gles) of a triangle are given, the other three are thereby implicitly and definitely determined and can be found by computation. Now we have three such parts given in the triangle *PZO*. The first is the side *PZ*, the complement of the latitude of the place where the shadow is cast. The second is the angle *PZO*, the sun's north azimuth, the supplement of its south azimuth *OZS* or *HAS* or *BAD*. This latter angle *BAD* is determined in the right plane triangle *BAD* by the sides *BD* and *AD* (or *CB*), the distances which the shadow falls east [or west] and north [or south]. And finally the third part is the side *ZO*, the complement of *OH*, or of the angle *OAH* or *OAB* the sun's altitude, this latter angle being found in the right plane triangle *OAB* by the sides *OB* and *AB*. Hence a measurement of the position of a shadow with respect to the object that casts it, that is, of the distances *BD*, east or west, *BC*, north or south, and *BO*, downward, or of its three space co-ordinates, as a mathematician would name them, will furnish us with all the data necessary and will determine the day of the year no less than the time of the day when the shadow occupied that particular position. It is evident that the object casting the shadow need not be a vertical rod, nor that the shadow should fall upon a horizontal plane. All we need absolutely is the direction in space of the line joining the shadow and the object, that is, technically, its altitude and azimuth, these data being best determined in practice by means of the three space co-ordinates, measured by a plumbline, level, compass, tape line, or similar instruments.

We come now to the second and practical part of the problem, the actual measurement of the three co-ordinates, *BD*, *BC*, and *BO*. And here we are at once confronted by two difficulties. The first and greatest of these lies in the identification, or rather in the determination of the exact location of the shadow of a known point upon a photograph. In our reproduction of the photograph of the Creighton Observatory it will be seen that the stone coping on the west side of the meridian slit in the transit room casts its shadow very conspicuously on the window casing. The shadow falls exactly upon the middle of the flat western side of the casing and on a level with the mortar line between the tenth and eleventh bricks below the coping stone. This casing is in reality two and a half inches wide, but upon the original photograph it is only 12 thousandths of an inch. An error of one thousandth of an inch in the localization of the shadow upon the photograph would make the result uncertain by a day. The second difficulty is a minor one, and lies in the practical measurement of the three co-ordinates. This measurement is, of course, executed upon the object itself from the information obtained from the photograph. It was found that the shadow fell 31.35 inches downward, 27.70 inches eastward, and 12.25 inches northward. These data coupled with the latitude of the place, 41 deg. 16 min. 6 sec., tell us by computation that the sun's declination was 15 deg. 15 min. north and the hour angle 41 deg. 12 min. or 2 hours 45 minutes afternoon, local apparent solar time. Reference to any large and good celestial or terrestrial globe, to the Nautical Almanac, or to similar sources, shows that the sun has the declination +15 deg. 15 min. on May 2 and August 11, that is on two dates, at one of which the sun is going north and at the other going south. In order to determine which of these two dates is the correct one, we must resort to evidence other than that furnished by shadows. In our case we see upon a close examination of the original photograph, that the condition of the grass in the foreground and of the trees in the background is such as to point unmistakably to the earlier date, that is, to May 2. Now, as the sun is 3 minutes fast on May 2, and as Omaha clocks are set 24 minutes fast in order to show central time, this gives us May 2, 3.06 P. M., central standard time, as the date and time when the photograph was taken.

In order to confirm our result, let us turn to Fig. 3, which represents a part of the window casing drawn to actual size, two and a half inches wide. The line *AB* is on a level with the mortar line between the tenth and eleventh bricks, and *DE* and *FG* are on a level with the next mortar lines above and below *AB*.

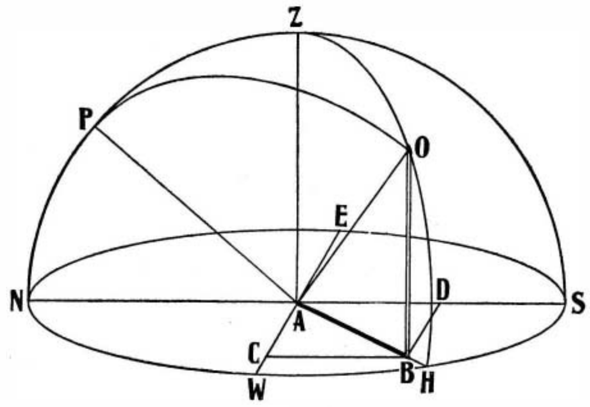


Fig. 2.

C is the location of the shadow, as shown on the photograph. The long oblique line passing through *C* shows the path of the shadow on the casing on May 2 and August 11, and the position of the shadow at intervals of one minute before and after its passage through the critical point *C*. The other two long oblique lines show the path of the shadow five days before and after, and the short lines show it for every day. After making due allowance for the practical difficulties of the problem, is it claiming too much to assert that in this case the date is correct within two or three days, and the time within as many minutes? If the shadow had fallen as many feet as it did inches away from its object, would not the very day and the minute be fixed? I dare say, however, that in spite of all this evidence most of my readers would rely more upon the word of the photographer or upon actual observation than upon all the mathematics in the world. To quiet their apprehensions, let me say that on last May 2 (1904) at 3.06 P. M., central time, the shadow was at the place assigned as accurately as anybody could desire. I will also add that I had finished the computation, and proposed the problem to my students two months before.

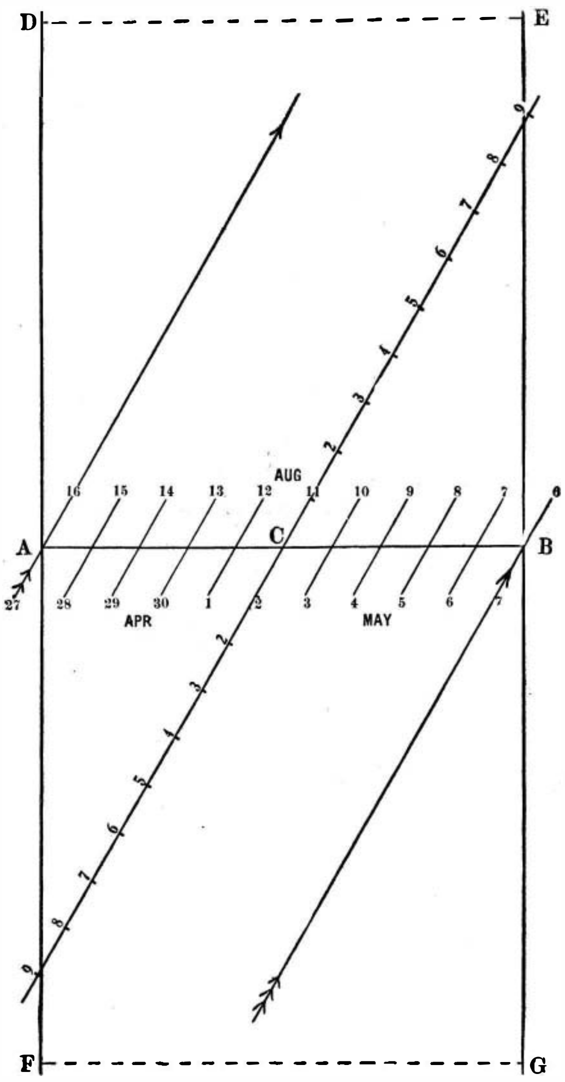


Fig. 3.

"Oh! but you are forgetting a most essential item, the year!" the reader may exclaim.

A half-tone of this photograph of the Observatory appeared in the Creighton University catalogue in June, 1894, hence it must have been taken at the latest in May of that year. As it was evidently taken in the sunlight, perhaps the weather conditions may decide the year. The cumulus clouds in the sky, the northwest wind indicated by the weather vane, and the transparency of the air, which on the original photograph allows trees about three miles away and bluffs about six miles away to be seen with great distinctness, show that there must have been a rain a short time before to clear the atmosphere, the wind must have continued to blow from the northwest for many hours, and the barometer must have been high. Prof. L. A. Welsh, our local weather forecaster, has very kindly examined his records and they, together with those kept at our Observatory, prove beyond the possibility of a doubt that May 2, 1893, is the day we are looking for. Not only do the weather conditions shown on the photograph apply to that date in all their completeness, but they also single it out most emphatically from the preceding and following days of that year. And more than that, they also determine the year, because they cannot be made to apply to May 2 or contiguous days in 1894, 1892, 1891, and 1890, and further back than that I need not go for reasons that would not interest the reader.

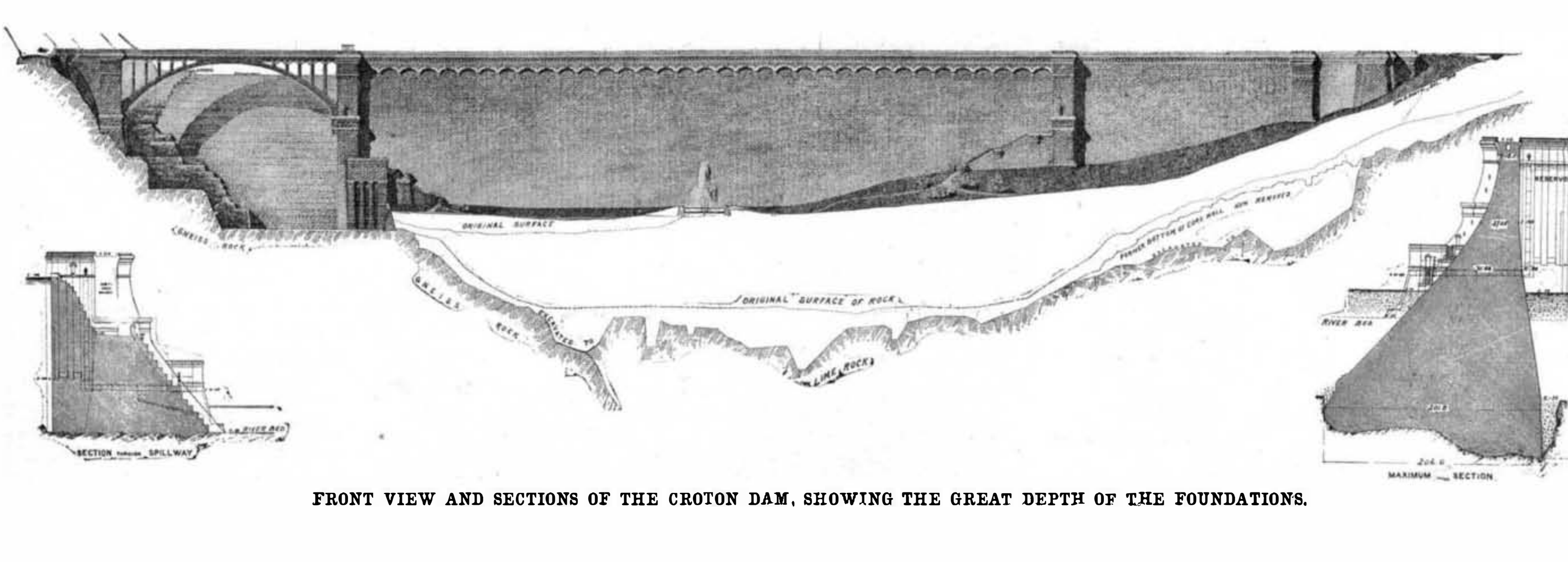
If, therefore, I am asked when this photograph of the Creighton University Observatory was taken, I can answer with an assurance and an accuracy superior to that of the photographer himself if he could now be found and interrogated: Tuesday, May 2, 1893, at 3.06 P. M.

Creighton University Observatory, Omaha, Neb.

COMPLETING THE NEW CROTON DAM.

For the first time in all the many years that it has been under construction, work at the great Croton dam is proceeding with positive energy. The activity is due to a desire to finish the gap in the southern end of the dam, where recent alterations in the plans have seriously delayed the work. In explanation of the delay it will be well to briefly recite the facts.

As originally designed, the Croton dam was to have consisted of a solid masonry structure for about two-thirds of its length and of an earth dam with a center core wall for the remaining third. This core wall was to consist merely of a thin masonry diaphragm impervious to the water, which was intended to seal the earth dam against the passage of any water. The substitution of earth for masonry was made by the then chief engineer, chiefly from considerations of economy. On the accession of the late chief engineer, Mr. Hill, to office, he at once condemned the composite nature of the structure, and recommended that the masonry work should be carried continuously across the valley, providing a homogeneous structure. In support of this recommendation he pointed out that there were strong engineering reasons against the use of the earth and core wall construction, especially in connection with an all-masonry structure. After a board of experts had indorsed his criticisms, the core wall as far as it had been built was taken down, and it was then discovered that the bottom on which it rested was of a treacherous and more or less friable material, which in the presence of water seemed to lose its consistency entirely. Accordingly it was decided to carry down the excavation until absolutely sound rock was reached.


FRONT VIEW AND SECTIONS OF THE CROTON DAM, SHOWING THE GREAT DEPTH OF THE FOUNDATIONS.

The accompanying engraving shows the great dam as it will appear when completed, if viewed from down stream. The length of the dam proper from the right abutment to the commencement of the spillway is 1,168 feet. This portion as now being constructed will be one continuous solid wall of first-class masonry laid up in cement, and everywhere carried down to solid rock. The illustration referred to shows the actual depth to which this excavation had to be carried. It will be noticed that on the left side of the valley the engineers encountered a solid and very satisfactory gneiss rock, which extends for more than a third of the distance across the valley. Then the sub-stratum consists of a lime rock not so satisfactory as the gneiss, but still sufficiently stable for a good foundation when excavated to the great depths shown in our engraving. The deep places in the foundation are due to the discovery of pockets of rotten rock which had to be excavated. The lowest point of foundation is 131 feet below the bed of the river. The top of the dam is 166 feet above the bed of the river, thus giving a total height of the masonry from foundation to crest of 297 feet. At the top the wall has a thickness of 18 feet, and it increases in thickness proportionately to the hydraulic thrust against it. This increase extends not merely to the bed of the river or bottom of the reservoir, but more than as far again below it, until the foundation is reached. Since the overlying material between the bottom of the reservoir and the bottom of the foundation will be saturated with water, the masonry dam has to be treated as though it had a head of water against it for practically its whole height of nearly 300 feet. Consequently, to secure sufficient weight and stability, the width of the dam at the lowest point is over 200 feet.

The section shown is continued throughout the full length of the dam until the spillway is reached. Here the masonry curves around to the right, parallel with the hillside, and extends for nearly a thousand feet up the valley, the total length of the spillway including the curve being an even thousand feet, and the total length of the dam and spillway together being 2,168 feet. As it is the intention to carry a carriage drive across the crest of the dam, an arch of steel or masonry (probably the latter) will be thrown across the spillway as shown in our illustration. At the junction of the spillway and dam is a gate-house; and on the down-stream side of the dam, in connection with this gate-house, a projecting column of masonry has been thrown out, within which is a stone stairway leading up to the crest of the dam. A clever use has been made of the break in the dam where the old earthen dam was to have commenced, by throwing out a column of masonry of the same design as that at the spillway, with an inside stairway leading to the crest of the dam. The architectural effect thus produced is harmonious and decidedly pleasing.

One of our photographic illustrations shows the method by which contractors are building the 300 feet of structure which has taken the place of the projected earth dam. Two steel working platforms have been erected, the foundations being placed right in the body of the masonry. At each corner of the platform is a steam derrick, the two platforms together thus providing eight derricks in addition to the large number which are erected outside the line of the dam. By this means the whole work is completely covered, and the material is handled to excellent advantage. As the masonry rises, the steelwork of the platforms is built into it and serves in a certain degree to tie it together. The rock, in masses which weigh many of them over five tons, is brought from granite quarries situated a short distance up the Croton valley. It is drawn alongside the dam in cars, from which it is picked up by the derricks and dropped into place. A new method of building the masonry has been adopted, which not only conduces to great speed of erection, but also provides a more solid monolithic mass, with less possibility of voids occurring in the body of it. The outside courses of masonry are first laid up, and transverse walls run across between these, thus forming pockets that may be from 12 to 20 feet square and from 3 to 5 feet in depth. A mass of cement is then poured into the pockets thus formed, through wrought-iron pipe chutes, that lead down from the cement mixers on the adjoining hillside. When the pocket is filled to the desired height with cement, the big rocks are picked up by the cranes and let drop from a considerable height into the liquid concrete and cement bed. The impact thus secured forces the cement with a crowding effect into all the interstices of the adjoining masonry. The swarm of Italian workmen are meanwhile throwing smaller rocks, that can be handled by hand, in around the bigger stones, and the speed with which the work progresses must be seen to be appreciated.

An important detail attending the completion of the dam is the reconstruction of the old aqueduct, which leads along the hillside over 30 feet below the high-water level of the new dam. It is necessary to strengthen the roof of the aqueduct, to enable it to withstand the water pressure resulting from the filling of the new dam, for the aqueduct will be covered with about 30 feet of water when the new dam is full. This is done by throwing over the aqueduct a thick concrete roof, which extends well down the sides and provides an absolute safeguard against crushing in of the structure.

The construction of the roads which will surround the Croton dam has been quite an extensive work in itself. It has necessitated the building of some very fine bridges, some of which we hope to illustrate in a future issue. The work of stripping the surface of the ground below the water line of the new dam has been pretty nearly completed, and it is now possible to look up the valley, and determine by the brush and timber line where this high-water line will extend. It is the hope of the Commission to commence to back up the water in the dam by the first of next year. Before that is done it will be necessary to close two tunnels through the masonry of the dam, one of which exists for the passage of work trains, and the other for the outflow of the Croton River. The work-train tunnel will first be blocked in, after which two 4-foot pipes provided with gates will be inserted in the tunnel through which the Croton River is now flowing. When everything is ready the gates in these two pipes will be shut down, and the work of filling the great reservoir will have fairly commenced. When we remember that the average daily consumption of water from the Croton watershed by New York city is nearly three hundred million gallons, and that the flow of the Croton River during a dry season may fall to between four and five hundred million gallons per day, it can be seen that it will be a long while before the water reaches the crest of the dam, if indeed it ever does so. Of course, the prevalence of heavy rain storms, or a thoroughly wet season, would expedite the filling of the dam.

Although it is hoped to close the dam by the beginning of 1905, it will not be for some months after that the whole work will be completed and everything put in its final shape.

Success of Governmental Enterprise in Italy Against the Spread of Malaria.

Italian scientists having proved that malaria is transmitted from infected districts by the mosquito, caused the Italian government to adopt measures of protection against its extension to government agents and officials required to reside in malarial districts.

In the "Nuovo Antologia" of Rome of recent date, is a comment on the remarkable decrease in the expenses of installation and maintenance of the means taken to diminish the causes of malaria in infected districts where customs officials are located. This reduction, however, does not impair the thoroughness with which the work is maintained.

The protection is purely mechanical, and could not have been more efficient or successful. The account goes on to say: "In the ninety localities thus protected for the first time in 1902 (the only year of which we have any complete data) there have been but one hundred and forty-two cases of the fever against six hundred and forty-two the previous year; the reduction, as we see, was nearly from five to one, and in some districts, as for example in those of Orbetello and of Terranovia in Sicily, where the cases of fever had been respectively twenty-nine and twenty-four in 1901, these had disappeared altogether when the protective measures were applied in 1902. In the twenty localities that had already been protected in 1901, the difference in the number of cases of malaria which came to light in 1900, when the defensive measures had not yet been adopted, and those which occurred in 1902 was still greater, when they dropped from two hundred and seven to twenty-five."

In the year 1902-3 the means of protection (small gauze nets, masks with veils, and gloves) were made applicable to one hundred and nineteen other localities, and this extension of the humanitarian means continues, and will continue to be applied to all the barracks and customs inspectors situated in the infected districts, to co-operate—as has just been said of the general directorate of customs—"to the supreme end of protecting against the ravages of this dread disease so many young and youthful existences."

But the most important results yet obtained have been from the anti-malarial measures adopted by the prison officials in charge of the prisoners condemned to spend their lives and energies in the salt works of Corneto, where the infection was so general and so grave indeed as to be declared invincible. Here among the confirmed criminals assigned to the labors of preparing and collecting the salt, the sufferers from malaria had amounted to three hundred and ninety-five in 1900; by 1903 these were reduced to a single one.

We desire to call the public attention to this, because it treats of works and facts that not only confer high distinction upon the Department of Finance, but also redounds indirectly to the honor and praise of the Italian scientists, to whom we are unmistakably indebted for the tireless researches and the grand discoveries that have made such wonderful achievements possible.

Peary and the North Pole.

Robert E. Peary has announced that he will again attempt to reach the North Pole in a specially constructed vessel, in which he will embark next summer. The presentation to Peary of the Paris Geographical Society's gold medal was the occasion of the announcement. M. Cordier, president of the Paris society, made the presentation speech. In responding, the explorer said:

"The contract for my new Arctic ship has been signed and her keel is being laid now. This means that the expedition upon which I have been putting my energies for the past two years is lifted out of the realm of uncertainty, and that if I am alive I shall start north again next summer in another attempt upon the North Pole.

"My vessel will, I believe, be the ablest ship that ever pointed her nose inside the Arctic or Antarctic circle. She will possess such shape as will enable her to rise to the pressure of the ice floes and escape destruction. She will possess such strength of construction as will permit her to stand this pressure without injury. She will possess such features of bow as will enable her to smash ice in her path, and will contain such engine power as will enable her to force her way through the ice. In maximum dimensions, viz., length over all, breadth of beam, and draft, etc., this ship will be of the size of the British Antarctic ship "Discovery"; in displacement she will be somewhat less; in power she will compare with our largest ocean-going tugs. She will have engines capable of developing 1,000 indicated horse-power continuously, and 1,500 horse-power for limited periods.

"My route north presents features very different from the route of a ship to the Antarctic regions; the voyage is short and the crux of the whole project is the successful negotiation of the comparatively short distance of ice-encumbered channels extending northward from Cape Sabine to the Polar basin.

"What I require, then, is not a sailing ship with weak auxiliary engines, a ship capable of remaining out for a number of years and covering long distances at slow speed, with moderate consumption of coal. My requirements are a powerful steamer, capable of forcing her way through this comparatively short distance and demanding only a minimum amount of sail power to enable her to creep home in case all her coal is burned—that is what I propose to build.

"My plan of campaign, in a very few words, is to force this ship to the north shores of Grant Land, taking on board at Whale Sound the pick and flower of the Esquimau tribe with whom I have worked and lived so long, to go into winter quarters on that shore, and to start with the earliest returning light on the sledge journey across the central polar pack, utilizing these Esquimaux, the people whose heritage is life and work in that very region, entirely for the rank and file of my party.

"Never before has it been in the power of a white man to command the utmost efforts and fullest resources of this little tribe of people, as I can do; and that fact will be of inestimable advantage to me."

The Current Supplement.

The St. Louis correspondent of the SCIENTIFIC AMERICAN opens the current SUPPLEMENT, No. 1499, with an admirably illustrated account of the Government Building and Post Office exhibit at the World's Fair. Historically, the exhibit is full of interest. It shows how the mails are handled and the various methods adopted in transporting mails in such remote regions as Alaska. Prof. F. B. Crocker and Mr. M. Arendt write instructively on electro-chemical industries. "Substances Liable to Decomposition by Light" is a subject discussed by F. A. Upsher Smith. Emile Guarini presents an account of a new system for the protection of trains by an audible signal in the train cab. The system is certainly ingenious, and has been tested with some success in Europe. Prof. A. Rateau, one of the great authorities on turbine engines, suggests methods of using steam turbines for current purposes. Of archæological interest is an article by Harlan I. Smith on shell heaps of the Lower Fraser River of British Columbia.

In a recent experimental investigation by Dr. T. Wulf, published in the Zeitschrift für physikalische Chemie, it is shown that the electromotive force at which hydrogen ions are liberated from solution, when determined galvanometrically, is quite independent of the pressure when this is varied between 0.01 and 800 atmospheres. On the other hand, the polarization of the hydrogen electrode increases with the pressure, and this increase is in quantitative agreement with Helmholtz's formula. The experiments show that the passage of a current through the solution is not necessarily accompanied by the liberation of the gas in the form of bubbles.

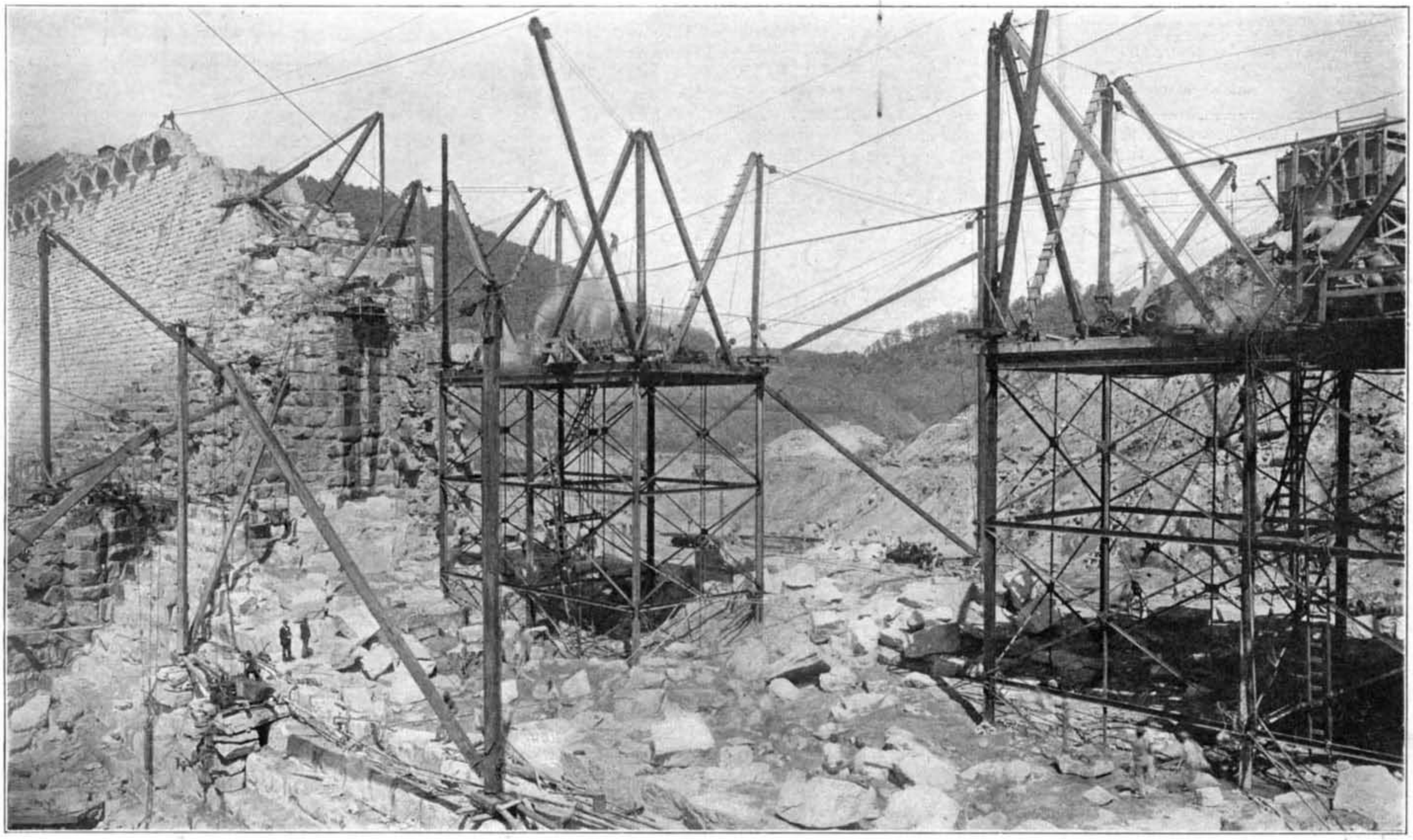
SCIENTIFIC AMERICAN

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

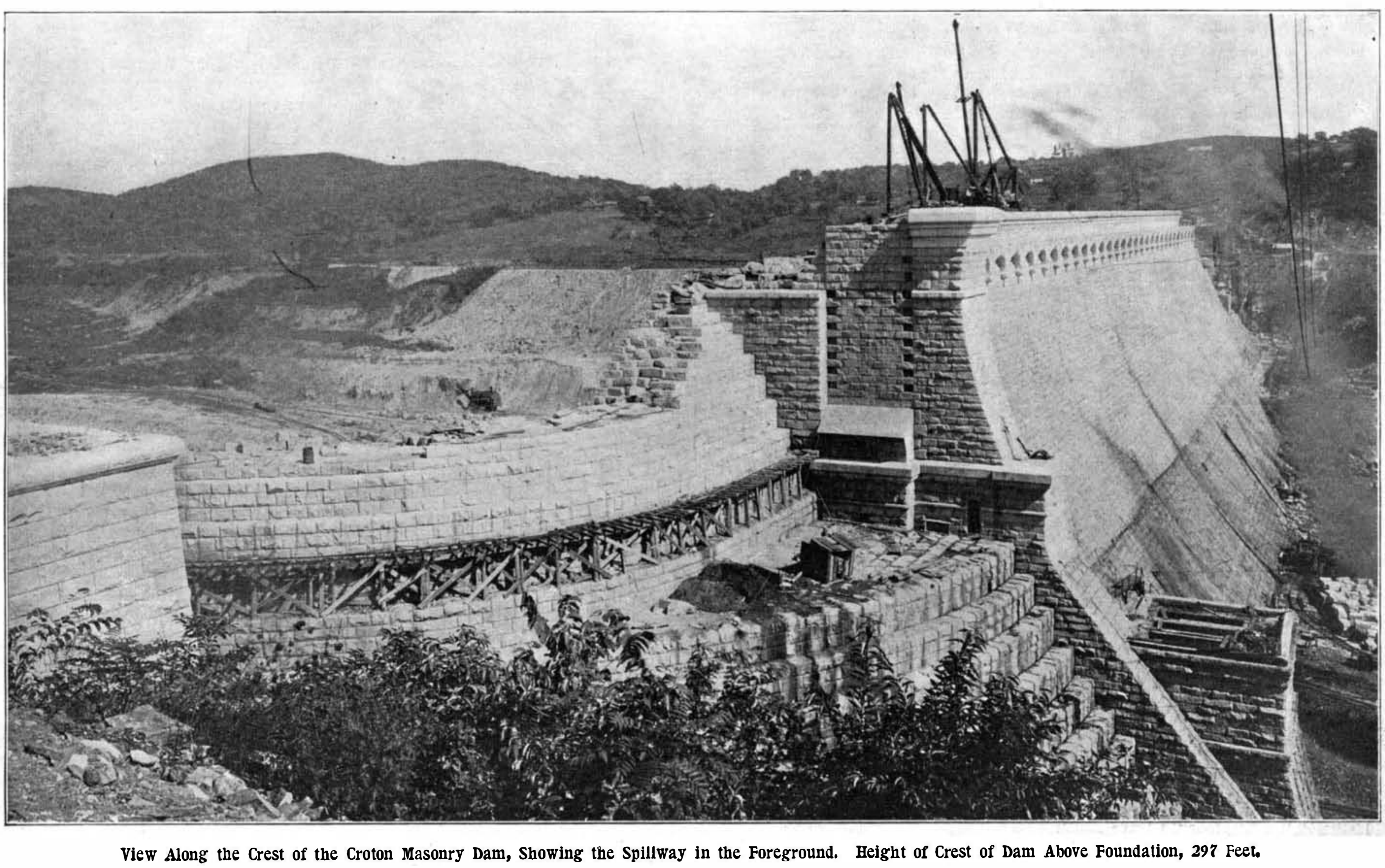
Vol. XCI.—No. 13.
ESTABLISHED 1845.

NEW YORK, SEPTEMBER 24, 1904.

[8 CENTS A COPY
$3.00 A YEAR.]



The portion of the dam here shown was originally to have been built of earth with a central core-wall. It is now for greater safety being built of masonry. The steel erecting towers are being built into the structure as it rises in height.



View Along the Crest of the Croton Masonry Dam, Showing the Spillway in the Foreground. Height of Crest of Dam Above Foundation, 297 Feet.

COMPLETING THE GREAT MASONRY DAM OF THE NEW CROTON RESERVOIR.—[See page 214.]