I was walking home with my assistant, meditating over these experiences, I was suddenly staggered by a thought. Years ago, when I wrote a chapter of my lecture before the Franklin Institute and the National Electric Light Association, it had presented itself to me, but I had dismissed it as absurd and impossible. I banished it again. Nevertheless, my instinct was aroused and somehow I felt that I was nearing a great revelation.

It was on the third of July—the date I shall never forget—when I obtained the first decisive experimental evidence of a truth of overwhelming importance for the advancement of humanity. A dense mass of strongly charged clouds gathered in the west and toward the evening a violent storm broke loose which, after spending much of its fury in the mountains, was driven away with great velocity over the plains. Heavy and long persisting arcs formed almost in regular time intervals. My observations were now greatly facilitated and rendered more accurate by the experiences already gained. I was able to handle my instruments quickly and I was prepared. The recording apparatus being properly adjusted, its indications became fainter and fainter with the increasing distance of the storm, until they ceased altogether. I was watching in eager expectation. Surely enough, in a little while the indications again began, grew stronger and stronger and, after passing through a maximum, gradually decreased and ceased once more. Many times, in regularly recurring intervals, the same actions were repeated, until the storm which, as evident from simple computations, was moving with nearly constant speed, had retreated to a distance of about three hundred kilometers (186 miles). Nor did these strange actions stop then, but continued to manifest themselves with undiminished force. Subsequently, similar observations were also made by my assistant, Mr. Fritz Lowenstein, and shortly afterward several admirable opportunities presented themselves which brought out, still more forcibly, and unmistakably, the true nature of the wonderful phenomenon. No doubt whatever remained—I was observing stationary waves.

* Electrical World and Engineer.

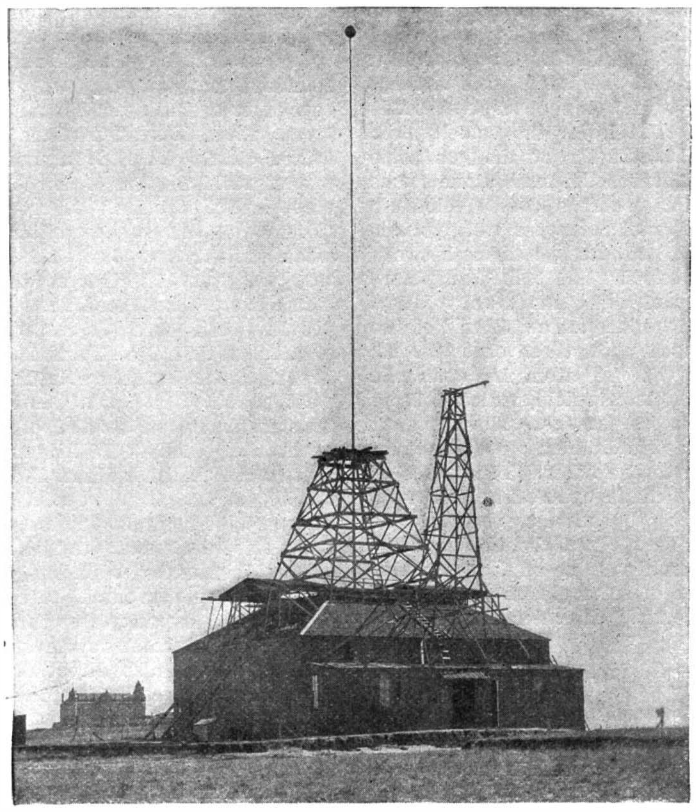


FIG. 1.—TESLA EXPERIMENTAL LABORATORY IN COLORADO, ERECTED DURING THE SUMMER OF 1899.

(The discovery by Mr. Tesla of the stationary waves in the earth was made here.)

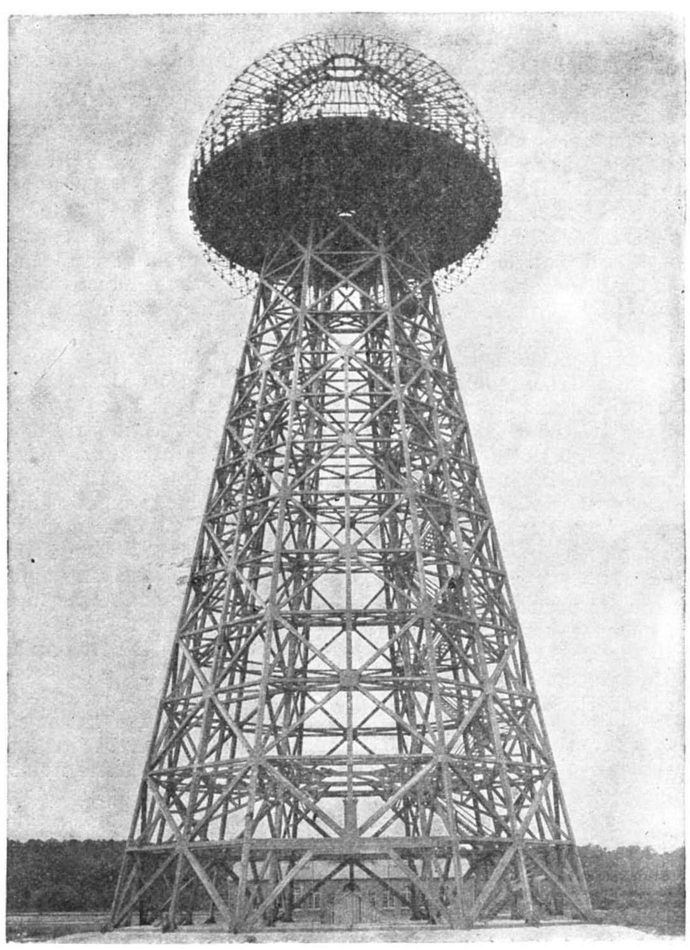


FIG. 2.—TESLA CENTRAL POWER PLANT AND TRANSMITTING TOWER FOR WORLD TELEGRAPHY, AT WARDENCLYFFE, LONG ISLAND, N. Y.

(The tower is a pyramid having eight sides; smallest dimensions across base, 95 feet; height, 154 feet; total height from ground to top, 187 feet; cupola on top, 65.62 feet in diameter.)

As the source of disturbances moved away, the receiving circuit came successively upon their nodes and loops. Impossible as it seemed, this planet, despite its vast extent, behaved like a conductor of limited dimensions. The tremendous significance of this fact in the transmission of energy by my system had already become quite clear to me. Not only was it practicable to send telegraphic messages to any distance without wires, as I recognized long ago, but also to impress upon the entire globe the faint modulations of the human voice, far more still, to transmit power, in unlimited amounts, to any terrestrial distance and almost without any loss.

With these stupendous possibilities in sight, with the experimental evidence before me that their realization was henceforth merely a question of expert knowledge, patience, and skill, I attacked vigorously the development of my magnifying transmitter, now, however, not so much with the original intention of producing one of great power, as with the object of learning how to construct the best one. This is, essentially, a circuit of very high self-induction and small resistance which, in its arrangement, mode of excitation, and action, may be said to be the diametrically opposite of a transmitting circuit typical of telegraphy by Hertzian or electromagnetic radiations. It is difficult to form an adequate idea of the marvelous power of this unique appliance, by the aid of which the globe will be transformed. The electromagnetic radiations being reduced to an insignificant quantity, and proper conditions of resonance maintained, the circuit acts like an immense pendulum, storing indefinitely the energy of the primary exciting impulses and impressing upon the earth and its conducting atmosphere uniform harmonic oscillations of intensities which, as actual tests have shown, may be pushed so far as to surpass those attained in the natural displays of static electricity.

Simultaneously with these endeavors, the means of individualization and isolation were gradually improved. Great importance was attached to this, for it was found that simple tuning was not sufficient to meet the vigorous practical requirements. The fundamental idea of employing a number of distinctive elements, co-operatively associated, for the purpose of isolating energy transmitted, I trace directly to my perusal of Spencer's clear and suggestive exposition of the human nerve mechanism. The influence of this principle on the transmission of intelligence, and electrical energy in general, cannot as yet be estimated, for the art is still in the embryonic stage; but many thousands of simultaneous telegraphic and telephonic messages, through one single conducting channel, natural or artificial, and without serious mutual interference, are certainly practicable, while millions are possible. On the other hand, any desired degree of individualization may be secured by the use of a great number of co-operative elements and arbitrary variation of their distinctive features and order of succession. For obvious reasons, the principle will also be valuable in the extension of the distance of transmission.

Progress, though of necessity slow, was steady and sure, for the objects aimed at were in a direction of my constant study and exercise. It is, therefore, not astonishing that before the end of 1899 I completed the task undertaken and reached the results which I have announced in my article in the Century Magazine of June, 1900, every word of which was carefully weighed.

Much has already been done toward making my system commercially available, in the transmission of energy in small amounts for specific purposes, as well as on an industrial scale. The results attained by me have made my scheme of intelligence transmission, for which the name of "world telegraphy" has been suggested, easily realizable. It constitutes, I believe, in its principle of operation, means employed, and capacities of application, a radical and fruitful departure from what has been done heretofore. I have no doubt that it will prove very efficient in enlightening the masses, particularly in still uncivilized countries and less accessible regions, and that it will add materially to general safety, comfort, and convenience, and maintenance of peaceful relations. It involves the employment of a number of plants, all of which are capable of transmitting individualized signals to the uttermost confines of the earth. Each of them will be preferably located near some important center of civilization and the news it receives through any channel will be flashed to all points of the globe. A cheap and simple device, which might be carried in one's pocket, may then be set up somewhere on sea or land, and it will record the world's news or such special messages as may be intended for it. Thus the entire earth will be converted into a huge brain, as it were, capable of response in every one of its parts. Since a single plant of but one hundred horse-power can operate hundreds of millions of instruments, the system will have a virtually infinite working capacity, and it must needs immensely facilitate and cheapen the transmission of intelligence.

The first of these central plants would have been already completed had it not been for unforeseen delays which, fortunately, have nothing to do with its purely technical features. But this loss of time, while vexatious, may after all prove to be a blessing in disguise. The best design of which I knew has been adopted, and the transmitter will emit a wave complex of a total maximum activity of ten million horse-power, one per cent of which is amply sufficient to "girdle the globe." This enormous rate of energy delivery, approximately twice that of the combined falls of Niagara, is obtainable only by the use of certain artifices, which I shall make known in due course.

For a large part of the work which I have done so far I am indebted to the noble generosity of Mr. J. P. Morgan, which was all the more welcome and stimulating, as it was extended at a time when those who have since promised most were the greatest of doubters. I have also to thank my friend, Stanford White, for much unselfish and valuable assistance. This work is now far advanced, and though the results may be tardy, they are sure to come.

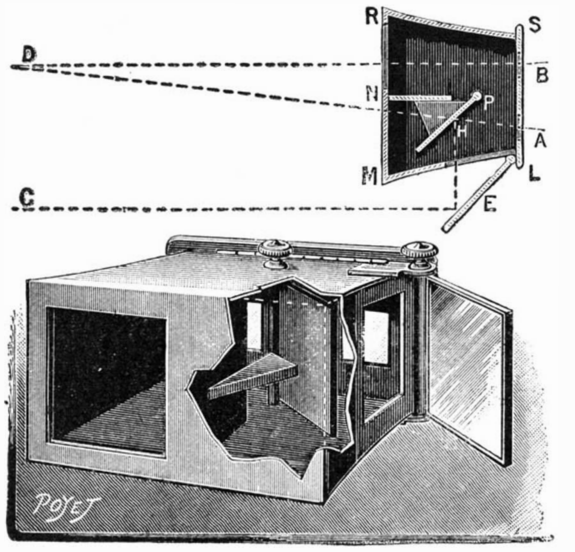


FIG. 1.—BELLIENI'S APEDIOSCOPE FOR OBSERVING STEREOSCOPIC PROJECTIONS.

Meanwhile, the transmission of energy on an industrial scale is not being neglected. The Canadian Niagara Power Company have offered me a splendid inducement, and next to achieving success for the sake of the art, it will give me the greatest satisfaction to make their concession financially profitable to them. In this first power plant, which I have been designing for a long time, I propose to distribute ten thousand horse-power under a tension of one hundred million volts, which I am now able to produce and handle with safety.

The energy will be collected all over the globe, preferably in small amounts, ranging from a fraction of one to a few horse-power. One of its chief uses will be the illumination of isolated homes. It takes very little power to light a dwelling with vacuum tubes operated by high-frequency currents, and in each instance a terminal a little above the roof will be sufficient. Another valuable application will be the driving of clocks and other such apparatus. These clocks will be exceedingly simple, will require absolutely no

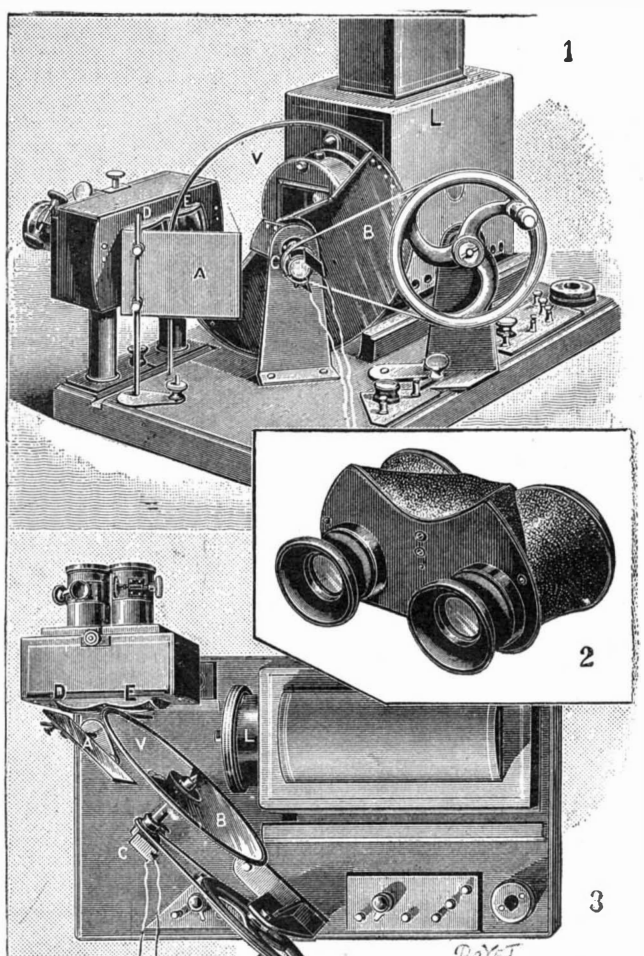


FIG. 2.—THE SCHMIDT AND DUPUIS APPARATUS AND OPERA GLASS FOR OBSERVING STEREOSCOPIC PROJECTIONS.

attention, and will indicate rigorously correct time. The idea of impressing upon the earth American time is fascinating and very likely to become popular. There are innumerable devices of all kinds which are either now employed or can be supplied, and by operating them in this manner I may be able to offer a great convenience to the whole world with a plant of no more than ten thousand horse-power. The introduction of this system will give opportunities for invention and manufacture such as have never presented themselves before.

Knowing the far-reaching importance of this first attempt and its effect upon future development, I shall proceed slowly and carefully. Experience has taught me not to assign a term to enterprises the consummation of which is not wholly dependent on my own abilities and exertions. But I am hopeful that these great realizations are not far off, and I know that when this first work is completed they will follow with mathematical certitude.

When the great truth accidentally revealed and experimentally confirmed is fully recognized, and this planet, with all its appalling immensity, is to electric currents virtually no more than a small metal ball, and that by virtue of this fact many possibilities, each baffling imagination and of incalculable consequence, are rendered absolutely sure of accomplishment; when the first plant is inaugurated and it is shown that a telegraphic message, almost as secret and non-interferable as a thought, can be transmitted to any terrestrial distance, the sound of the human voice, with all its intonations and inflections faithfully and instantly reproduced at any other point of the globe, the energy of a waterfall made available for supplying light, heat or motive power, anywhere—on sea, or land, or high in the air—humanity will be like an antheap stirred up with a stick. See the excitement coming!

STEREOSCOPIC PROJECTIONS.

IN order that images may be seen in relief by stereoscopic projections, it does not suffice to project upon the screen the two images emanating from a stereoscopic negative, but it is also necessary that it shall be possible for each eye of the spectator, through an appropriate arrangement, to receive only that one of the two images that is designed for it. There exists a stereoscope for images of large dimensions, and that is the mirror apparatus of M. Cazes; but this is not easily manipulated and cannot be employed by the spectators at an ordinary exhibition of stereoscopic lantern slides. Other inventors, and M. Knight especially, have indicated the possibility of constructing portable apparatus on the same principle. We do not know whether or not the idea was ever carried out, but it appears, at all events, to have fallen into oblivion. Quite recently, M. Bellieni, taking up the same idea, and without knowing anything at all about the work of M. Knight, has succeeded in constructing the apediosope, a small and easily portable apparatus of moderate price, with which each spectator may provide himself when a lecture, for example, is illustrated with stereoscopic projections. Experimented with recently at a meeting of the French Photographic Society, in which the inventor placed thirty of these apparatus at the disposal of the members, it gave excellent results.

Use is made of the stereoscopic positive upon glass, such as is found in the collections for the ordinary stereoscope (care being taken to remove the ground glass if any exists). This is passed into a single-objective lantern. A 6-inch condenser suffices for 3¼ x 6½-inch slides, and a 4¾-inch one for 2¼ x 5-inch slides.

The two images are thus projected upon the screen, one alongside of the other. In order to answer the requirements of the principle mentioned above, the spectator's apparatus consists of a small box, *M R S L*, containing two apertures, *A* and *B*, situated at the normal distance apart of the eyes (Fig. 1). Through one of these, *B*, we see directly with the right eye, for instance, one of the two images, *D*, which is the one intended for that eye. The other image, *C*, is concealed from the right eye by a wooden partition, *N P*, placed in the apparatus. But this other image is reflected in a small mirror, *E*, situated upon the other side of the box, and capable of being set in the proper position by means of a button. After the image, *C*, is properly perfected by this mirror, it is received by a second mirror, *H*, placed in the interior of the apparatus. It is here that the right eye, placed at *A*, sees it appear, and instinctively transfers it to *D*, beyond the mirror superposing it upon the first image. This gives the effect of reliefs, as in the ordinary stereoscope.

The slight regulation necessary for the proper reception of one of the images in the mirror is done once for all at the beginning of the lecture or other entertainment by means of a geometrical figure, for example, of which only a part need be projected on each side, but of which the superposition must be made to appear complete. It is to be remarked that this system occasions no loss of light.

There are still other methods of viewing stereoscopic lantern slides in relief. This question was discussed by us thirteen years ago, when M. Molteni projected the two images one upon the other, after having colored one of them red and the other green, by means of colored glasses placed before them. The spectators had to be provided with eye-glasses having the same colors. It is evident that, under such circumstances, each eye can see only the image that is designed for it, and the relief is easily perceived. But these multicolored screens upon the lantern and the eyes absorb too great a quantity of light, and that is what has prevented the development of this system of stereoscopic projection.

The idea has been taken up under another form by various persons, and, among others, by M. Rateau; and we have recently seen it carried out in a very complete manner by MM. Schmidt and Dupuis. The process consists in projecting the two images successively. If the spectator opens but one eye at a time—the left

one when it is the image to the left that appears, and the right one when it is the image to the right—he will perceive the relief, and the loss of light will be much less than with colored screens. It would have been difficult to ask the spectators to give themselves up to such eye gymnastics, which are so much the more difficult to perform, in that it is necessary for the two images to succeed one another with sufficient rapidity to make it appear that there is but a single one, thanks to the continuity of the impressions upon the retina. It therefore became necessary to effect such eclipses automatically, and for this purpose it sufficed to provide each spectator with a double opera glass on which a shutter alternately covers and uncovers the lenses, so that the eyes shall see the images projected alternately only and never together. It is indispensable to obtain a perfect coincidence between the projection of the image and the opening of the eye that is to view it. In order to reach such a result, things are arranged in the following manner: The two stereoscopic images upon glass are placed, as with an ordinary stereoscope, at the back of a camera, *D E*, provided with two lenses (Fig. 2). A lantern, *L*, sends a pencil of light parallel with the plane of the images, and this pencil is reflected through the latter by two mirrors inclined at an angle of 45 deg. The first, *A*, is stationary, and illuminates the image, *D*, up to a moment at which the mirror, *B*, which is revolvably mounted upon an axis, places itself in front of *B* and sends the light through the image *E*. The rotation of this mirror continuing as quickly as may be desired, it will therefore be possible to project the images upon the screen rapidly and in succession. The synchronizing of the shutter of the opera glass placed in the hands of the spectator, with the revolving mirror, is controlled electrically.

The current from a battery is led to a two-segment commutator, *C*, mounted upon the rotary axis of the mirror, *B*. Two brushes, terminating the flexible wire connected with the opera glass, rub against this commutator and lead the current to the electro-magnets that actuate the shutter of the opera glass.

It suffices, then, to arrange things in such a way that the right lens shall be uncovered only when the mirror, *B*, passes in front of the other, in order that the right eye may be able to see upon the screen only the image coming from *E*. The left lens, on the contrary, will be uncovered only when the mirror, *B*, being out of the way, allows the mirror, *A*, to illuminate the image, *D*. Thus the left eye will never see anything but the latter on the screen.

It is clear that it is possible to control as many opera glasses at once as may be desired, provided that each one of them be connected with the projection apparatus through a pair of wires.

We have found that the apparatus thus constructed gives an excellent solution of the problem. The continuity of the impression is complete, and the relief is perceived with the greatest facility without the necessity of any regulation on the part of the spectator. This apparatus can be used also for animate stereoscopic projection.

The two processes that we have just described are both very interesting and complete each other perfectly. That of M. Bellieni is designed rather for families and for gatherings of a few persons in which each spectator may be placed sensibly in the axis of the projection. The Schmidt and Dupuis apparatus is adapted for theatres, in which an electric wiring, easily installed, leads the current to the opera glass placed in front of the spectator's seat.—Translated from La Nature for the SCIENTIFIC AMERICAN SUPPLEMENT.

CURIOUS OPTICAL ILLUSIONS.

THE lunar halo, which by many persons is regarded as a remarkable and unexplained luminosity associated with the moon, is to meteorological students neither a mysterious nor an anomalous occurrence. It has been frequently observed, and for many years thoroughly understood, and at the present time admits of an easy scientific explanation. It is an atmospheric exhibition due to the refraction and dispersion of the moon's light through very minute ice-crystals floating at great elevations above the earth, and is explained by the science of meteorology, to which it properly belongs; for it is not of cosmical origin, and in no way pertains to astronomy, as most persons suppose, except as it depends upon the moon, whose light, passing through the atmosphere, produces the luminous halo, which, as will be seen, is simply an optical illusion, originating, not in the vicinity of the moon—240,000 miles away—but just above the earth's surface, and within the aqueous envelope that surrounds it on all sides.

A lunar halo, or circles of prismatic colors, seen around the moon, never occurs except when the sky is somewhat hazy, and presents a dull, leaden appearance. Usually only one circle is seen surrounding the moon, and it is always of large size, being about 45 deg. in diameter, or 80 times the apparent diameter of the moon, corresponding to one-half the distance from the zenith to the horizon. The sky within the circle is always apparently much darker than it is for some distance on the outside—a feature which is the peculiar characteristic of a halo when seen under the most favorable conditions—and the circle exhibits the seven prismatic colors seen in the rainbow, and the inner edge being red and quite sharply defined, while the other colors are more or less mingled and superposed, so that the outer edge of the circle is nearly white, and usually not very clearly defined.

Sometimes a number of large circles are seen around the moon, presenting a peculiar and very complicated appearance, and they are seldom concentric as in a lunar corona, but intersect each other with mathematical exactness, exhibiting a structure that is often wonderful to behold. A true halo is never produced when the sky is perfectly clear, as a slight haze is essential to its appearance, and the beautiful illusion is visible only under rare and peculiar atmospheric conditions. In connection with the halo, white bands, crosses, or arches are sometimes observed, which also result from the same conditions of the atmosphere at great elevations above the earth.

A halo may form around the sun as well as around the moon, and all the curious features above described are similarly observed; but a halo is most frequently noticed about the moon for the reason that we are too much dazzled by the sun's light to distinguish faint colors surrounding its disk, and to see them it is necessary to look through smoked glass or view the sun by reflection from the surface of still water, by which means its brilliancy is very much reduced. When a halo is seen around the sun, a white circle passing through the sun and parallel to the horizon is sometimes observed, which is known to meteorologists as the "parhelic circle," from the fact that parhelia or mock-suns are frequently noticed in connection with it. These productions, which are commonly called "sun-dogs," are faint images of that luminary, appearing at one, two, or more points in connection with a halo, and at those parts where the circles cross each other, or cut the parhelic circle above mentioned. The number of these mock-suns, or parhelia, visible at the same time is variable; sometimes one or two only are to be seen, at other times four or five, and on some occasions as many as seven have been observed at once. These mock-suns usually appear about the size of the real sun, but not quite so bright, though on rare occasions they are said to rival their parent luminary in brilliancy and splendor.

Such appearances, which are also seen about the moon (known as "mock-moons" or "moon-dogs") are most frequently observed in the polar regions, but often occur in the more temperate latitudes, and are produced by the extra light concentrating at those points where the circles intersect, there being at such places a double cause of illumination, presenting the singular spectacle of a faint white disk, resembling that of the sun or moon. Parhelia, or mock-suns, are generally red on the side toward the sun, and they sometimes have a prolongation in the form of a tail, several degrees in length, which coincides in direction with that of the parhelic or horizontal circle. A recent writer on the subject says: "Parhelia have been observed frequently both in ancient and modern times. Aristotle records two appearances of these meteors, and Pliny mentions their occurrence at Rome. A double parhelion, which was noticed before the Christian era, is referred to by St. Augustine. Many others have been observed from different points on the Continent. On January 2, 1586, Christopher Rotham saw, at Cassel, before sunrise, an upright column of light of the breadth of the sun's disk. As he rose to view he was preceded and followed by a parhelion, which appeared in contact with his orb, and continued visible for thirty minutes, and then was hidden by a cloud. On February 28, 1551, mock-suns were seen at Antwerp; and on March 17 of the same year a similar phenomenon, with two halos, was witnessed at the same place. Four days after the last-named two parhelia, with three halos, were seen at Magdeburg."

A halo may be produced artificially, and its appearance beautifully illustrated, by crystallizing some salt (such as alum) upon a glass plate, and then looking through the plate at the sun or a bright light, then the luminous circles above described will be observed. The formation of a circle of light around the sun or moon, and the production of the dark circle to which we have referred, may also be illustrated by an interesting imaginary experiment, which is thus described by the late Prof. Loomis, an eminent authority on the subject of atmospheric phenomena: "If we conceive a beam of light to be admitted through a small aperture into a dark room, and to fall upon a large number of ice-prisms having angles of sixty degrees, and occupying every possible position, all the incident rays will be deviated from their first direction, but in no case will the deviation be less than about twenty-two degrees. A large number of spectra will be cast upon the opposite wall, but opposite to the aperture through which the light is admitted there will be a circle of twenty-two degrees radius upon which no spectrum can fall, and the red end of each spectrum will be turned toward the center of the circle. If the number of the spectra be sufficiently great, they will together form a circle of twenty-two degrees radius, bordered with the red upon the inside; but beyond the red the different colors will be so superposed as to produce a light nearly white. The circle within the halo is much darker than the space without it, because from no part of this circle can a ray of the sun, refracted by the ice-prisms, reach the eye of the observer."

The halo is less brilliant and beautiful, but far more frequent, than the rainbow. Scarcely a week passes during the whole year in which the exhibition does not occur. In summer the ice-crystals that produce the halo are three or four miles high, above the limit of perpetual frost, and for this reason the apparition is sometimes called the "frost-bow." As the rainbow is sometimes seen in dewdrops on the ground, so the "frost-bow," just after sunrise, has been noticed in the crystals which fringe the grass. A halo is the bright border of an illuminated zone, and Prof. Olmsted says: "As in the rainbow, so in the halo, the visible band of colors is the only border of a large illuminated space on the sky. The ordinary halo, therefore, is the bright inner border of a zone, which is more than 20 deg. wide. The whole zone, except the inner edge, is too faint to be generally noticed, though it is perceptibly more luminous than the space between the halo and luminary."

A corona is an appearance of faintly-colored rings, often seen around the sun and moon when a light, fleecy cloud passes over them, and should not be mistaken for a halo, which is much larger and more complicated in its structure, as explained above. These two phenomena are frequently confounded by inexperienced observers, but they exhibit peculiar features by which each may be easily distinguished from the other. Both exhibit the seven prismatic colors; but in a corona the colors are reversed, the red being on the outer edge instead of on the inner edge, as in a halo, and the circles of a corona, besides being smaller, are concentric with each other—the inner one being small, the diameter of the second being double, and that of the third treble the diameter of the first. The structure of the corona is quite simple, and never exhibits the attractive features observed in the halo, which is a production of comparatively rare occurrence, while a corona may be seen every time a light transparent cloud comes between us and the sun or moon, and is produced by the diffraction of light passing between the minute globules of condensed vapor in a cloud.

What we have said regarding the size of a halo will alone enable an observer to recognize this phenomenon, and distinguish it from a corona. Prof. Loomis says: "The mean of eighty-three measurements of the radius of the red circle of a halo is 21 deg. 36 min., which is almost identical with the radius computed from theory." The diameter of the luminous circles of a corona is not always the same, and while they are never large, the diameter of the first red ring varies from 3 deg. to 6 deg., and that of the second red ring from 5 deg. to 10 deg.

A corona, like a halo, may be easily produced artificially. If we sprinkle upon a pane of glass a small quantity of lycopodium, or any very fine dust of nearly uniform fineness, and then look at the moon through this glass, we shall see it surrounded by luminous rings of prismatic colors, precisely like those that are formed by a cloud; and if, on a cold winter evening, we breathe upon a pane of glass, the breath will condense into very small globules and freeze. If we look at the moon, or even at a street lamp, through this glass, we shall see a similar system of colored rings, having violet on the inside.

More solar and lunar halos are usually seen in winter than in summer, owing to the favorable conditions of the former season for the formation of ice-crystals in the upper regions of the air for their production, and the singular appearances they present. During the cold weather that prevailed in the winter of 1887-8, the frosty condition of the atmosphere was particularly favorable for the production of these curious displays, and many exhibitions of the kind were observed in various portions of the country where such appearances are uncommon, and have seldom, if ever, occurred before. Many reports of such luminous circles appeared in the newspapers at that time, some of the exhibitions having been unusually interesting and remarkable; but none of the accounts seen by the writer—with one or two exceptions—explained the phenomena correctly, or mentioned their real nature, which was evidently not known or misunderstood by those who described them. On the evening of March 30, 1890, a beautiful lunar halo, accompanied by a "moon-dog," was observed by the writer, and on the following morning a brilliant solar halo with two "sun-dogs," appeared about one hour after sunrise, which attracted great attention from those who were fortunate enough to witness the interesting exhibition.

Of all the numerous weather proverbs current among the people, those relating to the production of a halo should be included with the few for which there is considerable scientific foundation, justified by actual experience and observation. There is perhaps no better known, or more popular, weather prognostic than that pertaining to the lunar halo, which has long been recognized, even among scientific persons, as an almost unfailing sign of foul weather, and reliable indication of an approaching storm. One of the old familiar proverbs relating to the lunar halo is expressed in the lines:

"When round the moon there is a brugh,
The weather will be cold and rough."

Prof. John Westwood Oliver, in a recent article on "The Moon and the Weather," published in Longman's Magazine says: "The halo is an old sign of bad weather. Of sixty-one lunar halos observed in the neighborhood of London, thirty-four were followed by rain within twenty-four hours, nineteen by rain within four days, and only eight by no rain at all." As a halo is never seen except when the sky is hazy, it indicates that moisture is accumulating in the atmosphere, which will form clouds, and usually result in a storm. But the popular notion that the number of bright stars visible within the circle indicates the number of days before the storm will occur is without any foundation whatever, and the belief is almost too absurd to be refuted. In whatever part of the sky a lunar halo is seen, one or more bright stars are always sure to be noticed inside the luminous ring, and the number visible depends entirely upon the position of the moon. Moreover, when the sky within the circle is examined with even a small telescope hundreds of stars are visible where only one, or perhaps two or three, were perceived by the naked eye.

A lunar halo, when seen under favorable conditions, with all the curious features that usually accompany it, is one of the most interesting and beautiful exhibitions of Nature; and there are many remarkable facts connected with its formation and appearance that cannot be dealt with in a popular description of the phenomenon, but which are fully explained in nearly every work on natural philosophy, meteorology, or physical geography. In Prof. Loomis' "Treatise on Meteorology" may be found a clear and exhaustive description of halos and coronas, fully illustrated and scientifically explained. There is an instructive popular article entitled "The Lunar Halo," by the late Prof. Proctor, in his admirable work, "Flowers of the Sky," which contains an excellent engraving illustrating the one-ring halo, most commonly observed, and showing the dark space around the moon, which is always noticed in a perfect halo, and is thoroughly explained in the above-mentioned work, together with many other paradoxical features and curious illusions associated with the wonderful atmospheric spectacle.—Arthur K. Bartlett, in Popular Astronomy.

COMPARATIVE FIGHTING VALUES OF MODERN WARSHIPS.

By OTTO KRETSCHMER, Chief Naval Constructor, German Navy.

MR. OTTO KRETSCHMER, chief naval constructor with the Royal German Navy, has computed, upon our request, a table of the military values of a number of the latest warships of various navies, on the basis of his P. A. formula for the mathematical determination of the fighting value of men-of-war. We present the table herewith to our readers. Mr. Kretschmer distinguishes:

1. A general fighting value.
2. A tactical fighting value.
3. A passive fighting value.
4. An active fighting value.
5. A vital fighting value.

The general fighting value embraces all factors of naval combat, such as armor protection; heavy, intermediary, medium, and light artillery; the torpedo armament, the ram, and the vessel's speed.

The tactical fighting value constitutes merely the military.mathematical valuation of the condition in which the vessels might be when the final decisive struggle commences; that is, when medium ordnance and light ordnance and their armor protection have been pierced or destroyed, so that there only remain for the valuation the belt armor, and armor of the heavy and intermediary artillery, the armored deck, and the said artillery armament.

The passive fighting value represents only all factors of the armor protection considered as projection upon the three planes, parallel to the longitudinal plane, of the vessel; upon a plane supposed vertical thereto through the middle of the length of the vessel; and finally upon a horizontal plane which coincides with the armor deck. This makes it possible to express thereby longitudinal protection, bow and stern protection, and horizontal protection.

The active fighting value represents the valuation of the artillery with regard to the living force of all single guns, the arc of command or sweeping angle, the firing rapidity, and the number of guns aboard; furthermore, the torpedo-weapon and the ram with regard to its fighting effect.

The vital fighting value gives the valuation with consideration of the speed and the radius of action.

The table as it is, then, contains only the mathematically computed fighting value of the vessels, expressed in figures, with respect to the artillery armament, with exclusion of the torpedo weapon and the ram, as well as the vital fighting value, since we intend to show thereby how indispensably necessary the torpedo armament, ram, and speed are, which will be demonstrated in another table to be published in the near future.

This analysis will present the question of the mathematical determination of the fighting value more strikingly, as it will show the importance of those factors which are now left out.

In publishing these completed tables we shall at the same time give a short evolution of the formula.

We would briefly call attention to the values in the different columns of the table, which admit of recognizing readily whether a certain navy gives preference to the offensive or to the defensive. The importance of good and thick armor protection is also quite obvious from the numerical values of the table.

In Nos. 15 and 16 (April 14 and 21) of the Elektrotechnische Zeitschrift, Dr. E. Müllendorff suggests the following method of calculating current distributing systems in the case of the consuming places and the central station being given: 1. After choosing the feeding points, the natural fields of action of the latter should be determined. 2. After ascertaining whether any one of these ranges is of undue dimensions, a test should be made as to whether the feeding points coincide with the centers of gravity of the natural fields of action, taking into account the central station itself. 3. The cross sections of the conductors in each field of action are calculated according to the simple method of current moments, this serving to determine the available minimum amount of conductive copper. 4. In the case of the cross sections having to be simplified, the definite cross sections are determined from the natural cross sections, when the definite current distribution is calculated. The point of maximum absolute tension loss will, in each independent portion of the network, determine the definite cross sections themselves. 5. The conductive material thus calculated should be compared with the minimum calculated in advance. In the case of a satisfactory agreement, a simplification of the cross sections will be possible, while a poor agreement will point to the necessity of a better adaptation to the natural cross sections. This method is valuable on account of the permanent checking of the amount of copper expended, as well as of the simplicity with which this is made possible.

American Shoe Trade in Great Britain. The annual report from this consulate, written in October, 1903, quoted local shoe dealers to the effect that the sale of American footwear was not increasing in this city; that complaint was made of its not wearing well. In commenting thereon the report noted that the American shoes sold here were comparatively high priced.

A recent issue of a local periodical, after noting that consternation was created among English shoe manufacturers when their markets were invaded by the "pushful Yankee," with the result that a year ago "nearly as many American as English shoes were being sold in this country," asserts that the tide has turned; that comparatively few dealers are repeating their orders; and that American shoes are now displayed almost solely in establishments belonging to American firms. The shape and light weight of the American shoe captured the British fancy, but now, adds the periodical, the English bootmakers are themselves turning out the same patterns and are retaking their markets. They are effecting this by using American machinery and American lasts, but, it is claimed, are using a better leather for this wet climate than that which forms the American shoes. In the neighboring counties of Leicester and Northampton—great shoemaking centers—shoes claimed to be of the best quality and of American patterns are made at a cost of less than $2 a pair and are retailed at $3 to $4. It is asserted that these are beyond foreign competition, quality and price considered.

Allowing for probable exaggeration in the published assertions, it is yet evident that the American shoe trade is not securely anchored in this country and that it needs the serious attention of our manufacturers and exporters.—Frank W. Mahin, Consul at Nottingham, England.

COMPARATIVE FIGHTING VALUES OF MODERN WARSHIPS.

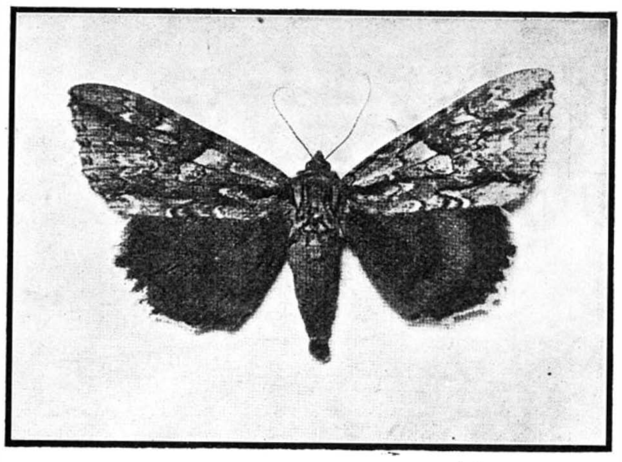
B=Battleship. Cr.=Cruiser. E=England. G=Germany. F=France. I=Italy. J=Japan. A=Austria-Hungary. R=Russia. U.S.=United States.

No.	Name of Vessel.	PA General Fighting Value	Type.	Country.	Name of Vessel.	PA Tactical Fighting Value.	Type.	Country.	Name of Vessel.	Pw (Passive Fighting Value)	No.	Name of Vessel.	Aw (Active Fighting Value)	No.	Name of Vessel.	Displacement in Metric Tons.	Type.	No. under PA	No. under PA (tact.)	No. under Pw	No. under Aw	Country	Launched.
1	Louisiana	66.8	B	U.S.	Regina Elena	30.0	B	I	Louisiana	1,882	1	Louisiana	53.01	1	King Edw. VII	16,760	B	3	3	3	4	E	03
2	Virginia	56.5	"	"	Virginia	29.9	"	U.S.	Virginia	1,723	2	Virginia	49.07	2	Louisiana	16,250	"	1	4	1	1	U.S.	03
3	King Edw. VII	46.9	"	E	King Edw. VII	28	"	E	King Edw. VII	1,721	3	Regina Elena	47.67	3	Mikasa	15,360	"	12	10	8	17	J	00
4	Czarevitch	40.6	"	R	Louisiana	25	"	U.S.	Republique	1,711	4	King Edw. VII	40.84	4	Virginia	15,240	"	2	2	2	2	U.S.	02
5	Republique	39.9	"	F	Republique	23.1	"	F	Suffren	1,698	5	Braunschweig	40.48	5	Shikishima	15,100	"	16	13	20	18	J	98
6	Borodino	38.2	"	R	Saint Louis	21.2	"	"	Czarevitch	1,512	6	Czarevitch	40.19	6	Republique	14,870	"	5	5	4	10	F	02
7	Regina Elena	37.1	"	I	Czarevitch	21.0	"	R	Borodino	1,424	7	Borodino	40.19	7	London	14,763	"	9	9	9	11	E	98
8	Braunschweig	34.	"	G	Borodino	21.0	"	"	Mikasa	1,408	8	Knjas Potemkin	39 61	8	Washington	14,700	Cr	15	28	19	16	U.S.	03
9	London	31.2	"	E	London	18.2	"	E	London	1,355	9	Retvisan	35.30	9	Drake	14,320	"	22	39	17	25	E	01
10	Knjas Potemkin	29.9	"	R	Mikasa	17.2	"	B	Duke of Edingb	1,346	10	Republique	34.96	10	Maryland	14,020	"	33	40	21	50	U.S.	02
11	Duncan	29.8	"	E	Duncan	15 2	"	E	Duncan	1,295	11	London	34.88	11	Duncan	3,780	B	11	11	11	12	E	01
12	Mikasa	28.0	"	J	Maine	14.8	"	U S.	Bouvet	1,289	12	Duncan	34 51	12	Borodino	13,740	"	6	8	7	7	R	01
13	Saint Louis	26.1	"	F	Shikishima	13 7	"	J	Jena	1,289	13	Benedetto Brin	33 95	13	Duke of Edingb	13,700	Cr	19	26	10	21	E	03
14	Retvisan	26.1	"	R	Retvisan	13.3	"	R	Saint Louis	1,287	14	Maine	30.69	14	Benedetto Brin	13,430	B	17	18	32	13	I	01
15	Washington	24.1	Cr	U.S.	Knjas Potemkin	12.9	"	"	Kearsarge	1,280	15	Saint Louis	30.41	15	Czarevitch	13,300	"	4	7	6	6	R	01
16	Shikishima	23.6	B	J	Braunschweig	12.6	"	E	Braunschweig	1,260	16	Washington	29.85	16	Braunschweig	13,208	"	8	16	16	5	G	02
17	Benedetto Brin	22.6	"	I	Henry IV	12	"	F	Drake	1,249	17	Mikasa	29.78	17	Retvisan	12,900	"	14	14	24	9	R	00
18	Maine	22.3	"	U.S.	Benedetto Brin	11	"	I	Fuji	1,215	18	Shikishima	29.38	18	Peresviet	12,880	"	21	23	31	20	"	98
19	Duke of Edingb	21	Cr	E	Bouvet	10.6	"	F	Washington	1,214	19	Canopus	29.09	19	Rossia	12,800	Cr	41	48	47	34	"	96
20	Canopus	17.7	B	"	Canopus	10.6	"	E	Shikishima	1,205	20	Peresviet	25.63	20	Canopus	12,746	B	20	20	38	19	E	98
21	Peresviet	17.1	"	R	Fuji	8.1	"	J	Maryland	1,170	21	Duke of Edingb	23.38	21	Suffren	12,730	"	25	31	5	42	F	99
22	Drake	16.7	Cr	E	Kearsarge	7.7	"	U.S.	Regina Elena	1,164	22	Ers. Laudon	22.68	22	Knjas Potemkin	12,700	"	10	15	23	8	R	00
23	Wittelsbach	15.7	B	G	Peresviet	7.3	"	R	Knjas Potemkin	1,131	23	Wittelsbach	22.57	23	Regina Elena	12,530	"	7	1	22	3	I	03
24	Bouvet	15.7	"	F	Ammiragl. d. S. B.	7.2	"	I	Retvisan	1,110	24	Kaiser Fredr. III	22.57	24	Fuji	12,600	"	28	21	18	35	J	96
25	Suffren	14.9	"	"	Kaiser Fredr. III	7.2	"	G	Maine	1,091	25	Drake	20 03	25	Victor Hugo	12,550	Cr	32	—	26	37	F	01
26	Kaiser Fredr. III	13.8	"	G	Duke of Edingb	6.7	Cr	E	Victor Hugo	1,072	26	Fürst Bismarck	19.74	26	Gromoboi	12,550	"	45	51	61	30	R	99
27	Ers. Laudon	12.9	"	A	Wittelsbach	6.5	B	G	Rostislaw	1,068	27	Bouvet	18 31	27	Maine	12,500	B	18	12	25	14	U S.	00
28	Fuji	11.6	"	J	Washington	6.1	Cr	U.S.	Wittelsbach	1,045	28	Ammiragl. d. S. B.	17.87	28	Cressy	12.200	Cr	37	42	45	29	E	99
29	Ammiragl. d. S. B	11.5	"	I	Fürst Bismarck	5 6	"	F	Adzuma	1,042	29	Cressy	17.31	29	Bouvet	12,050	B	24	19	12	27	F	96
30	Adzuma	10.8	Cr	J	Ers. Laudon	5.2	B	A	Alabama	1,031	30	Gromoboi	17.27	30	Jena	12,030	"	34	34	13	52	"	98
31	Kearsarge	9 9	B	U.S.	Suffren	5.1	"	F	Peresviet	1,003	31	Asama	15.61	31	Wittelsbach	11,832	"	23	27	28	23	E	00
32	Victor Hugo	9 9	Cr	F	Iowa	4.9	"	E	Benedetto Brin	1,000	32	Adzuma	15 61	32	Alabama	11,700	"	36	33	30	43	U.S.	98
33	Maryland	9.6	"	U.S.	Alabama	4.8	"	U.S.	Iowa	995	33	Kent	15.58	33	Kearsarge	11,685	"	31	22	15	41	"	98
34	Jena	9.53	B	F	Jena	4 8	"	F	Ammiragl. d. S. B.	960	34	Rossia	15.30	34	Iowa	11,500	"	44	32	33	57	"	96
35	Fürst Bismarck	8.8	Cr	G	Hapsburg	4.7	"	A	Ers. Laudon	926	35	Fuji	14.30	35	Jeanne d'Arc	11,330	Cr	55	—	42	60	F	99
36	Alabama	8.8	B	U.S.	Adzuma	4.7	Cr	J	Jakumo	921	36	Monarch	14.23	36	Saint Louis	11,300	B	13	6	14	15	"	96
37	Cressy	8.4	"	E	Jakumo	3.7	"	"	Kaiser Fredr. III	916	37	Victor Hugo	13.77	37	Kaiser Fredr. III	11,150	"	26	25	37	24	G	96
38	Jakumo	8.4	"	J	Monarch	3.7	B	A	Canopus	914	38	Habsburg	13.77	38	Diadem	11,200	Cr	58	—	56	62	E	96
39	Hapsburg	8.4	"	A	Drake	3.3	Cr	E	Habsburg	912	39	Jakumo	13.69	39	Devonshire	11,000	"	42	—	40	49	"	02
40	Asama	8.0	Cr	J	Maryland	3.2	"	U S.	Devonshire	844	40	St. Louis	13.68	40	Fürst Bismarck	10,700	"	35	29	51	26	G	97
41	Rossia	7 3	"	R	Asama	3.1	"	J	Amir Aube	755	41	Kearsarge	13.19	41	Ers. Laudon	10,600	B	27	30	35	22	A	03
42	Devonshire	7.0	"	E	Cressy	3.0	"	E	Jeanne d'Arc	755	42	Suffren	13.19	42	Amir Aube	10,000	Cr	57	—	41	61	F	00
43	Kent	6 5	"	"	Prinz Adalbert	2.0	"	G	Ers. Radetzky	650	43	Alabama	12.77	43	Kent	9,950	"	43	—	54	33	"	01
44	Iowa	6.2	B	U.S.	Roon	2 0	"	"	Giuseppe Garib	735	44	Prinz Adalbert	12.61	44	Asama	9,900	"	40	41	46	31	J	99
45	Gromoboi	6.0	Cr	R	Kaiser Karl VI	2.0	"	A	Cressy	730	45	Roon	12.61	45	St. Louis	9,850	"	52	—	60	40	U.S.	00
46	Prinz Adalbert	5.9	"	G	Prinz Heinrich	1 8	"	E	Asama	720	46	Bayan	12.60	46	Jakumo	9,800	"	38	37	36	39	J	99
47	Roon	5.9	"	"	Ers. Radetzky	1.8	"	A	Rossia	715	47	Bogatyr	12.56	47	Ammiragl. d. S. B	9,750	B	29	24	34	28	I	97
48	Monarch	5.6	B	A	Rossia	1.7	B	R	Prinz Adalbert	699	48	Askold	12.55	48	Dupet. Thuars	9,510	C	60	—	53	63	F	99
49	Rostislaw	5 7	"	R	Giuseppe Garib	1.7	Cr	I	Roon	699	49	Devonshire	12.42	49	Roon	9,500	"	47	44	49	45	E	03
50	Bayan	5 2	Cr	"	Rostislaw	1 6	B	R	Henry IV	692	50	Maryland	12.40	50	Adzuma	9,500	"	30	36	29	32	J	99
51	Ers. Radetzky	5 1	"	A	Gromoboi	1.5	Cr	"	Furst Bismarck	668	51	Prinz Heinrich	11.49	51	Prinz Adalbert	9,050	"	46	43	48	44	G	01
52	St. Louis	5.1	"	U.S.	D'Entrecasteaux	1.2	"	F	Carlo Alberto	646	52	Jena	11.09	52	Rostislaw	9,000	B	49	50	27	59	R	96
53	Giuseppe Garib	4.9	"	I	Bayan	1.2	"	R	Dupetit Thuars	626	53	Ers. Radetzky	10.25	53	Henry IV	8,950	"	61	17	50	65	F	99
54	Prinz Heinrich	4.3	"	G	16 large cruisers for lack of heavy artillery, have no tactical fighting value				Kent	626	54	Giuseppe Garib	10.07	54	Prinz Heinrich	8,930	Cr	54	46	59	51	E	00
55	Jeanne d'Arc	3.8	"	F					Bayan	624	55	D'Entrecasteaux	9.91	55	Habsburg	8,340	B	39	35	39	38	A	00
56	Kaiser Karl VI	3.7	"	A					Diadem	596	56	Kaiser Karl VI	9.49	56	Chateaurenault	8,280	Cr	67	—	65	69	F	98
57	Amir Aube	3.5	"	F					Monarch	590	57	Iowa	9.27	57	D'Entrecasteaux	8.120	"	59	52	63	55	"	96
58	Diadem	3.3	"	E					Kaiser Karl VI	590	58	Diana	8.87	58	Bayan	7 900	"	50	53	55	46	R	00
59	D'Entrecasteaux	2.8	"	F					Prinz Heinrich	560	59	Rostislaw	8.02	59	Kleber	7,710	"	64	—	62	64	F	00
60	Dupetit Thuars	2.7	"	"					St. Louis	556	60	Jeanne d'Arc	7.57	60	Giuseppe Garib	7,440	"	53	49	44	54	I	99
61	Henry IV	2.4	B	"					Gromoboi	518	61	Amir Aube	6.87	61	Ers. Radetzky	7,400	"	51	47	43	53	A	03
62	Carlo Alberto	2.2	Cr	A					Kleber	455	62	Diadem	6.58	62	Diana	6,70)	"	66	—	67	58	E	99
63	Bogatyr	2.1	"	R					D'Entrecasteaux	429	63	Dupet. Thuars	6.54	63	Carlo Alberto	6,500	"	62	—	52	66	I	96
64	Kleber	1.9		F					Bogatyr	251	64	Kleber	6 40	64	Bogatyr	6,400	"	63	-	64	47	R	01
65	Askold	1.7	"	R					Chateaurenault	204	65	Henry IV	5 20	65	Kaiser Karl VI	6,240	"	56	45	58	56	A	98
66	Diana	1.1	"	"					Askold	199	66	Carlo Alberto	5.19	66	Askold	6,000	"	65	—	66	48	R	00
67	Chateaurenault	0 59	"	F					Diana	178	67	Arrogant	4 51	67	Arrogant	5,870	"	68	—	68	67	E	96
68	Arrogant	0.44	"	E					Arrogant	145	68	Furien de la Grav	4.45	68	Furien de la Grav.	5,680	"	69		69	68	F	99
69	Furien de la Grav	0.34	"	F					Furien de la Grav	114	69	Chateaurenault	4.31	69	Monarch	5,550	B	48	38	57	36	A	96

THE PROTECTIVE RESEMBLANCE OF INSECTS.

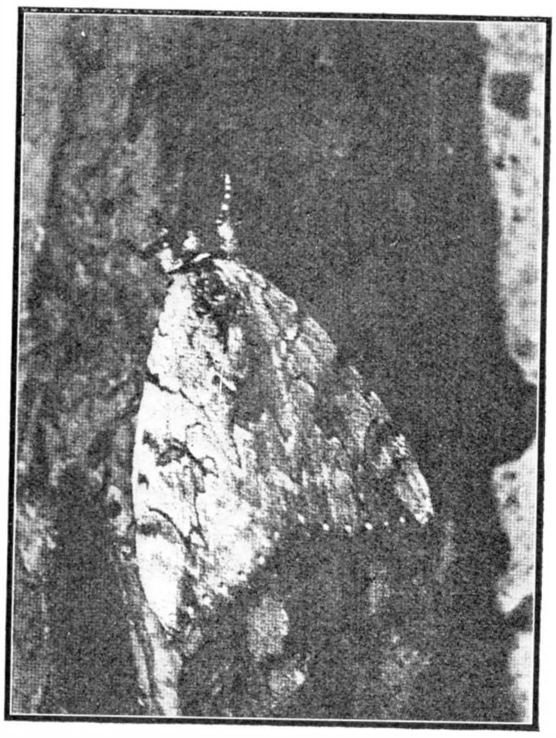
By PERCY COLLINS.

THE story of insect life has many phases of entrancing interest; nor is this altogether surprising when we remember that the earth, the air, and the



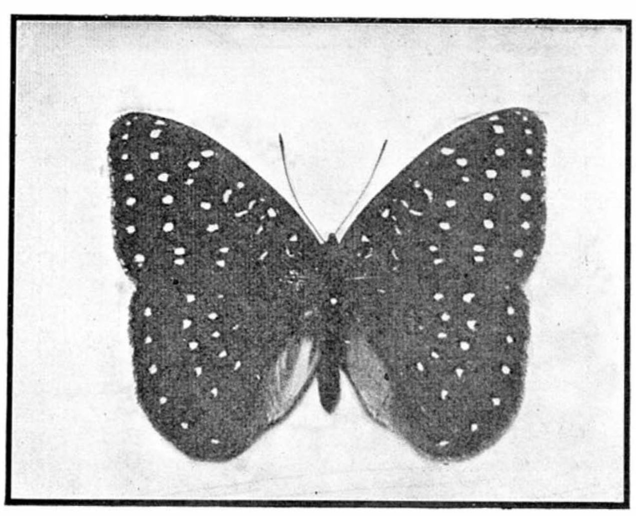
CATOCALA SP. JAPAN.

water are alike peopled by the vast army of the six-footed. These varied conditions of life have left their mark not only upon the habits and movements of insects, but upon their color, their form, and their instinctive attitudes of repose. So that although insects are more diverse than any other natural group of living creatures, the explanation is simple; they are and have been subjected to almost every condition under which life is known to be possible. Thus, to the entomologist,



CATOCALA SP. JAPAN. AT REST ON BARK.

every difference of form, color, or attitude seems worthy of serious investigation. He realizes that an unusual tint or a quaint pattern carries with it a definite meaning—that it is in some way linked to the ancestral history of its possessor. Often enough this meaning is mysterious. But occasionally the colors and form of an insect, or of a group of insects, can be explained as the direct outcome of certain known influences. Not infrequently such interpretations reveal the fact that the shape or color of an insect, or both in



HAMANUMIDA DEDALUS. AFRICA.

combination, are mainly responsible for its well-being. The creature's peculiar appearance either mystifies its enemies or enables it to approach unobserved the smaller insects upon which it preys. The whole subject, to which the general term "mimicry" is commonly applied, constitutes one of the most fascinating phases of entomological study.

The simple protective resemblance of an insect may be either general or special. That is to say, the protection may originate in the mere likeness of an insect's surface coloring to that of its customary surroundings, or it may consist in an actual reproduction in both form and color of a certain object with which the creature is commonly associated throughout its life.

Instances of general protective resemblance must be familiar to observers in all countries. The numerous moths which are accustomed to rest for hours together upon rocks or tree trunks are oft-cited examples. Conspicuous among them is the whole genus *Catocala*, the various species of which are widely distributed in the Palæarctic region and elsewhere. These moths have brightly-colored hind wings, the usual tint—which has given to them their popular title of "Red-underwings" —being some shade of crimson or pink. When they are on the wing they are sufficiently conspicuous, and are liable to be snapped up by a hungry bird. But when at rest upon a tree trunk in their customary attitude of repose, the soft gray or brown color of their fore wings produces a general effect so well in keeping with the rough surface of the bark, that they are extremely difficult to detect. Their color pattern alone constitutes a most effectual hiding.

The same may be said of countless other moths, especially of the great *Noctua* group; and it is interesting to trace how closely the color of the fore wings in a given species corresponds to its habitual resting place. The appearance of all kinds of bark, of mossy twigs, and of lichen-covered rocks is faithfully reproduced; nor is it necessary to search beyond the moths of our own islands for striking examples.

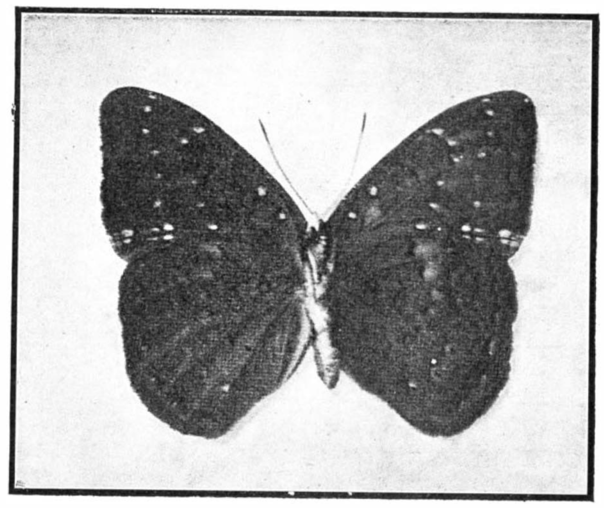
Many butterflies, especially of the great group *Nymphalinæ*, possess—in the tints of their underside—a general resemblance to the ground upon which they habitually settle. Moreover, many species seem to have acquired the trick of inclining their folded wings out of the perpendicular, by this means covering, or minimizing, their own shadow, as well as bringing the protectively colored underside into more prominent view. This habit may be observed in many of our common "brown" butterflies—for instance, in *Pyrarga megaera* and in *Satyrus semele*. In connection with this apparently acquired aid to protected resemblance, the habits of *Hamanumida dedalus*, an African butterfly, are exceedingly interesting. It is authoritatively stated that this insect rests in West Africa with its wings folded over its back after the common habit of butterflies, in which position its tawny under surface, which agrees with the general tone of the soil, is exposed to view. In South Africa, on the other hand, the same insect sits with its wings expanded, showing the brownish gray upper side which harmonizes with the colors of the rocks in that region.

Many of the *Coleoptera*, from their color, are almost indistinguishable when resting upon lichen-incrusted bark. The accompanying photograph of a *Longicorn* from Bhutan admirably illustrates this phase of general protective resemblance. Although the insects are in full view, the casual glance quite fails to detect their presence. This surprising result is largely gained by the manner in which the color is, as it were, cut up into dark and light patches. This is particularly noticeable in the long antennæ, the sharp outline of which is entirely effaced from their being colored in alternate lengths of black and gray.

Turning from general to special protective resemblance, we find a number of extremely interesting and remarkable examples, especially among exotic insects. The butterflies of the genus *Kallima*—"leaf butterflies," as they are popularly called—bear striking testimony to the powers of natural selection. When flying in the full sunlight, their wings flash with color, but directly they come to rest upon a twig they are, to all appearances, brown and withered leaves. This sudden transformation is made possible by the tinting of the under surface of the wings, and by the curiously erect attitude which the insect is able to assume—its wings drawn upright over the back and its head and antennæ concealed between their anterior margins. When we consider the marvelous accuracy of the color imitation, the uncommon shape of the insect's wings, and its unusual pose, the leaf butterfly must still be ranked as one of the most amazing instances of protective resemblance yet recorded, notwithstanding the many marvels which have been brought to our notice within recent years.

The larvæ of moths grouped under the title *Geometridæ* usually bear a curiously accurate resemblance to little twigs or sticks, both in shape and in their brown or gray coloring. Moreover, this deception is materially heightened by the unique attitude of repose obtaining among these caterpillars, which differ from most lepidopterous larvæ in possessing only two instead of five pairs of pro-legs. These are placed at the extreme posterior end of the body, while the three pairs of true legs at the other extremity are usually exceedingly diminutive. The perfect stick-likeness is gained in the following manner. The caterpillars of the *Geometridæ* usually feed at night. When daylight comes, or under the stimulus of alarm, they take a firm hold upon the twig with their four pro-legs and stretch out their cylindrical body stiff and straight at an acute angle. In this position they are capable of remaining, absolutely motionless, for hours together. But to counteract the terrible strain which the attitude would impose upon the body of the caterpillar, each usually spins a strong, though practically invisible silken thread from its mouth to the twig on which it rests.

A family of insects remarkable above all others for the almost universal protective resemblance of its members is the *Phasmidæ*. In order to understand these creatures, which are numerous in all tropical countries, it is necessary to know something of their habits. Unlike their near relatives, the *Mantidæ* or "praying insects," which are voracious insect eaters, the *Phasmidæ* are exclusive vegetarians, feeding

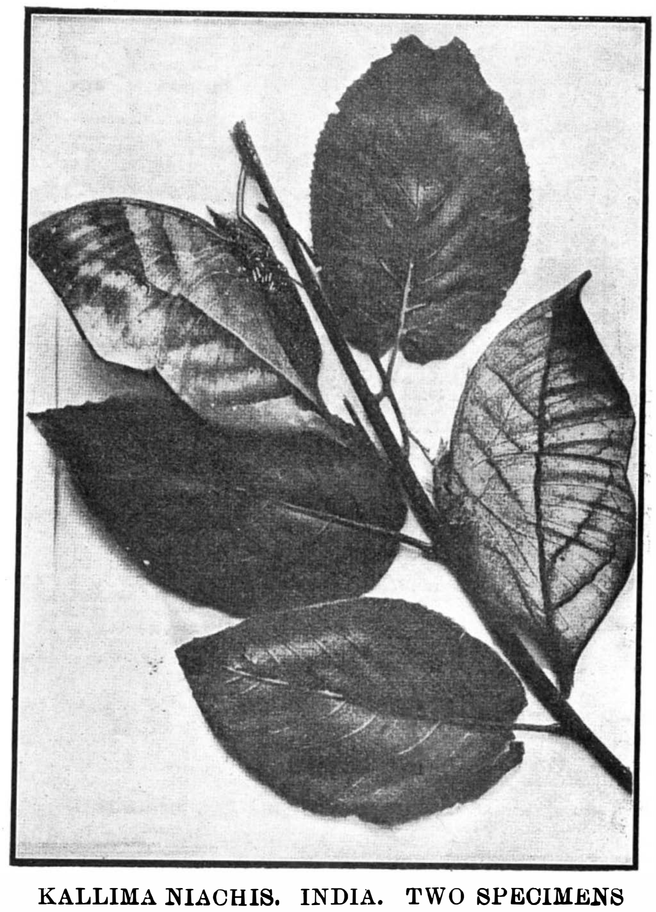


HAMANUMIDA DEDALUS. (UNDERSIDE.) AFRICA.

greedily upon the leaves of the plants which form their resting places. In movement, Phasmids are extremely sluggish, and many of the species—being apterous or possessing, at most, only rudimentary wings—are incapable of flight. Thus, they are much exposed to

APALIMNA DUCALIS. MALE AND FEMALE. BHUTAN. ON LICHENOUS BARK.

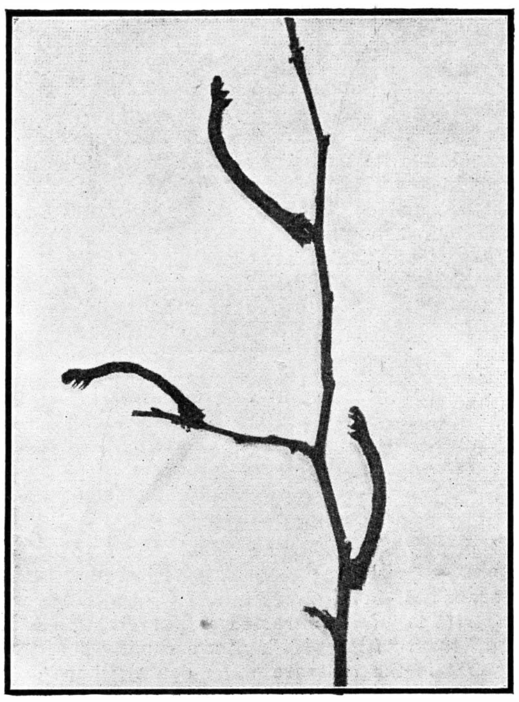
the attacks of birds and other insectivorous creatures—have been so, in all probability, for ages past. This persecution might be supposed to foster any variation in shape or color likely to be of protective value. And, as a matter of fact, the whole of the *Phasmidæ*, al-



KALLIMA NIACHIS. INDIA. TWO SPECIMENS AT REST AMONG LEAVES.

most without exception, have undergone striking modifications in the direction of special resemblance.

As a rule, the bodies of these insects have become

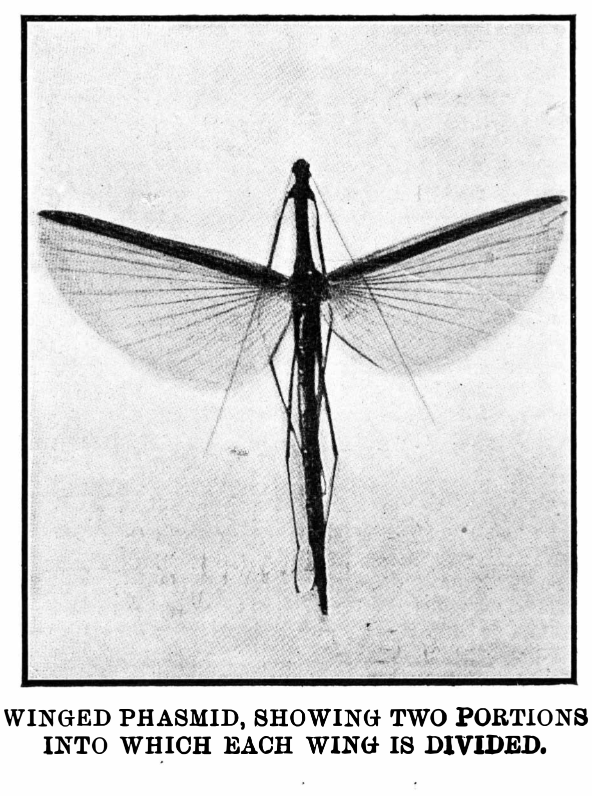


THREE CATERPILLARS OF HEMEROPHILA ABRUPTARIA. ENGLAND.

greatly lengthened, while the legs are long and slender. Those known popularly as "walking sticks," of which the *Clitumnus sundaicus* shown in the accompanying

CLITUMNUS SUNDAICUS. STICK-LIKE PHASMID.

photograph is a good example, are generally of a uniform brown tint. Many of the species have curious knotty protuberances, or even prickles, upon their bodies and legs, this, of course, adding much to the



WINGED PHASMID, SHOWING TWO PORTIONS INTO WHICH EACH WING IS DIVIDED.

stick-like aspect of the insect. After examining a dried specimen of a "stick" Phasmid, one does not need the assurance of foreign collectors to believe that these creatures are practically invisible when at home among the branches of their native shrubs.

Other *Phasmidæ*—fairy-like creatures with exquisitely colored wings—resemble grass rather than twigs when at rest. Their bodies, legs, antennæ, indeed every part of them, with the exception of certain portions of the wing area, is green. Their first pair of wings is rudimentary; but their hind wings are ample, gauzy, and fan-like in their manner of folding. A narrow strip at the anterior margin of each wing is thickened and green in color, contrasting strangely with the gauzy area, which is usually bright pink. Under this narrow cover, the whole of the bright, flimsy portion of the wing is packed away when the insect comes to rest. And so closely are the wings folded that the casual observer imagines the creature to be apterous. It is, indeed, the exact counterpart of a crumpled or slightly-thickened grass blade, while its legs and antennæ are too slender to attract much notice.

Perhaps the most remarkable genus of the *Phasmidæ* is *Phyllium*, whose members—unlike the majority of their allies, which we have seen to be slender and lengthened—have the body and legs flattened into leaf-like plates. In some instances this design of leaf resemblance is carried out with amazing accuracy and attention to detail. Every portion of the insect seems modified to the one end. Its body is flat and leaf-like; its wings and wing cases (where present) look like leaves; while even its legs are flattened and fitted with leaf-like appendages. To crown all, the color of these insects, when alive, is the brightest and freshest of vegetable greens; so that, when crawling among herbaceous foliage, a species of *Phyllium* is, to all appearances, not an insect at all, but just a moving mass of leaves.

Certain species of the *Membracidæ*, which are rather small, frog-hopper-like insects, have a most curious thorn-like or knot-like appearance. This is gained by an unusual development of the pronotum, which is produced behind into a long process, or, it may be, into a kind of shield. In the case of *Umbonia spinosa*, from Brazil, this process extends completely over the insect, and is drawn upward to a point. In fact, it is an exact imitation of a sharp vegetable thorn, from which it is indistinguishable. Thus, the *Umbonia* has merely to crouch down upon a thorny twig and withdraw its legs beneath the shield-like pronotum to be completely hidden.

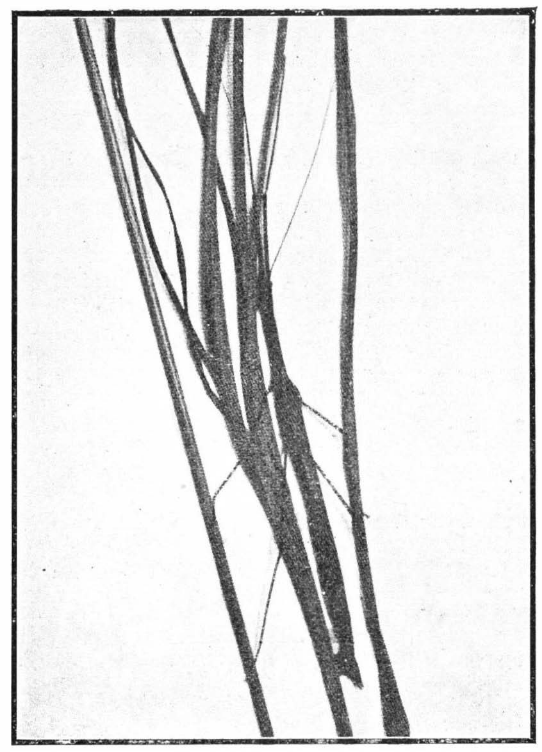
The above examples include some of the more striking instances of protective resemblance, both general and special. They must not, however, be regarded as even typically exhaustive, for sticks, leaves, mosses, and lichens, though common patterns, are by no means the only objects copied in insect color and form. Flowers, seed pods, or seeds, patches of mold or decay —even the droppings of animals and birds—are all prototypes for insect disguise. Moreover, the modifications of form and the varieties of color and marking which have been called into being by the need for protection are too numerous even to tabulate. In the course of his investigations, every observant student will constantly have new and striking instances brought to his notice, even though he may never wander beyond the confines of his own county.

But it should be recollected that to form a true estimate of the protective value of an insect's color and form, it is absolutely essential to study them in relation to their habitual surroundings; for, as a rule, it is quite impossible to tell from a casual examination whether a special appearance is protective or not. A butterfly in a cabinet drawer is merely a scientific specimen. Its colors may be bright and beautiful, dull and unattractive, as the case may be; but suspended above a surface of white paper, they have no special significance. On the other hand, when the insect is alive and among its natural surroundings, its color and shape are often seen to have a direct bearing upon its well-being. Thus the study of living specimens cannot be too strongly urged upon the student—not of entomology alone, but of every branch of natural history.—Knowledge.

THE PRACTICAL BENEFIT OF HYDROGRAPHIC RECORDS.

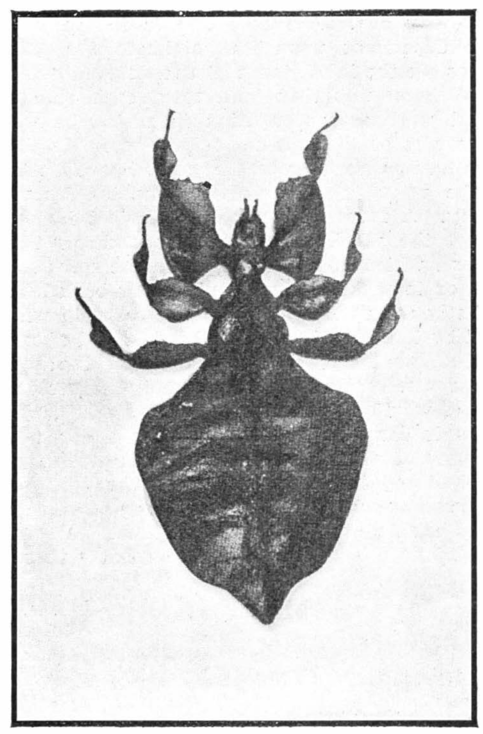
THE parable of the sower is applicable to all educational work. Much of the mission of the great departments maintained by the government, especially the scientific bureaus, is educational in its nature. The government is in the position of a progressive and ambitious instructor in a modern college, who, surrounded by every laboratory and library facility, spends part of his time in making original investigations and part in communicating to his pupils the results of his studies. The seed he sows falls on all kinds of soil, but, however poor the ground, it is sure to bring forth fruit in some measure, if there is life in the kernels that he sows. There is great variation in the returns from the different kinds of educational work prosecuted by the government. The ultimate value of much of it can be determined only after the lapse of many years, but some of it seems to bear fruit a hundred fold from the very start. An instance of this is seen in the results that have followed the hydrographic work of the United States Geological Survey in many quarters. The cases in which it has been a benefit to the one State of Colorado, for example, are numerous and interesting.

None of the irrigation work contemplated by the government would, ordinarily, be possible without long delay were it not for the hydrographic data accumulated by the Survey during many years of observation



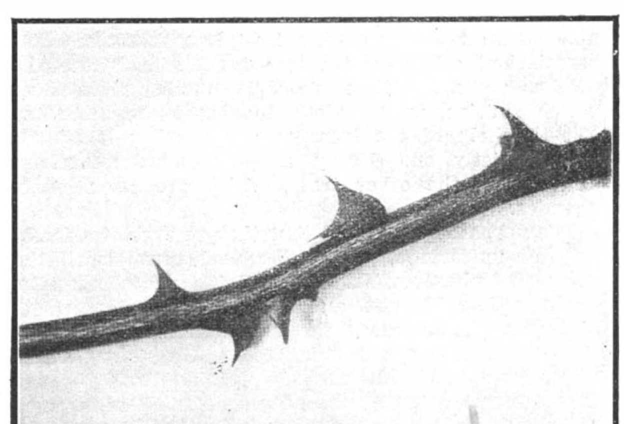
WINGED PHASMID, AT REST AMONG GRASS BLADES.

and measurement. In addition to that, the work of private individuals is constantly facilitated by the same records. No large engineering enterprises are now undertaken without reference to the Survey's records



PHYLLIUM SP. FEMALE. CEYLON.

concerning the supply of water available at the chosen site. The South Platte Land and Reservoir Company, which has under way canals and reservoirs that probably aggregate $500,000 in value, has established stations at Orchard and Kersey, Colorado, because of the superior hydrographic advantages offered by those localities. The choice of those points is directly traceable to the data compiled by the Survey. Equally important is the fact that projects that would have resulted disastrously have in numerous cases been aband-



UMBONIA SPINOSA. BRAZIL. (MIDDLE "THORN" ON UPPER PART OF STEM.)

oned after a study of Survey records that threw light on the probable outcome. Data concerning the flow of water on the Arkansas and South Platte rivers pre-

vented the expenditure of great sums of money on the State canal in the first instance, and upon the Pawnee Pass reservoir project in the second.

Survey data seem to be in great demand as unimpeachable testimony in the legal controversies that have arisen in this State in regard to irrigation matters. A most notable instance is the case of the Colorado and Southern Railroad vs. the Denver Union Water Company, in which the sum of $100,000 was involved.

Data obtained by the Survey in regard to the amount of water power available at certain places have influenced the plans of the Glenwood Springs Light and Power Company, the New Century Light and Power Company, and also proposed power companies on Clear and St. Vrain's creeks. None of these projects has yet been carried to a conclusion, but some of them will undoubtedly be eventually constructed.

Colorado cities seeking a suitable water supply have frequently consulted data obtained by the Survey. In the case of Durango, in southwestern Colorado, the discharge of Florida River was especially studied in order to ascertain whether a gravity water system would be feasible at that point.

The location of various manufacturing industries has been determined by reports from Survey engineers on the available water supply. Conspicuous instances of this are the construction of the American Beet Sugar Company's plant at Rocky Ford and the erection of the sugar factory at Loveland.

THE LIFE OF A FOREST.*

By GIFFORD PINCHOT.

THE history of the life of a forest is a story of the help and harm which the trees receive from one another. On one side every tree is engaged in a relentless struggle against its neighbors for light, water, and food, the three things trees need most. On the other side, each tree is constantly working with all its neighbors, even those which stand at some distance, to bring about the best condition of the soil and air for the growth and fighting power of every other tree.

The life of a community of trees is an exceedingly interesting one. A forest tree is in many ways as much dependent upon its neighbors for safety and food as are the inhabitants of a town upon one another. The difference is that in a town each citizen has a special calling or occupation in which he works for the service of the commonwealth, while in the forest every tree contributes to the general welfare in nearly all the ways in which it is benefited by the community. A forest tree helps to protect its neighbors against the wind, which might overthrow them, and the sun, which is ready to dry up the soil about their roots or to make sun cracks in their bark by shining too hotly upon it. It enriches the earth in which they stand by the fall of leaves and twigs, and aids in keeping the air about their crowns, and the soil about their roots, cooler in summer and warmer in winter than it would be if each tree stood alone. With the others it forms a common canopy under which the seedlings of all the members of this protective union are sheltered in early youth, and through which the beneficent influence of the forest is preserved and extended far beyond the spread of the trees themselves. But while this fruitful co-operation exists, there is also present, just as in a village or a city, a vigorous strife for the good things of life. For a tree the best of these, and often the hardest to get, are water for the roots and space and light for the crown. In all but very dry places there is water enough for all the trees, and often more than enough, as for example in the Adirondack forest. The struggle for space and light is thus more important than the struggle for water, and as it takes place above ground it is also much more easily observed and studied.

Light and space are of such importance because the leaves cannot assimilate or digest food except in the presence of light and air. The rate at which a tree can grow and make new wood is decided chiefly by its ability to assimilate and digest plant food. This power depends upon the number, size, and health of the leaves, and these in turn upon the amount of space and light which the tree can secure.

The story of the life of a forest crop is then largely an account of the competition of the trees for light and room, and, although the very strength which enables them to carry on the fight is a result of their association, still the deadly struggle, in which the victims are many times more in number than those which survive, is apt alone to absorb the attention. Yet the help of the trees to one another is always going quietly on. Every tree continually comforts and assists the other trees, which are its friendly enemies.

The purpose here is to follow the progress of a forest crop of uniform age from the seed through all the successive phases of its life until it reaches maturity, bears seed in its turn, and finally declines in fertility and strength until at last it passes away and its place is filled by a new generation. The life history which we are about to follow, as it unfolds itself through the course of several hundred years, is full of struggle and danger in youth, restful and dignified in age. The changes which pass over it are vast and full of the deepest interest, but they are very gradual. From beginning to end one stage melts insensibly into the next. Still, in order to study and describe them conveniently, each stage must have limits and a name.

A very practical way of classifying trees according to size is the following: Young trees which have not yet reached a height of 3 feet are *seedlings*. They are called seedlings in spite of the fact that any tree, of whatever age, if it grew from a seed, is properly called a seedling tree. Trees from 3 to 10 feet in height are *small saplings*, and from 10 feet in height until they reach a diameter of 4 inches they are *large saplings*. *Small poles* are from 4 to 8 inches in diameter, and *large poles* from 8 to 12 inches in diameter. Trees from 1 to 2 feet through are *standards*, and, finally, all trees over 2 feet in diameter are *veterans*.

It is very important to remember that all these diameters are measured at the height of a man's chest, about 4 feet 6 inches from the ground. In forestry this is, roughly speaking, the general custom.

Let us imagine an abundant crop of tree seeds lying on the ground in the forest. How they came there does not interest us at present; we do not care to know whether they were carried by the wind, as often happens with the winged seeds of many trees, such as pines and maples, whether the squirrels and birds dropped and planted some of them, as they frequently do acorns and chestnuts, or whether the old trees stood closely about and sowed the seeds themselves. We will suppose them to be all of one kind, and to be scattered in a place where the soil, the moisture, and the light are all just as they should be for their successful germination, and afterward for the later stages of their lives. Even under the best conditions a considerable part of the fallen seed may never germinate, but in this case we will assume that half of it succeeds.

As each seed of our forest germinates and pushes its first slender rootlet downward into the earth, it has a very uncertain hold on life. Even for some time afterward the danger from frost, dryness, and excessive moisture is very serious indeed, and there are many other foes by which the young seedlings may be overcome. It sometimes happens that great numbers of them perish in their earliest youth because their roots cannot reach the soil through the thick, dry coating of dead leaves which covers it. But our young trees pass through the beginning of these dangers with comparatively little loss, and a plentiful crop of seedlings occupies the ground. As yet, however, each little tree stands free from those about it. As yet, too, the life of the young forest may be threatened or even destroyed by any one of the enemies already mentioned, or it may suffer just as severely if the cover of the older trees above it is too dense. In the beginning of their lives seedlings often require to be protected by the shade of their elders, but if this protection is too long continued they suffer for want of light, and are either killed outright or live only to drag on stunted and unhealthy lives.

The crop which we are following has had a suitable proportion of shade and light during its earliest years, and the seedlings have spread until their crowns begin to meet. Hitherto each little tree has had all the space in the air and soil that it needed for the expansion of its top and roots. This would have been entirely good, except that meanwhile the soil about the trees has been more or less exposed to the sun and wind, and so has become dryer and less fertile than if it had been under cover, and consequently the growth has been slow. But now that the crowns are meeting, the situation becomes wonderfully changed. The soil begins to improve rapidly, because it is protected by the cover of the meeting crowns and enriched by the leaves and twigs which fall from them.

In so far the conditions of life are better, and in consequence the growth, and more especially the height growth, begins to show a marked increase. On the other hand, all the new strength is in immediate demand. With the added vigor which the trees are now helping each other to attain, comes the most urgent need for rapid development for the decisive struggle at hand. The roots of the young trees contend with each other in the soil for moisture and the plant food which it contains, while in the air the crowns struggle for space and light. The latter is by far the more important battle. The victors in it overcome by greater rapidity of growth at the ends of the branches, for it is by growth there, and there only, that trees increase in height and spread of crown. Growth in this way was going on unchecked among the young trees before the crowns met, but now only the upward-growing branches can develop freely. The leaves at the ends of the side branches have now less room and, above all, less light, for they are crowded and thrust aside by those of the other trees. Very often they are bruised by thrashing against their neighbors when the wind blows, or even broken off while still in the bud. Leaves exposed to such dangers are unhealthy. They transpire less than the healthy undisturbed leaves of the upper part of the crown, and more and more of the undigested food from the roots goes to the stronger leaves at the top as the assimilating power of the side leaves dwindles with the loss of light. The young branches share the fortunes of their leaves and are vigorous or sickly according to the condition of the latter. For this reason the growth of the tops increases, while that of the lower lateral branches, as the tops cover them with a deeper and deeper shade, becomes less and less. Gradually it ceases altogether, and the branches perish. This process is called natural pruning, and from the time when it begins the existence of the young forest, unless it should be overtaken by fire or some other great calamity, is practically secure.

At this time, as we have seen, the crowns of all the young trees are growing faster at the tops than at the sides, for there is unlimited room above. But some are growing faster than others, either because their roots are more developed or in better soil than those of the trees about them, because they have been freer from the attacks of insects and other enemies, or for some similar reasons. Some trees have an inborn tendency to grow faster than others of the same species in the same surroundings, just as one son in a family is often taller than the brothers with whom he was brought up.

Rapid growth in height, from whatever cause it proceeds, brings not only additional light and air to the tree which excels in it, but also the chance to spread laterally, and so to complete the defeat of its slower rivals by overtopping them.

Those trees which have gained this advantage over their neighbors are called dominant trees, while the surviving laggards in the race are said to be overtopped when they are hopelessly behind, and retarded when less badly beaten. Enormous numbers of seedlings and small saplings are suppressed and killed during the early youth of the forest. In the young crop which we are following many thousands perish upon every acre. Even the dominant trees, which are temporarily free when they rise above their neighbors, speedily come into conflict with each other as they spread, and in the end the greater portion is overcome. It is a very deadly struggle, but year by year the differences between the trees become less marked. Each separate individual clings to life with greater tenacity, the strife is more protracted and severe, and the number of trees which perish grows rapidly smaller. But so great is the pressure when dense groups of young trees are evenly matched in size and rate of growth that it is not very unusual to find the progress of the young forest in its early stages almost stopped and the trees uniformly sickly and undersized, on account of the crowding.

The forest we have been following has now passed through the small-sapling stage, and is composed chiefly, but not exclusively, of large saplings. Among the overtopped and retarded trees, which often remain in size classes which the dominant trees have long since outgrown, there are still many low saplings. Even between the dominant trees, in a healthy forest, there are always great differences. Increase in height is now going on rapidly among these high saplings, and either in this stage or the next a point is reached when the topmost branches make their longest yearly growth, which is one way of saying that the trees make their most rapid height growth as large saplings or small poles. Later on, as we shall see, these upper branches lengthen much more slowly, until, in standards and veterans, the growth in height is small, and in very old trees finally ceases altogether.

While the trees are pushing up most rapidly, the side branches are most quickly overshadowed, and the process of natural pruning goes on with the greatest vigor. Natural pruning is the reason why old trees in a dense forest have only a small crown high in the air, and why their tall, straight trunks are clear of branches to such a height above the ground. The trunks of trees grown in the open, where even the lower limbs have abundance of light, are branched either quite to the ground or to within a short distance of it. But in the forest not only are the lower side branches continually dying for want of light, but the tree rids itself of them after they are dead, and so frees its trunk from them entirely. When a branch dies the annual layer of new wood is no longer deposited upon it. Consequently the dead branch, where it is inserted in the tree, makes a little hole in the first coat of living tissue formed over the live wood after its death. The edges of this hole make a sort of collar about the base of the dead branch, and as a new layer is added each year they press it more and more tightly. So strong does this compression of the living wood become that at last what remains of the dead tissue has so little strength that the branch is broken off by a storm or even falls of its own weight. Then in a short time, if all goes well, the hole closes, and after a while little or no exterior trace of it remains. Knots, such as those which are found in boards, are the marks left in the trunk by branches which have disappeared.

While the young trees are making clean trunks so rapidly during the period of greatest yearly height growth they are also making their greatest annual gains in diameter, for these two forms of growth generally culminate about the same time. A little later, if there is any difference, the young forest's highest yearly rate of growth in volume is also reached. For a time these three kinds of growth keep on at the same rate as in the past, but afterward all three begin to decrease. Growth in diameter, and in volume also, if the trees are sound, goes on until extreme old age, but height growth sinks very low while the two others are still strong. For many years before this happens the struggle between the trees has not been so deadly, because they have been almost without the means of overtopping one another. When the end of the period of principal height growth is reached the trees are interfering with each other very little, and the struggle for life begins again in a different way. As the principal height growth ceases, and the tops no longer shoot up rapidly above the side branches, the crowns lose their pointed shape and become comparatively flat. The chief reason why trees stop growing in height is that they are not able to keep the upper parts of their crowns properly supplied with water above a certain distance from the ground. This distance varies in different kinds of trees, and with the health and vigor of the tree in each species, but there is a limit in every case above which the water does

* Abstracted from Farmers' Bulletin No. 173 of the U. S. Dept. of Agriculture.

not reach. The power of the pumping machinery, more than any other quality, determines the height of the tree.

Now that the tree can no longer expand at the top, it must either suffer a great loss in the number of its leaves or be able to spread at the sides; for it is clear that not nearly so many leaves can be exposed to the light in the flattened crown as in the pointed one, just as a pointed roof has more surface than a flat one. It is just at this time, too, that the trees begin to bear seed most abundantly, and it is of the greatest importance to each tree that its digestive apparatus in the leaves should be able to furnish a large supply of digested food. Consequently the struggle for space is fiercely renewed, only now the trees no longer attempt to overtop one another, having lost the power, but to crowd one another away at the sides. The whole forest might suffer severely at this point from a deadlock such as sometimes happens in early youth were it not for the fact that the trees, as they grow older, become more and more sensitive to any shade. Many species which stand crowding fairly well in youth can not thrive in age unless their crowns are completely free on every side. Each of the victors in this last phase of the struggle is the survivor of hundreds (or sometimes even of thousands) of seedlings. Among very numerous competitors they have shown themselves to be the best adapted to their surroundings.

Natural selection has made it clear that these are the best trees for the place. These are also the trees which bear the seed whence the younger generations spring. Their offspring will inherit their fitness to a greater or less degree, and in their turn will be subjected to the same rigorous test, by which only the best are allowed to reach maturity. Under this sifting out of the weak and the unfit, our native trees have been prepared through thousands of generations to meet the conditions under which they must live. This is why they are so much more apt to succeed than species from abroad, which have not been fitted for our climate and soil by natural selection.

The forest which we saw first in the seed has now passed through all the more vigorous and active stages of its life. The trees have become standards and veterans, and large enough to be valuable for lumber. Rapid growth in height has long been at an end, diameter growth is slow, and the forest as a whole is increasing very little in volume as time goes on. The trees are ripe for the harvest.

Out of the many things which might happen to our mature forest, we will only consider three.

In the first place, we will suppose that it stands untouched until, like the trees of the virgin forest, it meets its death from weakness and decay.

The trees of the mature primeval forest live on, if no accidents intervene, almost at peace among themselves. At length all conflict between them ends. The whole power of each tree is strained in a new struggle against death, until at last it fails. One by one the old trees disappear. But long before they go the forerunners of a new generation have sprung up wherever light came in between their isolated crowns. As the old trees fall, with intervals often of many years between their deaths, young growth of various ages rises to take their place, and when the last of the old forest crop has vanished there may be differences of a hundred years among the young trees which succeed it. An even-aged crop of considerable extent, such as we have been considering, is not usual in the virgin forest, where trees of very different ages grow side by side, and when it does occur the next generation is far less uniform. The forest whose history has just been sketched was chosen, not because it represents the most common type of natural forest, but because it illustrates better than any other the progress of forest growth.

The wood of a tree which dies in the forest is almost wholly wasted. For a time the rotting trunk may serve to retain moisture, but there is little use for the carbon, oxygen, and hydrogen which make up its greater part. The mineral constituents alone form a useful fertilizer, but most often there is already an abundance of similar material in the soil. Not only is the old tree lost, but ever since its maturity it has done little more than intercept, to no good purpose, the light which would otherwise have given vitality to a valuable crop of younger trees. It is only when the ripe wood is harvested properly and in time that the forest attains its highest usefulness.

AQUATIC FURS USED BY HATTERS.*

By CHARLES H. STEVENSON.

DURING the seventeenth and eighteenth centuries an important if not principal use of aquatic furs in Europe was in making fashionable hats, commonly called beaver hats, beaver fur being the chief material in their make-up. The general adoption of the silk hat about sixty years ago resulted in greatly reducing the quantity of aquatic furs used by hatters, but those manufacturers are yet large consumers of these articles for the production of fine grades of soft hats.

The principal felting furs among the aquatics are nutria, muskrat, beaver, fur-seal, otter, and mink, named in the order of the extent to which they are now used. Rabbit, cony, and hare furs are used far more extensively than all the foregoing combined, owing to their cheapness, but are less desirable than most varieties of aquatic furs. Hatters' furs are both cut and blown, the former being taken from the whole skins, and the latter from small pieces, clippings, roundings, and other waste obtained in cutting skins for sewing into garments.

The choicest felting fur is that of the beaver; but its high cost limits its use in hat-making. A felt hat of average size and weight made of fur cut from choice beaver pelts could not be made for less than $500 per dozen, and no demand exists for such expensive goods. But manufacturers receive a quantity of beaver cut from damaged skins of little value as dressed furs and also considerable blown from clippings and the waste from cutting skins into garments. The choicest beaver fur for hatters' purposes is obtained from the cheeks of the animal, with that from the belly, the back, and sides, following in the order named.

Beaver clippings sell for about $1 to $1.25 per pound, and the fur, when blown free from hair and impurities, sells for $8 or $10 per pound. Cut beaver has been sold as high as $224 per pound by brokers yet in the business. The quantity of beaver fur used by hat manufacturers throughout the world averages about 6,000 pounds annually. It is made into very light soft hats, which sell wholesale at about $80 or $90 per dozen. These are very durable, and if occasionally cleaned or dyed may be worn almost indefinitely. A small demand still exists for the old fashioned beaver-napped hats, shaped somewhat like the present style of silk hat, being the fashionable headgear for the guards on drags and coaches, and to a small extent for ladies' riding hats.

The next highest grade of fur used by hat-manufacturers is nutria, which is the standard choice fur for making into soft felt hats. It is estimated that about one-third of the total product of nutria skins are cut for hatters' use, and in addition the hat-manufacturers receive large quantities of blown fur from manufacturers' clippings. Nutria is very nearly as desirable as beaver for felting, selling at present for about 80 per cent of the value of the latter, whereas in the dressed-fur trade it is worth only 30 per cent as much as an equal area of beaver fur. During the past twenty-five years the average value of cut and blown nutria fur has ranged between $2.25 and $7.50 per pound. In 1877 it was $5.50, and gradually decreased to $2.25 in 1886; it increased to $7.50 in 1897, and in 1900 it averaged $6.50 per pound. Single sales have been made as high as $14 per pound. The total product of nutria fur used in hat-manufacturing in 1900 is estimated at 80,000 pounds, valued at $520,000. It is claimed that a single manufacturer in Philadelphia has at times over a million nutria skins in warehouse.

Otter ranks next in grade among felting furs, but only a small quantity of this kind is used, and that is obtained from fur-cutters' waste. The clippings and waste sell for about 45 cents per pound, and the cut and blown fur for about $3.50 per pound. The quantity used by hat manufacturers annually probably approximates 700 pounds.

Muskrat fur is used extensively in hat-making, the whole skin as well as cutters' waste being utilized. Like beaver fur, it is assorted into three grades—backs, sides, and bellies—on account of difference in color and texture. The belly fur is the choicest and is used for making light or pearl hats. During the last twenty-five years the price has ranged from $1.80 to $3.25 per pound, averaging about $2. In 1876 it was $2.25, from which it varied little till 1890, when it began to increase, reaching $3.25 in 1892, and since then it has steadily decreased to the present price $1.80 per pound. The cutters' waste sells for 35 to 40 cents per pound and the blown fur for $1.30 to $2 per pound. The standard mixed grade of blown muskrat fur usually sells for 30 or 40 cents less per pound than the belly fur, while dyed muskrat sells usually for one-third the price of cut belly, or about 60 cents per pound.

A small quantity of mink fur is used by the hat-manufacturers, the amount not exceeding 1,500 pounds annually, obtained entirely from cutters' waste, no whole skins whatever being used for this purpose. Mink fur is rather poor for felting, as may be inferred from the price at which it sells, the clippings fetching about 15 cents and the blown fur about $1.10 per pound, or only one-sixth the price of beaver.

The cheapest aquatic fur received by the hatters is that of the fur-seal, of which probably 5,000 pounds are used annually. This is obtained almost exclusively from cutters' waste of dyed clippings, and when cut and blown sells for about 75 cents per pound.

The preparation of all these furs for felting purposes is practically the same in each case. Preparatory to cutting them from the whole skins, the pelts are scoured thoroughly with soap water to remove the grease and other impurities, then they are properly dried and plucked, each one of these several processes being performed in much the same manner as in the fur-dressing establishments, except that it is done with greater expedition and less care. The overhairs are of no value in felting, and are sold as stuffing in upholstery, for plasterers' use, etc. The plucked skins are next carroted, consisting in moistening the fur with a solution of quicksilver and nitrc acid or chloride of mercury, and then spreading them out flat to dry. This is done either in the open air or in rooms heated by steam, according to the color desired.

When dried in the open air the fur becomes whitish, and when dried by subjection to steam or other artificial heat it assumes a yellow carrot-like hue. This explains the abbreviations W. C. (white carrot) and Y. C. (yellow carrot) always given in connection with the designation of each kind of felting fur. In the preparation of beaver and some other furs, the carroting is occasionally omitted, but this raw stock does not felt so readily and is usually mixed with properly carroted fur.

After drying, the carroted skins are brushed by holding each one for a few seconds against a revolving wheel studded with quills. This is for the purpose of removing all dust and to straighten the fur so that it may be readily cut from the skin. Originally the cutting was done by manual labor, a pair of shears being used, and later by means of an ingenious mechanism giving a chopping motion to a vertically mounted knife. At present a much better machine is used, which with great rapidity cuts the pelt from the fur in little narrow strips about one-sixteenth of an inch in width and equaling in length the width of the skin. These strips of coriaceous membrane fall into a receptacle and go to the waste heap or to the manufacturers of certain oleaginous compounds. An endless apron carries the fur forward without disarranging it or changing its natural formation, where it is properly assorted by experienced operators.

Each assortment consists of the fur from a particular part of the skin, the chief divisions being the back, the sides, and the belly. Fur cut from the back is the darkest in color; that from the sides is lighter, and somewhat lower in quality. The belly fur is nearly always the lightest in color. It varies in quality, however, being the finest of the principal grades when cut from the beaver, nutria, or muskrat skins, and the lowest when obtained from the skins of land animals, such as the cony and rabbit. Minor assortments consist of the fur cut from the tails of various animals and from the cheeks of the beaver, the latter being the choicest felting fur obtainable. Belly fur is used in making light-colored hats; that from other portions is available for the production of felt hats of every desirable color. All of these assorted furs are placed separately in paper bags, containing 5 pounds each in America and England and 1½ kilogrammes each in France, in which they are stored or marketed.

The blown furs are those obtained from fur-cutters' waste, which every furrier establishment saves carefully. These pieces are assorted and sold to the cutters of hatters' furs at prices ranging from $1.25 per pound for beaver to 15 cents per pound for mink clippings. The fur-cutter runs them through a chopping machine, where they are cut into minute pieces, and afterward are repeatedly blown to separate the fur from the overhairs and pieces of skin. Blown fur is not usually carroted, and since it is short and is not readily assorted into various grades it sells for considerably less than cut fur.

* Extracted from U. S. Fish Commission Report 1902.

NORWEGIAN COD LIVER OIL.

PURE cod liver oil has for some time been a scarce article in the world's markets, owing largely to the many admixtures and adulterations used by unscrupulous and careless manufacturers. The best Norwegian oil is extracted from the fat livers of the cod in the early part of the winter fisheries in the Lofoten Islands. The livers at this time, in January, February, and a part of March, are as a rule light colored, plump and very rich in oil, which is extracted after careful sorting of the livers, with simple machinery, by steam. The product is as clear as crystal, nearly tasteless, and without smell. The islands present many advantages over other places for the production of strictly pure oil. The shoals of fish seek the shore for spawning purposes and the banks are so near land that the boats sometimes land two catches in one day, consequently the livers are, except when stormy weather interferes, received fresh at the factories daily. The United States Consul at Christiania says that the average annual catch of cod in the islands is 30,000,000. Unlike other districts in the country, the cod at this time of the year is about the only kind of fish caught, so there is less opportunity for mixing the livers from cod with those from inferior fish, such as pollock, ling, haddock, tusk, and others. Oil from these contains less fat, the color of the oil is darker, and its medicinal properties are of less value. Oil from these and other inferior fish may be bleached by exposure to the sun in glass coverings, and by various chemical processes. Experiments have been made in Norway for manufacturing cod liver oil on board ships located among the fishing fleet in the open sea, but it has been found that the ship's motion had a detrimental effect on the oil thus produced. Establishments on shore in places where unmixed cods' livers can be obtained fresh every day, are found to be the best. The livers have to be carefully cleaned, and only those of the right color selected for medicinal oil. The year 1903 was an exceptional one as regards the Norwegian winter cod fisheries. In ordinary years, the shoals of fish arrive in the beginning of January, but last year no fish whatever appeared before the middle of March, and they were then found to be in such poor condition that only a very insignificant quantity of oil was provided—only 3,000 barrels against 30,000 barrels in ordinary years. The quality of the 1903 output was also, as a rule, poor. It is estimated that in ordinary years the livers of 4,500 cod are required to produce a barrel of 30 gallons of medicinal oil, while 40,000 livers were required in 1903 to produce the same quantity. Cod liver oil can be properly tested as to purity by chemical analysis only. Where large quantities of oil of inferior grade are added, it can be detected by experienced people without any scientific test simply by the difference in taste and color. Fears have been expressed that the conditions ruling the Lofoten fisheries in 1903 will also make themselves felt in 1904. According to recent reports the Greenland seal has again

appeared in great numbers in the bays of Finmarken. Before 1903, the Greenland seal was never found near the Norwegian coasts in any number, but that year they came in large shoals as early as January, and the fishermen believe contrary to the views of scientific men that they were the cause of keeping the cod so long away from its customary spawning places. It is generally believed that the Norwegian winter cod is the very same species of fish as appears and is caught on the banks of Newfoundland, but it differs from the common cod caught in all seasons of the year.—Journal of the Society of Arts.

THE COMPRESSED-AIR POWER PLANT AT THE ST. LOUIS EXPOSITION.

THE central compressed-air power plant at the St. Louis Exposition will contain two main compressing units; one cross-compound, two-stage, Cincinnati gear compressor, having 13 and 24-inch steam cylinders, 22 and 14-inch air cylinders, and 24-inch stroke with a displacement at 125 revolutions per minute of 1,300 cubic feet per minute; and one cross-compound, two-stage, Meyer gear compressor having 12 and 20-inch steam cylinders, 18 and 11-inch air cylinders, and 18-inch stroke, with a displacement at 100 revolutions per minute of 530 cubic feet per minute. The first machine is to supply the general compressed-air requirements of the exposition, while the second is to supply the transportation exhibits. The larger machine is of special interest as being the first compressor of its type publicly exhibited, although a number of similar machines have been, and are being, installed in private plants. A 2,800-foot machine is at the present time being placed in the Jersey City power house of the Central Railroad of New Jersey.

The general construction of one of these machines is shown in Figs. 1 and 2. The frames, as will be noted, are of massive construction, with a long bearing on the foundation, while the steam and air cylinders, joined in the direct line of thrust by heavy cast-iron housings, are also supported by bed plates under their entire length, the weight of each side being thus taken on two large bearing surfaces extending to the ends of the machine, avoiding the objectionable features of overhung cylinders, and giving the compressor great stability. The general construction is characteristic of the best grade of engine work, and comprises removable quarter boxes and main bearings, steel-forged connecting rods, with wedge take-up, specially large crank and wrist pins, and cast-steel cross-heads with adjustable babbitted slippers, top and bottom, working in bored guides. The reciprocating motion is of the simplest possible character, this simplicity in construction permitting low reciprocating weights without sacrifice of strength. These features allow satisfactory balancing and, in connection with the long bearing on the foundations, insure an especially easy-running machine. The steam valve-gear is of the four-valve type. Steam distribution is effected by means of short, double-ported, slide valves, working at either end of the steam chest on a valve face as close as possible to the cylinder bore, the port volume being restricted as far as the large valve area will allow. The exhaust valves are of the Corliss rotary type, and are placed at the bottom of the cylinder. This construction has been followed in order to produce a valve gear having the essential advantages of a Corliss, namely, separate passages for the steam and the exhaust, with corresponding reduction in cylinder condensation, together with short, straight ports and small clearance. On the other hand, the complicated Corliss releasing gear, which is necessarily prejudicial to even moderate speeds, has been eliminated, the action being positive throughout.

The air-valve gear is, however, the distinguishing feature of this machine, combining in a very ingenious manner the positive action, noiseless operation, and durability of the mechanically-moved valve with the elasticity of the poppet valve. The noise and rapid wear of the poppet valve, due to the impact of the valves closing at the reversal of stroke, is eliminated by mechanically closing the passages underneath the poppet valve, and leaving a cushion of air upon which the latter seats.

These machines are built by the Laidlaw-Dunn-Gordon Company, of Cincinnati, Ohio.

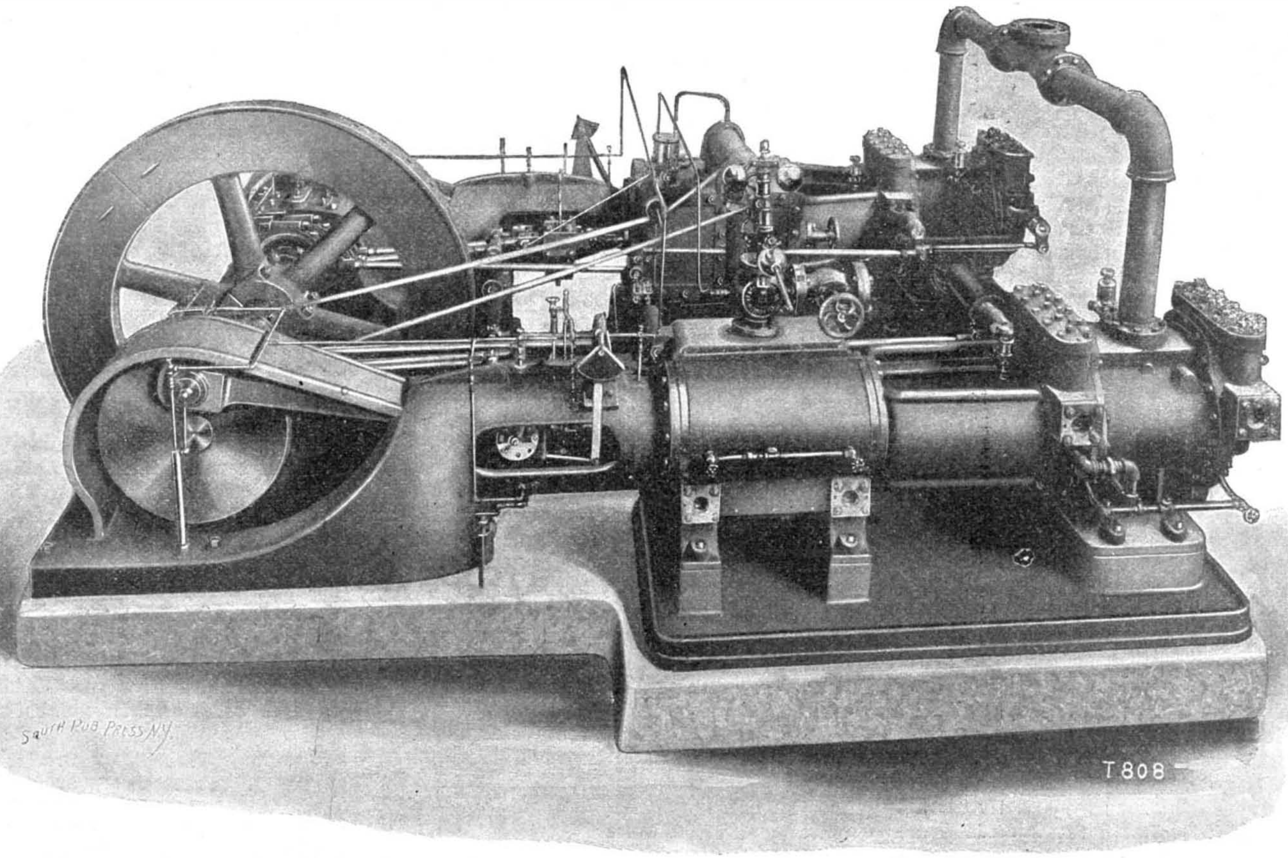


FIG. 1.

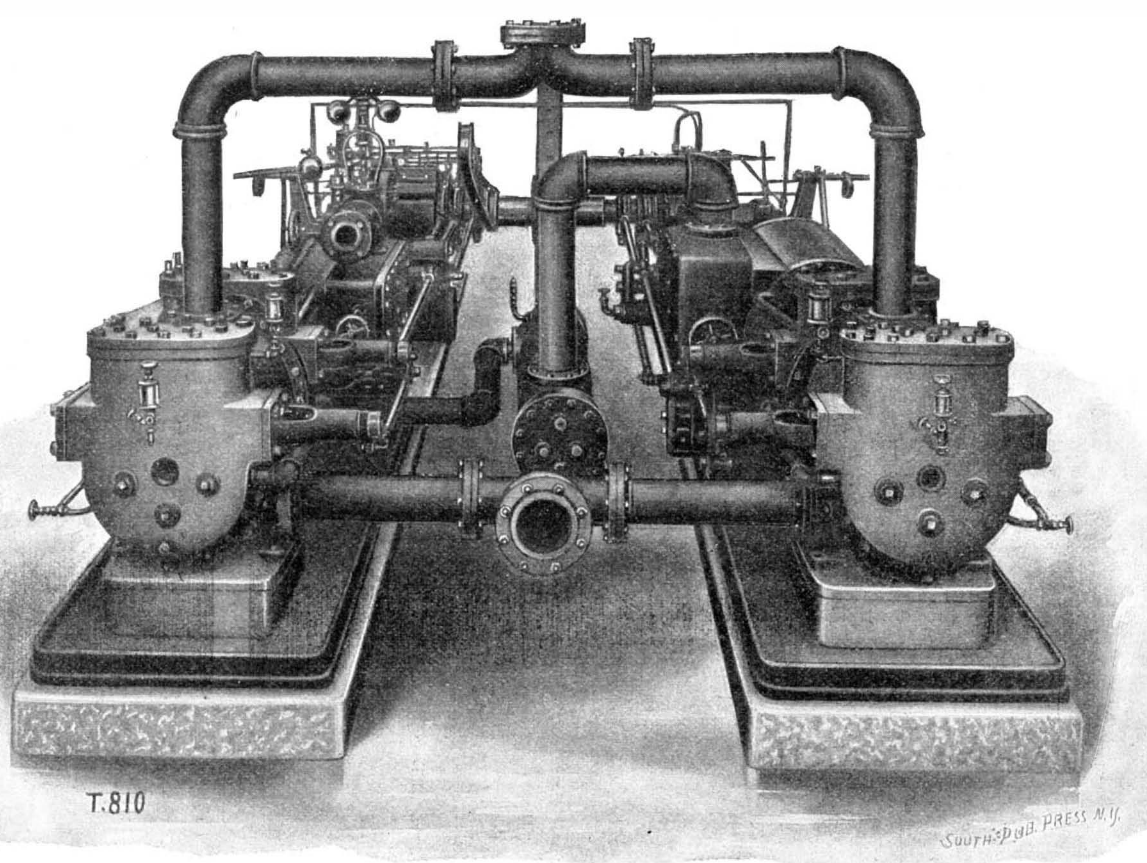


FIG. 2.

ELECTRICAL METHODS OF MEASURING TEMPERATURE.

THE first of a series of three lectures dealing with electrical methods of measuring temperature was recently delivered in the Royal Institution by Prof. H. L. Callendar, F.R.S., whose platinum resistance thermometers are now coming into pretty extensive use in a number of different industries. The lecturer stated that there were two methods of measuring temperature by electric means—viz., the change in the resistance of a wire with a variation in its temperature, and the electromotive force which is observed when heat is applied to the junction between two dissimilar metals. The first method had the advantage that the change to be measured was a large one, since the resistance of a coil of platinum wire at a high temperature was about five times as great as it was at the temperature of the room, and was thus a greater change than the change in volume of a perfect gas as compared at the same tem-

peratures. Secondly, the resistance coil could be used to get the average temperature of a relatively large space, which was often convenient, as, for example, in taking the temperature of a gas. For this particular purpose a mercury thermometer had the drawback that its reading depended partly on radiation losses, which were fifty to one hundred times as great as with the platinum thermometer. Coming to the thermo-junctions, these were very convenient when it was required to know the temperature at a particular point, since the couple was affected by heat applied at the junction only, and not at all by heat applied elsewhere. The effect to be measured was, however, much smaller than the change of resistance in the other type, but for determining high temperatures, or great differences of temperature, the thermopile was excellent; though for measuring low temperatures or small temperature differences the electric-resistance thermometers were about one hundred times as sensitive. In both types of thermometer platinum or platinum alloys were adopted as the material to which heat was to be applied, since there was then no trouble from zero errors due to repeated heatings and coolings, or to chemical action; while their infusibility was such that there was a very large range of temperature over which they could be used.

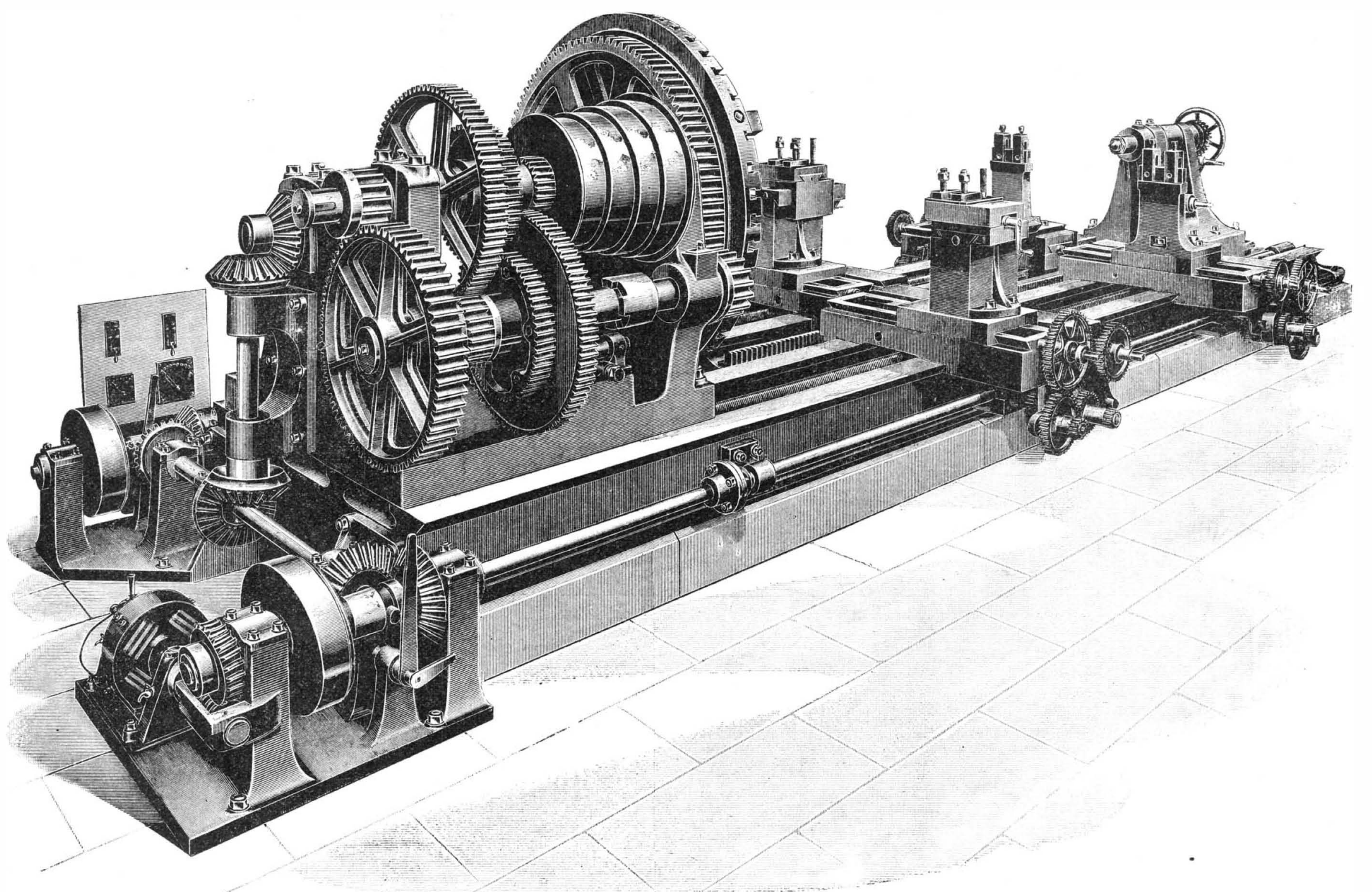
Both methods were sensitive and accurate, and could, moreover, be arranged so as to give their indications at any desired distance from the source of heat. Both were also well adapted for taking continuous temperature records either by photography, or by pen and ink, while mercury recording thermometers, on the other hand, were clumsy and slow. The calibration of electric thermometers was effected by comparing them with a gas thermometer. The change of electrical resistance was not exactly proportional to the temperature, but the law connecting the two had been established by a number of different experimenters. Between 0 deg. and 100 deg. Cent. the error made in assuming the resistance to be proportional to the temperature was about ½ deg. Cent., but at 400 deg. Cent. it was 25 deg. Cent. It was found, however, that the resistance was a parabolic function of the temperature, and this was now found to be the case not only with platinum, but with other pure metals. A number of different empirical formulas had been proposed for the resistance of iron at different temperatures.

Between 0 deg. and 100 deg. Cent. they were all fairly correct, but, as would be seen, differed greatly at higher temperatures; and the experimental points plotted showed that, as with platinum, a simple parabolic formula fitted best into the results, holding right up to the temperature at which iron lost its magnetism. The recognition of this law simplified the calibration of a resistance thermometer, the constants of which were determined by heating the coil up to some known high temperature, such as the boiling point of sulphur.

The reduction of the indications given by a thermocouple was a more complicated matter, as would be seen by comparing the curves of temperature electromotive force. (Here the scale given is correct for the copper-iron couple, but the numbers must be multiplied by ten for the other couples.) Here it would be noticed that the Ni Fe couple had a fairly uniform curve, and it could, moreover, withstand exposure to a high temperature. The iron-copper couple, on the other hand, had a maximum electromotive force at 250 deg., which became zero at 530 deg.—Engineering.

A HUGE DUPLEX LATHE.

THE accompanying engraving illustrates a huge lathe built at Manchester, England. The weight of the lathe is 98 tons, and it is especially adapted for turning crank shafts of the heaviest types, though it is also used for cutting large forgings and castings. The machine will admit a piece 27 feet long and 9 feet in diameter. It will be observed that the bed of the lathe is formed with two parallel pairs of tracks, on each of which two carriages are mounted to slide. The carriages are so geared as to be capable of independent as well as simultaneous movement. Instead of the ordinary arrangement of feed by means of a central rotating screw operating in a stationary nut on the carriage, the mechanism in this lathe is reversed. The stationary threaded guide rod is mounted centrally between the rails of each track, and the carriages are moved by means of nuts, which operate on the guide rods and are rotated by means of suitable gearing driven from rotating spline shafts at the front and rear of the lathe bed. Obviously, by this arrangement, while the feed of the carriages is central, the carriages are all independent of each other, and their travel may be separately controlled as desired by different combinations of the change gears on each carriage. Since the lathe is built for work running up to 9 feet in diameter, it is obvious that the range of cross feed is much greater than ordinarily required, and consequently that the carriage, in order to run true under extreme conditions, must be fed forward at more than one point. On this lathe, therefore, a rack is provided which lies longitudinally along the center of the lathe bed. This rack is formed with teeth on both side faces, into which a pinion from the feeding mechanism of each carriage meshes. In this way all cross straining is avoided. The head stock of the lathe is quadruple geared, and it has thirty-two changes of speed. The face plate is fitted with four cast-steel chuck jaws independently operable by means of screws. The face plate is 9 feet in diameter, and is operated by an external gear at the rear. The hard, gun-metal spindle is adjustably mounted in bearings which are grooved to reduce friction. The tail stock is fitted with a worm-gear mechanism, for forcing the center into the work, and also with a hand wheel for quick adjustment of the same. The tail stock may be moved along the bed by worm and wheel gearing, or by means of a rack and pinion. The four carriages are each fitted with reversing gear, swing-frame and change wheels, and by means of the latter control is had, not only of the longitudinal feed of the carriage, but also the transverse feed. It will therefore be seen that one or more tools may be surfacing while the others are roughing out the work. Front and rear carriages nearer the head stock are fitted with compound rests for turning crank pins and inside webs. These may be also fitted to the carriages nearer the tail stock. The rear compound rest, in order to resist the upward pressure of the cut, is hooked under a V-shaped guide. This guide is formed on each of the rear carriages. The lathe is driven by an electric motor, and a separate motor is used for rapid power traverse of the carriages along the bed.



A HUGE DUPLEX LATHE.

PRODUCTION OF OXYGEN AND VITALIZED AIR.

A RECENT discovery is that agglomerated sodium peroxide allows of preserving in the latent state in a one hundred gramme tube fifteen liters of chemically pure oxygen (99.9 per cent) costing some two or three centimes per liter. The equation is $Na_2O_2 + H_2O = 2NaOH + O$.

So numerous are the applications of "vital air," that it is necessary to facilitate its production by strong portable apparatus, secure, easy to clean, and of moderate cost. The Sabbatier oxygenophore seems to respond to these conditions.

It is indispensable in chemical laboratories and establishments of industrial analysis, in order to obtain the oxygen instantly and without preparation. Workmen in mines, wells, cesspools, fermentation vats, etc., should be furnished with it, to be able to restore the asphyxiated. Instant treatment is needed in case of the escape of lighting gas, or asphyxiation from deleterious vapors.

The working of this little automatic generator is so simple that any one can use it.

Oxygen deodorizing putrid matters and rendering water aseptic, by oxidizing all morbid germs, is the best disinfectant; it destroys all organic substances, poisonous or otherwise. It renders healthful infected places, hospitals, theaters, or other places where the air is vitiated by the lighting gas.

The action is doubly beneficial, for the solution of caustic soda, the residue of the chemical reaction, exposed to the air, absorbs its carbonic acid, forming crystals of sodium carbonate. Thus, this artificial air permits the sailors of submarine vessels to sojourn in an atmosphere which is reconstituted by the use of one hundred grammes per man per hour.

The apparatus produces oxygen without pressure, furnishing a regular current of gas, of which the flow corresponds to the respiration. It is formed completely of nickeled metal, and has a chamber at the junction of the rubber tube, to be lined with wadding for arresting the watery vapor drawn in mechanically. This may be soaked in a medicated substance.—Translated from La Revue des Produits Chimiques.

GENERAL RESULTS ACHIEVED BY THE GEOLOGICAL SURVEY IN TWENTY-FIVE YEARS.

THE members of the United States Geological Survey in Washington recently celebrated the quarter-centennial anniversary of its organization. The more important results achieved by the Survey during the twenty-five years of its existence are set forth in its recent bulletin (No. 227) entitled "The United States Geological Survey: Its Origin, Development, Organization, and Operations." This bulletin is intended for gratuitous distribution, and copies of it will be given away as souvenirs in connection with the Survey's exhibit at the Louisiana Purchase Exposition.

Since the establishment of the Survey a complete topographic map has been made of 929,850 square miles of the area of the United States. In other words, the Survey has finished the mapping, on more or less detailed scales, of 26 per cent of the area of the country, including Alaska, or 31 per cent exclusive of Alaska.

This great map of the United States, of which nearly one-third has been completed, is necessarily published in the form of an atlas. The portion completed consists of 1,327 atlas sheets printed in three colors from copper-plate engravings. The topographic maps of the Geological Survey have greatly expedited investigations made by cities of their water supply and have been of the highest value to railway companies and State highway bureaus. The improvement of highways in New York, Maryland, Massachusetts, and other States has been greatly facilitated and the cost of the State work has been materially reduced by these maps. The elaborate and valuable reports recently completed on the future water supply of the city of New York and on the New York State Barge Canal have been, in large measure, rendered conclusive only through the agency of the existing topographic maps.

The geologic mapping of the surface formations has been extended over about 171,000 square miles and 106 geologic folios have been published, while nearly an equal number are in various stages of preparation. Each of these folios presents a practically complete history of the topography, geology, and mineral resources of the area described. Coincident with the geologic work, important experiments and investigations relating to rocks have been made in the Survey's physical, chemical, and petrographic laboratories.

The Survey, through its hydrographic branch, including the reclamation service, has recorded, during the last fifteen years, the maximum, minimum, and mean discharges of all the more important rivers, and for shorter periods the same facts concerning all the lesser tributaries of the many hundreds of streams in the United States. The physical characteristics of the river basins have been studied in respect to their forestation, soil-covering, etc., and a vast amount of data has been accumulated from which it is possible to estimate closely the volume or run-off of each of the streams. The development of the water powers of the country, especially in the Southern States, has received a great impetus during the last few years through facts brought to light by the Survey's work. Many unknown water powers have been found. Projects already commenced have had their value or their defects made manifest through the evidence procured by these surveys. Data have been gathered concerning irrigable public lands and their relation to possible water supplies. A large number of reservoir sites have been examined and surveyed in a preliminary way, and the lands which the reservoirs would serve have been withdrawn from sale or occupation pending more detailed studies. Surveys of the irrigable lands as well as of canal lines have been made, and several irrigation projects have been finally approved for construction by the reclamation service.

The Survey, by its division of geography and forestry, has examined in detail 110,000 square miles and has made a classification of the lands as forested, grazing, desert, and arable. Final reports on these reserves have been prepared, which show the character and amount of the timber on each and furnish many other facts that will serve as a basis for the forest management of these properties.

Perhaps the immediate value to the people of the Survey's work is best shown by the aid it renders in developing the mineral resources and in forwarding important engineering projects. The investigation of the mining geology of Leadville has, for instance, guided exploration and secured economical mining in a district that has produced between $200,000,000 and $300,000,000. It has also taught the mining engineer and the miner the practical importance of geologic study in their work. The investigation of the origin and geologic relations of the Lake Superior iron ores and the publication of numerous reports on that region have directed the prospector in the discovery of deposits and have suggested to the miner the most economical methods of development. The result is that this region now leads the world in the production of iron ore. Detailed areal mapping and the determination of underground structure in the Appalachian coal field are placing the development of its coal, petroleum, and gas resources upon a scientific basis and relieving these industries of a large part of the hazard and uncertainty which have always attended them; and the publication of reliable statistics of mineral production has furnished a sound commercial basis for all branches of the mineral industry.

A mint to be used in exemplifying the coining process has been sent from Philadelphia to the World's Fair.

ELECTRICAL NOTES.

The conclusions drawn by Dr. Sokoltzeff in a paper presented to the Russian Physico-Chemical Society, are as follows: Of the two electric emissions occurring in the disruptive discharge in the air, and at normal pressure, the positive emission plays the essential part. This conclusion is borne out by the following facts: In the case of the point being positive, the spark passes at a much higher distance than from a negative point. In the case of both electrodes being identical, connecting the anode with the earth will constantly weaken the spark, whereas, by connecting the cathode to the ground, the intensity of the spark is always augmented. The electric emission from the anode is stronger than that given off from the cathode, producing the spark more easily. On investigating the transformation of the slow discharge into a spark, the discharge is found to pass from the anode to the cathode. Several facts recorded in literature show the predominant part played by the anode in the formation of the spark, namely, the action of magnetic fields, the pressure and the fall of potential in the spark, the incandescence of the cathode, and the analogy with the discharges taking place in Geissler tubes. The positive emission is paralyzed under the action of radium, while no appreciable action is noted in the case of the negative emission. The influence of radium is the smaller as the shape of the electrode is more like a point. If in the spark circuit there are no appreciable strong oscillations, the radium will extinguish a rather long spark, the more easily as the surface of the anode is greater. The action exerted on oscillating sparks is of quite a special order; with positive points and negative disks, radium is found to extinguish a spark in the neighborhood and to light a spark at a distance, in the case of the spark length being upward of a certain limit; any other oscillating sparks are easily lit up by radium.

ENGINEERING NOTES.

The Sorachi Colliery of Japan is in the Sorachi district 9 miles east of Sunagawa Station. The aggregate area of the properties is about 5,368 acres. The location of the mine is 412 feet above sea level at Utashinaimura, Sorachi-gum of Ishikari Province, and is situated about 78 miles southeast of Otaru and 117 miles southeast of Muroran on the Tanko Railway. The discovery of the mine is said to have dated as far back as 1854, and to have been made by Mr. Takeshrio Matsura, the famous explorer of Hokkaido (then called Yezo Island). In 1873 Viscount Enomoto, then chief of the Colonization Bureau, went up the Sorachi River while traveling to investigate the products of Hokkaido, and finding coal, brought back samples for analysis. In the following year Mr. B. S. Lyman made a sketch of the locality and distributed it to the public. Not until 1876, however, was an official survey undertaken. In December, 1889, this company obtained the mining concession, and work was commenced in 1891, the railway being opened in the same year. The quality of the coal is bituminous coking coal with a brilliant luster. Although there are ten beds of coal now worked, their quality is practically the same. The comparatively friable quality of the coal, as compared with that of the other mines of the company, is one defect of the Sorachi coal, but it acquires a high reputation in the market, especially for coke and gas making.

The workmen employed above and below ground in this colliery are about 2,300, of whom 260 are women employed exclusively in the screening works. Workmen's houses, provision store, and a public school have been built by the company. A medical department for sick and wounded, together with fire engines and telephone communication, have also been established here, as at the Yubari Mines. The output of the last five years of this colliery is as follows:

	Tons.
1898	149,377.03
1899	127,717.04
1900	135,297.93
1901	187,917.94
1902	205,343.20

—Extract from article by K. Yonekra in Mines and Minerals.

Goethe and the Panama Canal.—The Frankfurter Zeitung of February 26, 1904, in an editorial states that the Panama Canal treaty has been ratified at Washington, that thereby the legal basis for the construction of the canal from the Atlantic to the Pacific has been created, and that the great work can be completed in a comparatively short time.

It is perhaps pertinent, the paper adds, to recall what Goethe said concerning these matters. During a conversation with Eckermann in 1827 with reference to Humboldt's travels, he said:

"This much is certain: If by a crosscut of this kind it could be accomplished that vessels with all sorts of cargoes and of every size could go through such a canal from the Gulf of Mexico to the Pacific Ocean, quite incalculable results would follow for the entire civilized and uncivilized human race.

"I, however, would be surprised if the United States would miss the chance to get such a work into her hands. It is to be foreseen that this young state, with its decided tendency toward the west, will in thirty to forty years have also taken possession, and will have populated, the large areas of land on the other side of the Rocky Mountains. It is furthermore to be foreseen that in this entire coast of the Pacific Ocean, where nature has already created the most roomy and safest harbors, in course of time very important commercial towns will carry on a large traffic between China and the East Indies with the United States. In such a case it would not only be desirable, but almost necessary, that merchant as well as war vessels should be able to have quicker connection with the western and eastern coast of America. I therefore repeat that it is entirely indispensable for the United States to make a passage from the Gulf of Mexico to the Pacific Ocean, and I am certain that she will accomplish it."

The specific heat of steam when superheated has never been accurately determined, and for this reason it is gratifying to learn from Engineering that some careful investigations to determine it are being made at the National Physical Laboratory, Teddington, with the financial assistance of the Manchester Steam Users' Association. The determinations made by Grindley and by Griesmann were some two per cent apart, while Regnault's experiments were conducted on a very small scale. The present investigation is in charge of Dr. Harker and Mr. Jakeman. Steam is generated in a gas-heated boiler and passed through a large drum and separator into a horizontal superheater pipe, which contains about thirty feet of very thin nickel-steel tape. An electric current at 100 volts can be sent through this resistance tape, and the steam heated thereby; the temperature generally used is about 165 deg. C., although as high as 300 deg. has been reached. Electric thermometers have been inserted at the ends of the superheater, which is lagged with mica and asbestos, and, it might be added, experiments on laggings will form part of the investigation. The steam finally passes into a condenser through a stuffing box, the apparatus being designed for a capacity of eighty pounds of steam per hour. The importance of such experiments at this famous research laboratory is very great, and it is worthy of note that a private company is supplying part of the funds, just as in the United States the most important investigation of superheated steam yet undertaken in this country is being carried on at the expense of a private corporation. Such expensive experimental work emphasizes what this journal has often asserted of late, that many of the most important engineering data are obtained by engineers in the employ of great manufacturing companies, and the time has gone by when the independent engineer can afford to belittle the scientific work of this nature.

The maintenance of a sufficiently high temperature in the combustion chamber of a boiler furnace is absolutely essential in the burning of fuels containing 10 per cent or more of volatile hydro-carbons, and it may be ignored only when using coke or anthracite fuels. Unfortunately, boiler engineers have not generally recognized this condition in the construction or setting of boilers, and nine-tenths of the factory smoke produced may be ascribed to the failure to maintain proper furnace temperature. The water-tube boiler makers are the chief offenders in this respect. In most of their boilers, as at present constructed and set, perfect combustion of the fuel can be obtained only when using anthracite coal. When ordinary bituminous fuels are used in such boilers, the volatile hydro-carbons which distill from the grate, even when mixed with a sufficiency of air, are brought too quickly into contact with the boiler tubes, and the temperature of the gases is thus greatly reduced before perfect combustion has had time to take place. It is not sufficient to have a mixture of the inflammable gases and air for perfect combustion to ensue. These gases must not only be mixed, but they must also be maintained at or above a temperature known as the combustion temperature. This temperature for the hydrocarbons distilled from coal is given by different observers as between about 940 and 1,200 deg. Fahr. The obvious method of obtaining this temperature is to provide a combustion chamber lined with some refractory and non-conducting material which will not allow heat to be dissipated before perfect combustion of the gases has occurred. Badly designed boilers may be made suitable for burning bituminous fuels without any very great capital outlay, and good results have been obtained with such modified forms of setting.—Cassier's Magazine.

The Revue Industrielle tells of a brewery in Paris in which the exhaust from a compressed-air motor is used for refrigerating purposes with quite satisfactory results. In this case an old steam engine with cylinder 17.7 inches in diameter and 35.4 inches stroke, at 60 revolutions per minute drives a dynamo which supplies 45 arc lamps and 50 to 400 incandescent lamps, the horse-power varying from 30 to 45. The use of an old steam engine, with the usual valve adjustment of such an engine, although quite common in connection with the compressed-air service of Paris, is, by the way, not the most economical way of employing the air. The air comes to the compressor at a gage pressure of 71 pounds and at a temperature of 53 to 59 deg. Fahr., sometimes going to 68 deg.; the temperature of the exhaust has been as low as —76 deg. The exhaust pipe discharges into the freezing chamber, which is in two parts, the first for freezing and the other for storing the ice, the entire chamber being heat-insulated by blocks of ground cork covered with wood sheathing. Besides these chambers there is a beer cellar to be cooled. The pipe, which is 7 inches, is enlarged to 15 inches in the wall of the freezing chamber. Valves are provided for directing the current so that what is not required for the refrigeration goes by a shorter route to the atmosphere.

The compressed air costs at the rate of 4.45 cents per 1,000 cubic feet of free air and the consumption per horse-power hour is about 847 cubic feet. The cost of the compressed air and the running of the apparatus is computed to be no greater than would be the cost of ice necessary to produce the same refrigerative effect, so that the entire lighting plant is practically operated for nothing.

TRADE SUGGESTIONS FROM UNITED STATES CONSULS.

Wurttemberg Industries and American Trade Opportunities.*—Musical Instruments.—The chief exports from Wurttemberg to the United States are musical instruments, chiefly mouth harmonicas.

There are found on the upper Danube several large harmonica factories in small towns. The largest one has one main and fifteen branch factories and employs 1,500 people, much of the work being done at the homes of the employes. The annual output of this firm has been for several years about 5,000,000 harmonicas.

The firm now announces that it has begun the manufacture of accordeons. The business indications in this line do not point to an immediate improvement.

Although the stocks on hand have been largely disposed of on account of the improved conditions of foreign markets, manufacturers do not seem to look for any immediate improvement in this industry. Wages have increased rapidly, while prices have been materially cut. Increasing competition, especially with the manufactures of Saxony, has been the chief characteristic of the trade in 1902 and 1903.

The expected improvement in Germany did not materialize, nor did it in Austria, where the factories protected by high tariffs hold the local market well in hand. In England and Russia business was not good, and failures caused large losses. Switzerland was still worse. In Australia and New Zealand business was quiet, the exports of the past summer thereto not being equal to those of last year. It is believed that the increase in the tariff in Australia has no influence upon this trade.

In South Africa business was good at the beginning of 1903, but suddenly became quiet, which is not attributed to the increased tariff, but to the great crisis now taking place there. Business is not as good there now as it was before the war. In India and China business was bad, but in Japan conditions were better.

The conditions in this industry have improved during 1903. The three large well-known manufacturers here report that business has increased very satisfactorily.

Though no pianos are exported from here to the United States, 50 per cent of the output is exported. There have been very few men out of work in this line, and factories are running on full time. The outlook for 1904 is satisfactory. Keen competition with American firms is reported in Central and South America.

Surgical Instruments.—The year 1903 has shown considerable improvement over the last three years. At the beginning of the current year there was a lively inquiry for goods and later on it increased still more, but profits, on account of competition, are always decreasing.

The industry is well represented in Wurttemberg, where one of the largest factories in Europe is located, producing over 20,000 different kinds of instruments for human and animal surgery.

Dry Colors and Chemicals.—In colors for printer's ink, largely exported to the United States, the improvement noticed at the beginning of the year was maintained; nevertheless competition is always increasing, and it is very difficult to get orders to keep the mills going. Prices have also ranged lower and longer time has been demanded and given.

In general the color business has been less satisfactory than in previous years. Although prices for raw materials have declined, selling prices on account of keen competition have decreased in still greater proportion.

In chemicals the business for the current year has been unsatisfactory; for, although coal declined in price, the prices in chemicals declined still more where overproduction and competition occasioned by cheaper coal caused prices to be greatly reduced. It is believed that it will be necessary to stop altogether the production of some articles, on account of the immense stocks now on hand. There has already been reported some reduction of working forces in this line.

Corsets.—The corset industry of Wurttemberg, which a decade ago enjoyed a large market in the United States, maintained, notwithstanding the very important loss of the American market, a successful career up to 1900, but has since then been less fortunate. Whalebone has increased from 38 to 80 marks ($9.04 to $19.04) per kilogramme (2.2046 pounds), and the price of the article has not materially advanced. There has been some increase the past year, variously estimated at from 5 to 9 per cent, but the profits have been materially curtailed.

Dry Goods.—The dry-goods trade reports some improvement, especially in the finer qualities. The large houses here carry fine displays of costly Paris-made dresses. These dresses are often copied and the general Parisian styles are closely followed. Within the last few years I have succeeded in creating a demand for American styles by distributing copies of illustrated American periodicals devoted to this trade, and several houses have subscribed to such journals. The manager of one large house here declared that the American styles were, not only in his opinion but in the opinion of many experts, superior to any other, and he predicted that there was a great future for these styles if the business were properly attended to.

Chicory.—The situation has changed but little in this industry in the past nine months. The only firm which exported chicory from Wurttemberg to the United States established a house on Long Island a few years ago, and there have been no exports of this commodity to the United States from this consular district since then.

* Extract from the annual report of Consul Ozmun, which will be printed in full in Commercial Relations for 1903.

Wurttemberg vs. American Furniture.—For many years furniture has been an important industry in Wurttemberg, and the large factories here have branch houses in several of the chief cities of the Empire, where the finest grades of all kinds of furniture find good markets. There is no export from Wurttemberg to the United States, and, as I have often pointed out in former reports, there exists here a good field for the exploitation of American furniture, especially of the cheaper grades. These goods are manufactured for the most part by very small concerns in the villages and small towns, are entirely hand made, and are not to be compared with the American-made furniture of that class, although considerably higher in price. The styles also are antiquated, the forms are clumsy, and the material poor. With only a moderate amount of enterprise on the part of our manufacturers these markets could be completely captured in a few years and held, as there exists no machinery here to compete with ours, and this business is in the hands of men of too small capital to erect factories for competition. These small manufacturers in such an event would not of necessity go into bankruptcy and starve, but on the other hand they could make more money in handling American-made furniture than in s 'ling their own laboriously-made product.

Business in this line in Wurttemberg showed some improvement over 1902, but still it was weak and slow. There were not so many expensive villas, as detached houses are called here, erected. Buyers bought as little as possible and the competitive bid system now in vogue here reduced profits materially. Export business was very bad, many houses doing nothing at all, and business in Switzerland was difficult, owing to the new gross-weight tariff. Wages were about the same, and one firm reports that the ability of young laborers has decreased.

American Office Furniture.—This sadly neglected line has shown some little improvement of late by the renting of a good shop in the principal business street of Stuttgart by a well-known dealer in office supplies.

His goods are displayed to advantage and attract considerable attention. He reports his sales as good and increasing satisfactorily, but it can be noticed that he has fully as much, if not more, German imitations of the American patterns, which he perhaps prefers to sell. It is needless to say that only when our manufacturers take the trouble to make sole agents for their goods will results be obtained at all commensurate with the opportunities. Had our manufacturers pushed their export business with proper vigor there would never have been any German imitation of American office furniture.

American Machinery and Tools.—These lines have shown no increase in the past year. There appears to be little if any effort made to secure a market here, and only a few are bought now and then of importing houses in Hamburg. American novelties are in good demand, but the dealers in general do not seem to know where to get the goods.

Boots and Shoes.—As has often been reported, there has never been a serious attempt on the part of American manufacturers to sell goods in the Wurttemberg market. There are a few shoes of American make here for sale, but they are used more for exploiting the German imitations than for any other purpose. There is a good trade awaiting the manufacturer who has sufficient enterprise to enter this market.

The trade in German goods has not been as satisfactory as last year. There is considerable overproduction and a large stock on hand. The German shoes have improved much in appearance in the past year, owing to improved American machinery being used in the German factories and the importation of American shoe-factory superintendents, but the quality is still lacking.

The best factory now produces quite a respectable-looking shoe, which was not the case a few years ago.

Automobiles.—There has been a very satisfactory automobile output and sale. One large well-known factory in this district, which employs 1,000 hands here and about 120 officials, has several branch factories. The branch factory in Marienfeld, a suburb of Berlin, employs about 800 men and officials; the one in Vienna, about 400 men and officials. Besides these, they established a branch in England and one in Milan, and repair shops at Puteaux, near Paris.

Part of the factory of this establishment burned last June, on account of which considerable loss was sustained. The new works at Untertürkheim, for which they purchased about 25 acres of land, will be very extensive; a portion of this plant will be in working order before the end of the year. The firm is always many months behind in its orders, and often the fortunate possessor of a new machine is able to sell it at considerable advance, so great is the demand for this popular make. The outlook for the coming year is also very satisfactory. There has been some slight attempt at establishing a salesroom for American automobiles, but, as usual, it has resulted in nothing, for the manufacturer believed that it could be accomplished without sending any one here to carry out and complete the arrangements.—Edward H. Ozmun, Consul at Stuttgart, Germany.

Austro-American Improved Communication.—The "Austro-Americana" Line has acquired a number of new vessels during the past year, and has now a fleet of nineteen steamers. This has enabled the company to make arrangements for a greatly improved service. There will be hereafter, besides the former semi-monthly sailings to New York, a sailing every three weeks to Philadelphia and every five weeks to Boston and Baltimore. As full cargoes cannot always be secured here, some of the ships will call on their westward voyage at Greek, Sicilian, and Spanish ports. From the United States the company will have regular semi-monthly sailings from Savannah and New Orleans and monthly sailings from Galveston.

The company has recently entered into a joint tariff agreement with the Louisville & Nashville Railroad Company, in consequence of which goods from any point on that company's line will be carried to Mediterranean and Adriatic ports with only one transshipment at Pensacola. This arrangement will prove of decided advantage to our Southern shippers, as their goods will be less liable to be delayed or to suffer damage in transit.

The Austro-Americana has furthermore added to its service a new line between Trieste and Veracruz, Mexico. The steamers of this line, which will also call at intermediate ports, have each accommodation for about 150 passengers.

In view of the constantly increasing flow of trans-Atlantic emigration from Austria-Hungary, the managers of the Austro-Americana have for some time been considering the advisability of adapting a portion of their fleet to the carrying of emigrants, but so far no definite conclusion has been reached. This irresolution has probably aided in bringing about the recent decision of the Cunard Company to have some of its passenger steamers ply, during the coming winter, between New York and the principal ports of Italy and Austria-Hungary for the transportation of second-class and steerage passengers, at rates which promise to compete successfully with the northern lines. The steamers have been fitted for carrying each 1,000 steerage passengers, besides several hundred saloon passengers, and will make the trip from Trieste to New York in twenty days. They are said to be superior emigrant ships, being even equipped with Marconi's system of wireless telegraphy. The first ship of the new line is advertised to leave here on November 10.—Fredk. W. Hossfeld, Consul at Trieste, Austria.

Trade Opportunities in Trebizond.—The Province of Trebizond gives promise of being an excellent field for the sale of United States products. The merchants with whom I have conversed during the short period this consulate has been established in Trebizond speak in the most eulogistic manner of the superiority of American goods and expressed their desire to cultivate closer relations with the manufacturers of the United States. Some have placed trial orders, and should the goods prove satisfactory it will lead to larger purchases.

The steamships of the Levant Line are in direct communication with the Black Sea ports and New York and are a valuable auxiliary in promoting trade.

Tobacco and filberts are extensively grown in this vilayet and the people are anxious to find a direct market for them. Among the exporters who have sought information is a Mohammedan, who is the largest exporter of hides, skins, and filberts, and has already made a trial shipment. Many others have intimated that they will do likewise. Manufacturers would do well to send catalogues and trade terms and wherever practicable supply samples for exhibition in this consulate.

The banking facilities of this city are ample and favorable to the transaction of business. American exporters will find no difficulty in transacting their business with the merchants here.

Besides the Imperial Ottoman Bank there are three others, viz., Messrs. Capayannides, Hostropulo frères, and Nemly Zade. The former (Capayannides) do a large business in sugar, tea, and coffee, and the latter, in addition to exporting goat skins, is also a large importer of flour. Mr. Capayannides will visit the St. Louis Exposition and endeavor to make arrangements with bankers in the United States with a view to business transactions.

Several commercial travelers from European countries have visited this city recently and were successful in obtaining orders. A large American exporting company is to send one of its agents here this month.—Edward J. Sullivan, Consul at Trebizond, Turkey.

INDEX TO ADVANCE SHEETS OF CONSULAR REPORTS.

Other Reports can be obtained by applying to the Department of Commerce and Labor, Washington, D. C.

SCIENCE NOTES.

The Neuė Tageblatt, of Vienna, reports that interesting experiments are being conducted at the agricultural bacteriological station of Vienna. It is a well-known fact that salts of iron are of great importance for the human system. The artificially prepared foods containing iron which are introduced into the human body have not always the desired effect because the quantities of iron contained therein, even if considerable, are not completely assimilated.

According to modern ideas, the human body may also supply its want of iron from vegetable foods, and it is expected that by increasing the quantity of iron in certain vegetables it will be possible to procure a natural means of supplying the human system with a nutriment rich in iron and easily assimilated. The first experiment was made with spinach, by adding hydrate of iron to the soil. The spinach grown from seed showed a percentage of iron seven times as great as ordinary spinach, without injury to the plant. This is considered a very favorable result, as the iron contents are perfectly sufficient for medicinal purposes and in a form which possesses none of the defects of the best artificial-iron preparations. It is presumed that other ferruginous plants rich in iron will yield similar results, so that not only the science of medicine will be benefited, but the gardener will also find their cultivation a source of profit.

Palladium is usually found associated with the rare metals rhodium, osmium, ruthenium, and iridium. It occurs usually associated with gold and has been found in the placer mines of the Cariboo district, British Columbia. Some gold ores of Brazil contain from five per cent to ten per cent of metallic palladium, which is obtained by fusing it together with silver and dissolving the granular alloy thus obtained in hot nitric acid, when the gold only remains. By addition of a solution of sodium chloride, the silver is precipitated as chloride, which is removed by filtration. The palladium in the solution is then precipitated by means of mercury cyanide in the form of a yellowish-white, gelatinous substance—palladinous cyanide. This, on heating to fusion, becomes a spongy, metallic palladium. Palladium has the lowest melting point of any of the platinum group of minerals—about 1,500 deg. C. It resembles platinum in color and luster and steel in hardness. It is more malleable than platinum and is more readily welded. When polished, it has a steel-like whitish luster and does not tarnish. Tincture of iodine will blacken the surface of palladium, but not of platinum. The metal, on account of its resistance to oxidation under ordinary atmospheric conditions, is used in the manufacture of chronometers and fine watches and also to some extent in the construction of balance beams of fine assay scales. Palladium may be detected, when present, by mixing a solution of sodium thiosulphate with a small amount of ammonia and adding a drop of the solution of the ore supposed to contain palladium, so as to color the liquid pale lemon yellow. Boil and watch for changes in color from wine-brown to black. Diluted with water, it returns to the former color but remains clear.—Mining and Scientific Press.

Most persons regard the education of blind deaf mutes as a development of modern philanthropy, says Science, and it will surprise many to learn that the method of tangible lip reading was invented nearly 230 years ago. Bishop Burnet, the famous English historian and theologian, in a letter dated Rome, December 8, 1685, and addressed to the eminent scientist, the Hon. Robert Boyle, wrote as follows: "There is a minister of St. Gervais—Mr. Gody—who hath a daughter that is now sixteen years old. At a year old the child spoke all those little words that children begin usually to learn at that age, but she made no progress; yet this was not observed till it was too late, and as she grew to be two years old they perceived then that she had lost her hearing, and was so deaf that ever since, though she hears great noises, yet she hears nothing that one can speak to her. But the child hath by observing the motions of the mouths and lips of others acquired so many words that out of these she has formed a sort of jargon in which she can hold conversations whole days with those that can speak her own language. I could understand some of her words, but I could not comprehend a period [sentence]; for it seemed to me a confused noise. She knows nothing that is said to her unless she seeth the motion of the mouths that speak to her, so that in the night when it is necessary to speak to her they must light a candle. Only one thing appeared the strangest part of the whole narrative. She hath a sister with whom she practised her language more than with any other; and in the night, by laying her hand on her sister's mouth, she can perceive by that what she says, and so can discourse with her in the night. It is true her mother told me this did not last long, and that she found out only some short period in this manner, but it did not hold out very long. Thus this young woman hath merely by a natural sagacity found out a method of holding discourse that doth in a great measure lessen the misery of her deafness. I examined this matter critically, but only the sister was not present, so that I could not see how the conversation passed between them in the dark."

Opening for American Trade in Quebec.—Under date of April 2, 1904, United States Consul W. H. Henry, of Quebec, Canada, reports a good opening in that city for some wholesale house in New York handling Japanese teas. The consul, upon proper advertisement, will place such party in communication with the Quebec firm desiring to do business therewith.

THE

Scientific American Supplement.

PUBLISHED WEEKLY.

Terms of Subscription, $5 a Year.

Sent by mail, postage prepaid, to subscribers in any part of the United States or Canada. Six dollars a year, sent, prepaid, to any foreign country.

All the back numbers of THE SUPPLEMENT, from the commencement, January 1, 1876, can be had. Price, 10 cents each.

All the back volumes of THE SUPPLEMENT can likewise be supplied. Two volumes are issued yearly. Price of each volume, $2.50 stitched in paper, or $3.50 bound in stiff covers.

COMBINED RATES.—One copy of SCIENTIFIC AMERICAN and one copy of SCIENTIFIC AMERICAN SUPPLEMENT, one year, postpaid, $7.00.

A liberal discount to booksellers, news agents and canvassers.

MUNN & CO., Publishers, 361 Broadway, New York.

TABLE OF CONTENTS.