

ed both revolve in the same direction and with the same axes, and contain within these axes, one a male and the other a female screw. These screws are so arranged that if the adhesion wheels both revolve with the same velocity, by being kept at the same distance from the axes of the circular disks by means of a lever acting through the medium of the slot, the screws, although loose in the wheels, will neither advance nor recede, but a difference of level moving both the lever and the slot, and bringing one adhesion wheel nearer and the other further from the axis of the disks, and, therefore, causing difference in velocities, will make the screw which carries the pencil of altitude advance or recede as long as difference of level causes difference of velocities in the adhesion wheels and the screws which move them.

The arrangement by which the paper is made to pass under the two pencils (one to mark the surface and the other the base line and station) is at once suitable and ingenious. The two rollers upon which the paper is wound is kept tightly straightened by a tendency to motion in opposite directions, communicated to them through friction and from the main shaft, while drum rollers geared to the true horizontal motion deliver the paper under the pencils with the smallest expenditure of force.

The pencil of altitude moves an inch for every 50 feet change of level, and the paper is drawn under the pencils at the rate of an inch for every 500 feet in distance.

The true horizontal distance can be read to tenths of a foot, and the surface distance to every 10 feet. The machinery by which so many complicated movements are produced is substantial and well adapted for service, capable of adjustment in every part, and not liable to get out of order if well used. The cistern containing the mercury is entirely of metal and the frame work is securely trussed and bolted.

The perambulator wheels are made of the best material with steel tires, while the handles by which the "Orograph" is propelled and managed are hinged to the frame work near the center of gravity, adding much to the stability of the machine. The machine, which was very costly to construct, has been frequently loaned as an exhibit at scientific exhibitions. It was last on public view at the World's Fair in Chicago.

Our Copper Industry.

The rapid growth of the copper industry in the United States, and the large proportion which this country supplies of the world's copper, is shown by a German publication entitled "A Century of Copper." It shows that the United States has during the years 1891-1900 produced more than one-half of the copper of the world, while in the preceding decade it supplied about one-third of the world's production, and in the decade, 1871-1880, the portion supplied by the United States was only about one-sixth of the total. The growth of the copper production in the century has been very rapid, being in the first decade 91,000 tons, in the fifth decade 291,000 tons, and in the tenth decade, which ends with 1900, 3,643,000 tons, of which 1,963,000 tons is supplied by North America, a large proportion of this being from the United States. The greatly increased demand for this material is illustrated by the fact that, although the production has increased from 505,909 tons in the decade, 1885 to 1890, to 3,643,000 tons in the decade, 1891 to 1900, the average price has fallen only a little more than half, so that while the production has increased more than six-fold, it costs about one-half what it did.

While the world's production has increased with startling rapidity during the century, that of North America has by far outgrown all other parts of the world. In the matter of consumption figures are equally interesting. The consumption of copper in England, France, Germany and North America was 400,583 tons in 1899, against 268,447 tons in 1893, being an increase of about 50 per cent during the period under consideration, while in North America alone the production is given at 77,433 tons in 1893 and 162,000 tons in 1899, the growth being over 100 per cent during that period.

TRIALS have recently been made on the section of the London Metropolitan Railway which has been equipped electrically from Earl's Court to Kensington. The Board of Trade will pronounce upon the merits of the scheme.

THE TOWERS AND APPROACHES OF THE NEW EAST RIVER BRIDGE.

The new East River Bridge, whose progress has been considerably delayed by the lack of structural material, is now making very satisfactory progress. The great masses of masonry which form the cable anchorages at each end of the bridge are nearly completed, and the steel work of the two towers has been carried up to the level of the floor of the bridge. The false-work upon which the portion of the bridge between the towers and the abutments will be erected, has been put up, and unless there is further delay in the shipment of steel work from the rolling mills, it is likely that the towers and the shore span of the bridge will be completed some time during the summer.

If not the handsomest, the new bridge will be at least the largest and stiffest of the notable suspension bridges of the world. Its entire length between terminals will be 7,200 feet; the length of the suspended span will be 1,600 feet, a few feet greater than that of the Brooklyn Bridge, while the extreme width of the floor between the outside railings of the bridge will be 118 feet. Provision will be made for four trolley tracks and two elevated railway tracks, all of which will be carried between the two stiffening trusses, 50 feet deep, which will run the entire length of the bridge from anchorage to anchorage. On the outside of these trusses, carried upon a cantilever extension of the floor-beams, will be two 18-foot roadways. Between the trusses and above the trolley tracks will be two bicycle tracks, each about 8 feet in width, and two 12-foot promenades, there being a promenade and a bicy-

oughly riveted together and the stiffening diaphragms which are worked in at the base of the column are replaced in the upper 4-foot section of the tower by eight built-up Z-bars, two on each interior face of the column. The distance, transversely of the bridge, from center to center of the columns is 24 feet, and they are spaced 40 feet apart, measured in the direction of the axis of the bridge. The four columns of each tower are carried up vertically and parallel as far as the level of the roadway. This portion of the towers has been completed and the summit of the steel-work as seen in our engraving represents, approximately, the roadway level.

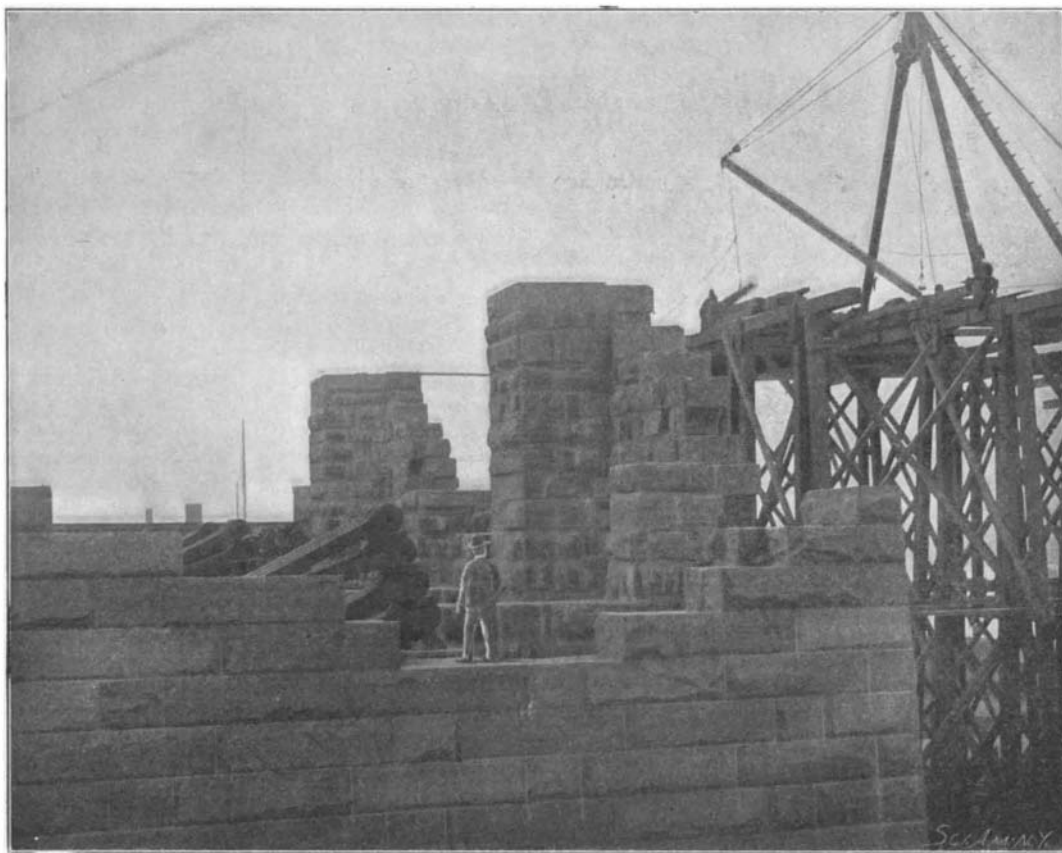
Above the roadway the towers will have a sharp inward batter, the inclination being 14 feet in a height of 215. The four columns are strongly braced together, the bracing being built up of heavy angles and tie-plates. Immediately below the floor of the bridge a system of massive lattice-bracing is run entirely around each tower, and extends also between the towers themselves. Similar lattice trusses will extend from tower to tower between the inner legs above the roadway. Additional stiffness and a pleasing architectural effect will be gained by the construction of a stiffening arch immediately below the roadway. The saddle castings, each of which is about 7 feet 8 inches in width by 19 feet in length, and weighs 32½ tons, will be placed immediately over the legs of the columns, a system of heavy column girders, 7 feet in depth, being interposed between the columns and the saddle castings. These girders will extend transversely from tower to tower, and will serve to give great rigidity at this point.

The erection of the towers is being carried on by means of timber false-work, whose construction is clearly shown in our larger front-page engraving. This false-work rests upon the masonry piers and is stiffened by being fastened to the tower itself and by a liberal use of wire cables with turn-buckle adjustments. The lighter material is brought to the tower over a trestle which is built out from the shore; while the heavier material, which in the case of the column footings weighed as much as 12 tons, and in the case of the bottom tapered sections of the tower, as much as 24 tons, was brought to the work upon lighters and picked up and placed in position by means of derricks, which at first were operated from lighters, but subsequently were rigged upon the top of the tower false-work.

Simultaneously with the erection of the towers, work is being pushed on the construction of that portion of the bridge which lies between the anchorages and the towers. Unlike the Brooklyn Bridge, this portion of the roadway will not be supported from the cables. The trusses at their inshore end will rest

upon the masonry anchorages, but at the bridge they will be supported upon massive rocker bents which will rest by means of hinged bearings upon heavy girders built into the structure of the tower. Midway between the towers and the anchorages will be an intermediate tower upon which the trusses will rest by means of a combination hinge-and-roller bearing. The main span between the towers will, of course, be carried by the main cables, except for the first 100 feet or so at the tower, which will receive a cantilever support from that portion of the truss which extends from the main tower to the intermediate tower. Unlike the stiffening trusses of the Brooklyn Bridge, the new East River trusses will not be cut at any point, or contain any slip-joints, but will be continuous from anchorage to anchorage; moreover, they will not be anchored rigidly either to the towers or to the anchorages. As we have already pointed out, they will be provided with roller bearings at the anchorages and at the intermediate towers, and with rocker shaft bearings at the main towers; consequently, being higher at the center than at the ends, they will expand evenly and freely from the center toward the anchorages on either shore.

It is estimated that at the present rate of consumption there is pine enough in Northern Minnesota to last from thirty-five to forty years. With a reasonable conservation of the forests, the establishment of a Northern Minnesota forest park, and the adoption of forestry, systematically undertaken, as is now proposed, the Northern Minnesota woods should furnish timber and a revenue to the commonwealth for an unlimited time.



TOP OF BROOKLYN ANCHORAGE, EAST RIVER BRIDGE, SHOWING END OF ANCHOR CHAINS TO WHICH MAIN CABLES WILL BE ATTACHED.

cle track on each side of the center line of the bridge, those on one side accommodating travel from Brooklyn to New York, those on the other reserved for travel in the opposite direction. The foundations of the towers, four in number, are timber and concrete caissons, sunk in every case until they rest upon bed-rock. Above these are solid masonry piers, two for each tower, the top course of the masonry being 23 feet above mean highwater of the East River. Upon each pier are laid four massive pedestal blocks of dressed granite, one at each corner. These blocks are not visible in our engraving as they have been boarded up to protect them from disfigurement during the erection of the towers. Upon the pedestal blocks are placed the heavy column pedestals, massive castings which measure 11 feet by 11 feet on the base and about 8 feet by 8 feet on the upper face; they are 3½ feet in depth and they are strengthened with a mass of intersecting 2-inch vertical ribs.

Immediately upon these pedestals are erected the four massive legs or columns which go to make up each half of the tower; they are square in section, measuring 8 feet on the side at the base, and tapering in the first 20 feet of their height to a square section measuring 4 feet by 4 feet, which they maintain throughout their full height. The massing of metal at the foot of the columns presents an interesting study. They are built up chiefly of ½-inch steel plates, stiffened by eight diaphragms which are disposed two on each inner face of the column. The columns throughout their full height, of over 310 feet, are built up of two thicknesses of plate, the total thickness of the metal at the base of column being 1½ inches, and at the top of the column from 1¼ to 1½ inches. The two thicknesses are thor-

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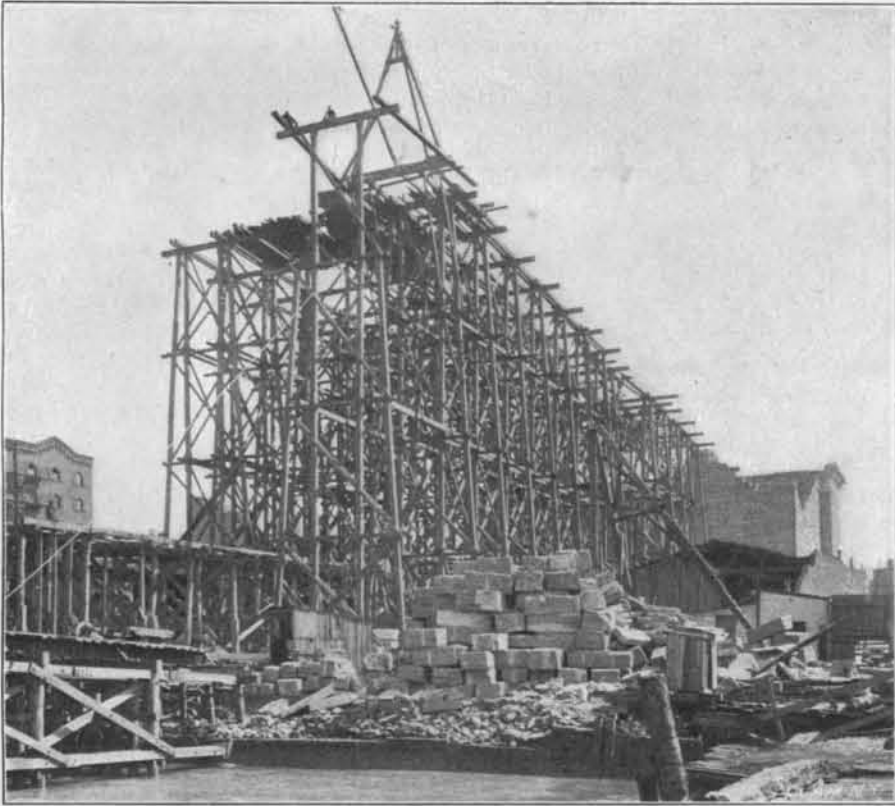
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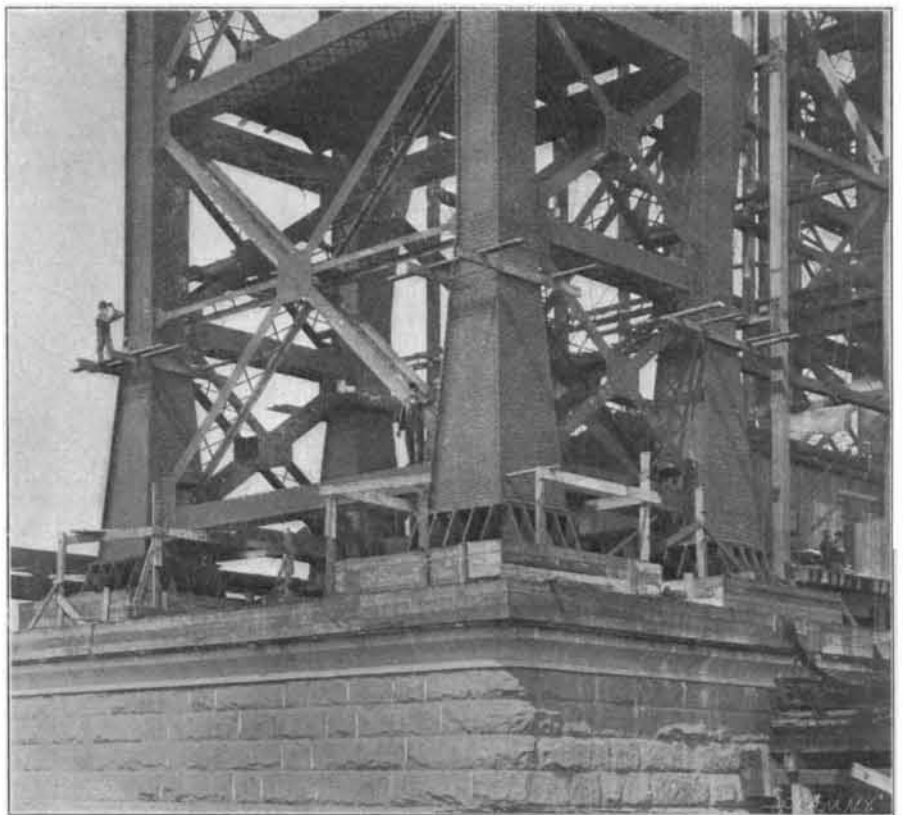
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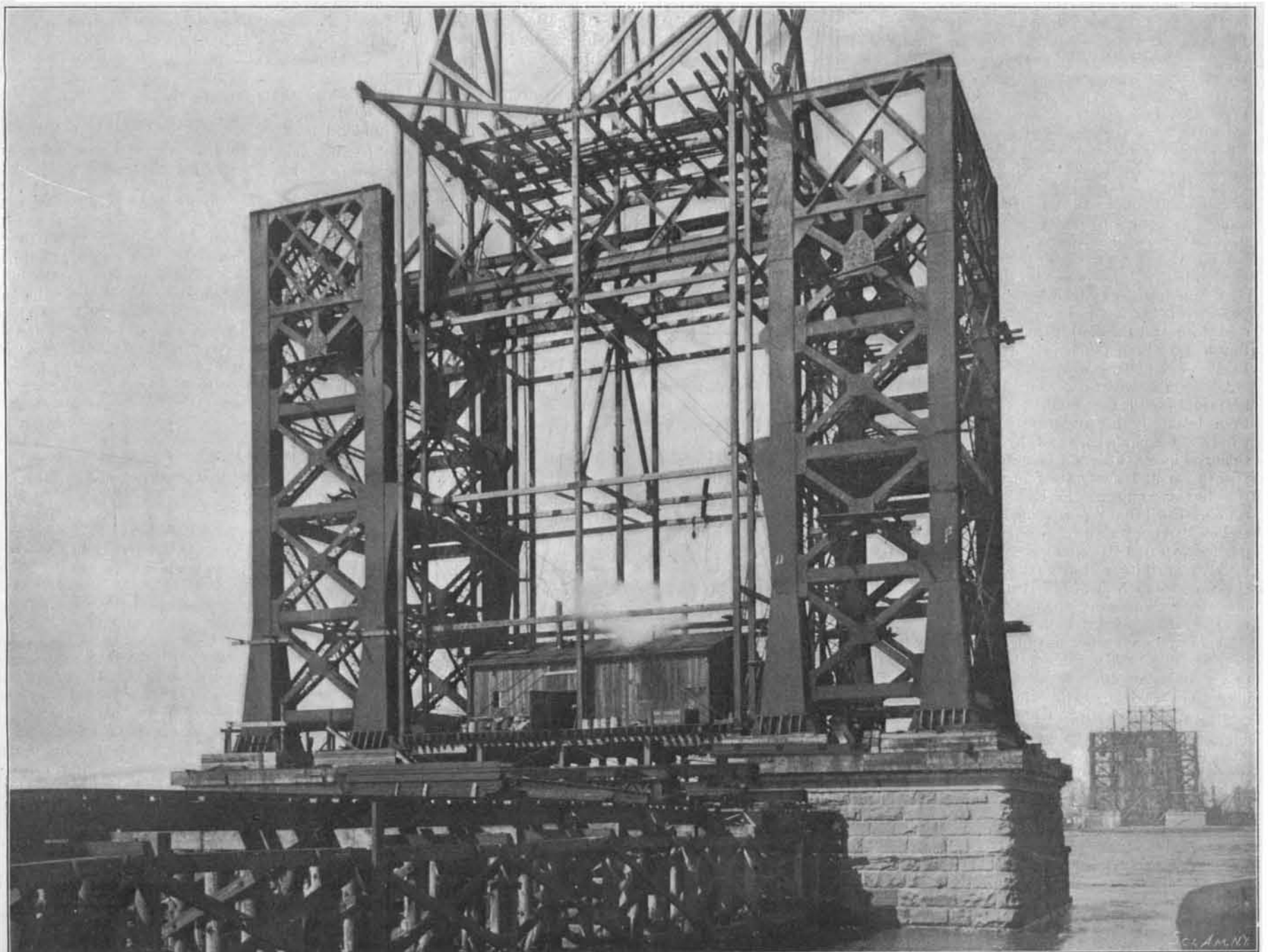
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False-work and Anchorage on the Brooklyn Side.



Base of Tower, Showing Enlarged Columns and Pedestals.



Size of Base, Center to Center of Columns, 24 feet by 40 feet. Section of Columns at Base, 8 feet by 8 feet.—Height of Towers, Top of Masonry to Center of Cables, 310 feet. Clear Span of Bridge, 1,600 feet.

ERECTION OF TOWERS OF THE NEW EAST RIVER BRIDGE.—[See page 294.]

Science Notes.

A train recently carried fifty-nine car loads of oranges from California east. There were in all 21,712 boxes.

In 1806 James Watt built an organ for St. Andrew's Church, Glasgow, which he attended. There was considerable opposition to its use, and many caricatures were published concerning it.

A committee of the Senate is now investigating the alleged deleterious action of alum as a constituent of baking powder, which was demonstrated many years ago in England. Small amounts of alum improved the appearance of bread made from inferior flour, but the product was prejudicial to the health of the consumers and its employment was prohibited by law.

On June 23 next, a festival will be held at Mayence to commemorate the 500th anniversary of the birth of Gutenberg, the reputed inventor of the art of printing. In this festival almost all civilized nations will take part, and it is to be hoped that the United States will be duly represented. In connection with this festival the foundations of a Gutenberg Museum is planned.

Arrangements are being considered for an exhibition of paintings to be shown at New York in aid of the Naval Arch Fund, the paintings to be American works, which were exhibited at the Paris Exhibition. The Board of Aldermen have directed that a sufficient amount of money be appropriated to preserve the arch for one year, and the care of it was assigned to the Commissioner of Buildings.

Plants containing hydrocyanic acid have been investigated with a view of determining the part played by this substance in the vital economy of the plant. He concludes that cyanogen compounds are transitional substances from which plants obtained their nitrogenous food materials. At the same time when the seeds begin to swell, as long as the embryo is dormant, the bitter almond contains no trace of hydrocyanic acid. It makes its appearance only in the stem, not in the root, nor in the cotyledons.

Prof. Trowbridge has perfected a new method of obtaining X-rays. The currents of electricity which have hitherto been used in making photographs have been fluctuating, making the pictures of uncertain value to surgeons. Prof. Trowbridge, of Cambridge, has succeeded in getting a steady current, and the pictures taken by his new system are remarkable for the clear and distinct outlines of the muscles and bones of the subject. To all appearances, the discovery will be of the greatest use to surgeons and in the study of anatomy.

An interesting telescope has just been put in position at Potsdam. It is a duplicate instrument, being composed of two tubes, side by side, the larger one for photographic purposes and the other is to be used visually and as an aid to keeping the star images stationary upon the plate during long exposures. The photographic one has a diameter of 32 inches and a focal length of 40 feet. The visual objective is slightly longer in focus, being 41½ feet, and is 20 inches in diameter. For this instrument, which will be employed to determine the motion of the stars in the line of sight by means of the spectroscope, a special dome has been built.

A celebrated American astronomer suffered acutely for over twelve years from an unknown trouble in his leg. The surgeons did not seem to be able to diagnose his case. He finally went to the Johns Hopkins Hospital at Baltimore, and an examination by two young surgeons showed that the lameness was due to a diseased nerve in the leg. The patient was told that the operation would be painful, and in the nature of an experiment, as it had been tried only once before, in France, in which instance it was successful. The patient refused to take anesthetics, as he desired to witness the operation as far as possible. The leg was opened and the nerve was found to be diseased, and the patient directed the surgeons to cut it out. The nerve was entirely removed, the wound closed and in ten days the patient was able to dress himself and walk about the hospital, and he is now able to go up and down stairs and walk half a mile at a time.

The accumulated files of newspapers have encroached very largely upon the space at the disposal of the authorities of the British Museum. The shelves occupied by London newspapers alone exceed 1,000 yards in length, while those devoted to the provincial, colonial and foreign numbers measure more than 3,000 yards, the total being close upon 3 miles. In a single year the British newspapers have been known to fill 111 yards of shelving, which is at the rate of 1 mile in sixteen years. Of course such a progress cannot be prolonged indefinitely. A bill is now before Parliament, which will authorize the trustees to deposit with local authorities any local newspapers which have been received by them at Bloomsbury since the year 1837, or which may be hereafter received, and also to make rules respecting the disposal by destruction or otherwise of printed matter deposited in the museum which is not of sufficient value to justify its preservation.

Electrical Notes.

An electric railway is now running between the north and south extremities of Berlin. The length of the line is 15,180 meters.

A submarine telephone cable has been laid through the Straits of Mackinac connecting Marquette with Detroit and other cities.

The Roentgen Society of the United States was organized in St. Louis on March 31, for the encouragement of the study of the X-rays and their use in medicine and the arts.

The street railways of Havana are to change the motive power from horses to electricity. The city is in great need of rapid transit, and the delay in the new improvements is caused by putting down new sewers, etc.

The suburban service between Paris and Versailles is to be operated by electricity. Steam locomotives are to be abandoned and electric motors substituted. The power station will be equidistant between the two places.

According to Prof. Borchers, says The Engineer, the world's manufacture of calcium carbide is utilizing a power equal to 180,000 horse power, that of alkalies and combinations of chlorine, 56,000 horse power; aluminium, 27,000 horse power; copper, 11,000 horse power; carborundum, 2,600 horse power.

The Volta School in Naples has 400 scholars, they provide their own tools and go through courses in electricity, chemistry and mechanics. The pupils pay a nominal fee and the institution is assisted by the government and by the city. It is said that it is easy to obtain employment on leaving the schools.

The telephone has proved very successful in the West in places where different farmhouses are connected by wire, as it enables them to give each other timely warning of the approach of tramps. It is also useful in cases of fire and sickness. The possibilities of the telephone in rural districts are very great.

A curious accident occurred in Sheffield, England. A passenger was riding on a double-deck electrical car, and a single-deck car passed in the opposite direction. The rope of the trolley boom of the latter was flying in the wind, and it wound itself around the passenger's neck. Fortunately, he had the presence of mind to seize the rope with both hands and release himself, or he would have probably been pulled from the car.

The result of draw-bar tests taken on the South London Electric Railway, says The Engineer, shows that the tractive resistance per ton of train is 40 pounds at that moment of starting, and that it drops quickly to 10 pounds at 6 miles. Between 6 and 13 miles per hour the resistance remains constant, and then continues to rise almost proportionately, to the speed until 26 miles per hour is reached, when the resistance is about 21 pounds per ton.

The underground-electric railway at the Paris Exposition will not be in use for some time to come. The trial, will now be held on May 15. Carriages of the corridor pattern will accommodate fifty, and each will be lighted by ten electric lights. Separate doors for the entrance and egress of the passengers are to be provided. The run of nine miles from Vincennes to the Bois de-Boulogne is to be accomplished in twenty-seven minutes, including stoppages.

The fire marshal of a Western city has just tested an automatic fire alarm, by which messages are sent over the telephone automatically with the aid of a phonograph, at intervals in the different rooms. Thermostates are provided. As soon as the rooms attain a certain temperature, these thermostats cause the phonograph to be switched over in front of the transmitter and recorded sentences are ground out over the telephone. The phonograph will continue to repeat the location of the fire until it is shut off.

Mt. Blanc Observatory is connected with the Grands-Mulets by telegraph wires and the naked wires are permitted to lie directly upon the surface of the glacier without any support or insulation. The wires are the regular French government standard, of galvanized iron, and no insulation was used even where they came in contact with the rocks. The results of many tests show that the insulation was almost perfect. The results of these experiments while, perhaps, limited in application, says The Engineering Magazine, may be of much importance in mountain exploration work.

A machine has been provided for automatically cleaning shoes. The foot is inserted into a properly arranged opening and the railing of the machine is firmly grasped. A small motor actuate rotary brushes that removes the mud. The foot is next placed in the blacking arrangement proper, which acts as the dauber and the third set of brushes is devoted to polishing. One shoe having been sufficiently polished the other foot is then inserted in the first aperture, etc. A needle on a machine indicates the various stages in the operation. The only precaution to be observed is to turn up the bottom of the trousers sufficiently so that they will not be caught in the rotating brushes.

Archæological News.

Lanciani has shown that a law was passed in Rome at the time of the Cæsars restricting the height of the fronts of buildings to 60 feet. Augustus, Trajan and Nero regulated the heights of buildings. Augustus fixed the height at 70 feet, Trajan at 60 feet and Nero at the same height.

An appeal has been made to archæologists and others, who are interested in Christian antiquities to subscribe toward the further exploration of the Catacombs. The Commissioner of Sacred Archæology has been performing an excellent work in continuing the excavations where De Rossi ended the work. The present Pope, Leo XIII., has aided the work generously, but the means at the disposal of the commission are still inadequate. Of the forty-five cemeteries, only about five are at present accessible to the visitor to Rome.

Experts of acknowledged reputation have been engaged by the University of California to make explorations and excavations in parts of the world which are rich with relics of ancient learning. The entire expenses will be borne by Mrs. Phœbe A. Hearst. The material collected by the archæologists will be placed in the archæological museum which will be established at Berkeley. Dr. George A. Rosiner will have charge of the explorations in Egypt. Dr. Uhle will pursue investigations in South America, Yucatan, California, and New Mexico. New Mexico will be searched for specimens by Dr. Philip Mills Jones. Dr. Alfred Emerson, recently professor in the School of Archæology at Athens, will work in Greece and Etruria.

Among the objects found by Schliemann at Troy and Mycenæ are a number of amber trinkets. As amber is derived from the shores of the Baltic the question arises whether the trinkets were made of true amber or of fossil copal of African origin brought to Troy by the Egyptians and Phœnicians. They have been found, however, to be true amber by a simple test based on the fact that amber contains sulphur, whereas copal does not. A small particle is placed in a test tube and heated until the fumes are given off, and allowing the fumes to come into contact with a piece of moistened lead acetate test paper, the characteristic black color will be given if the specimen is amber, but with copal no such color will be obtained.

Roman Christian monuments of historical interest are now receiving a fair share of attention, both from public institutions and private individuals. Prof. Lanciani has recently given an interesting account of some of the recent discoveries relating to Christian Rome. There has been a Roman house discovered under the church of St. Cecilia; Santa Maria in Cosmedin has been reopened and has been restored in a scientific archæological sense, and the same process will be followed in connection with the churches of St. Maria in Araceli and S. Saba. The underground church of SS. Petronilla, Nereus and Achilles was restored and was inaugurated on May 14 last. The columns of the Narthex have been set up again on their bases, the enclosure of Schola Cantorum restored, the tombstones set in the pavements have been made visible again, and the walls of the aisles turned into a local epigraphic museum.

A large well, with its mouth sharply cut in the Etruscan manner, has been discovered in connection with the Forum excavations. Five of the broken columns of the Æmilian Basilica are being pieced together, and the opinion now gains among serious students that when Pliny wrote "Phrygian" he intended the marble nowadays called "Africano." Not a single chip of Phrygian marble has been found during the excavations on this site, while the other precious marble has literally abounded, and here are columns of it belonging to the inner naves of the building. This is rather a blow to those who have theorized, says The Builders' Journal, that the columns of former Basilica of S. Paolo outside the walls had been taken from the Æmilian Basilica in the Forum. The fact is that the columns destroyed in that church in 1823 by fire were of a dimension far larger than even those of the outer porticoes of this pagan Basilica.

An interesting discovery has recently be made by M. George Seure, of the French Archæological School at Athens, in the shape of a Thracian triumphal car of the later Roman period, or about the fourth century A. D. It was excavated in the tumulus at the foot of Rhodopes, near the village of Pastousha, situated southwest of Philippolis. Here were probably buried the servants and belongings of some great general who evidently fell in some battle nearby. All the metallic fittings of the chariot, with small bronze figures as decorations, and the harness for one horse, were found, together with human skulls and several semi-decayed swords and lances. The whole has been put together, and the complete chariot is now on exhibition. The Bulgarian government has been greatly pleased by the archæological researches in the country and Prince Ferdinand has contributed 10,000 francs from his private purse and the Bulgarian government has added \$5,000 more to help along the work.