exploding a half stick of dynamite; a handful of powder is then exploded in the pocket thus formed. This starts a horizontal crack or cleavage across the greater diameter. The charges of powder are now increased in size, and are exploded in the cavity, the drill hole being plugged at every blast to confine the gases and cause constant force upon the stone, until the crack has extended 75 or 100 feet in all directions from the lift hole. A pipe is then cemented into the hole, and connected with the air pipe line of the air compressor by means of a globe valve, and is used gradually to admit compressed air at between 70 and 80 pounds pressure until the crack or cleavage extends until it becomes visible in a thin edge out on the hillside.

Sheets of several acres and of any required thickness can be so "lifted," thus affording a bed plane to which quarrymen can work, drilling and splitting the stone into proper sizes for the purposes required.

It can readily be seen that a great deal of time, labor, and expense are saved by this unique process.

THE HEAVENS IN NOVEMBER.

BY HENRY NORRIS RUSSELL, PH.D.

Morehouse's comet, which at the time of writing is visible with the naked eye, and conspicuous in a field-glass, will continue in sight throughout November, though diminishing somewhat in brightness as it recedes from us. Its apparent path is almost directly southward, through Lyra and Aquila. On October 25 it is close to the star γ Lyræ, on November 7 near ζ Aquilæ, and on November 30 near λ Aquilæ. These three stars are shown on our map, and with their aid it will be easy to find the comet.

At present it shows a nebulous head, without any well-defined nucleus, and a long, nearly straight tail, brighter in comparison with the head than is usually the case. At least this was its telescopic appearance two nights ago. Last night (October 15) the tail was conspicuously distorted and bent. Whether this remarkable change is due to some change in the emission of the fine particles of which the tail is composed, or to interference with their motion after leaving the head, or some such thing as collision with a swarm of meteors, no one can say yet.

It is to be hoped that many photographs of the comet will be obtained at this interesting time, for their study may help us to explain these strange phenomena.

The comet is still approaching the sun, and if it follows the usual behavior of such objects, we may expect that its tail will increase in length and brightness. It will be well worth the careful study of both the amateur and professional astronomer as long as it remains visible in our skies.

By the end of December it will be apparently very near the sun. Indeed, it will very nearly pass behind it about January 1, and after that date it will be visible only in the southern hemisphere, where it will probably be observable for some time.

THE HEAVENS.

The great square of Pegasus, whose acquaintance we made last month, is now almost overhead. Its western side points downward toward the bright star Fomalhaut, far below, near the southern horizon. On the way we pass by Aquarius, west of which is Capricornus, with its pretty double star α. The eastern side of the square, carried down, but not so far, points out the planet Saturn, which is in Pisces only a few degrees from the vernal equinox, the point from which the right ascensions of all the stars in the sky are measured.

Below Saturn, about as far again, in the same line, is an isolated star of the second magnitude, β Ceti. The rest of the constellation to which it belongs may be identified upon the map. The variable Mira has now passed maximum, but is still visible to the naked eye, though fading steadily. In the east the forerunners of the winter constellations are in sight. Taurus is pretty well up. The cluster of the Pleiades, and the more extensive group of the Hyades, which includes the bright star Aldebaran and the V-shaped group near it, once identified, cannot be mistaken.

To the left of Taurus is Auriga, with the very bright yellow star Capella. Below these Orion and Gemini are rising, and above them are Perseus and Aries. Andromeda is still higher, and the great nebula (shown on the map) is almost exactly overhead—not the most convenient place for observation, though theoretically the best.

Cassiopeia and Cepheus are between the pole and the zenith. Ursa Minor and Draco are below the pole on the left, and the Great Dipper lies close along the northern horizon.

In the west Cygnus is high up, with Lyra below it, and Hercules setting in the northwest. Farther south is Aquila, with the small groups of Delphinus and Sagitta above it. This is at present the most interesting region of the sky, for it is here that we may look for the comet—as already described.

THE PLANETS.

Mercury is morning star in Virgo and is well placed for observation around the time of his greatest elongation on the 13th. At this time he rises about 5 A. M. and is well clear of the horizon before dawn. The bright star Spica is about 10 deg. west of the planet, and rises forty minutes earlier; but Mercury is much the brighter of the two, and may be distinguished by this, as well as by his position.

Venus is also a morning star, and in Virgo, but rises earlier, not far from 3:30 A. M. She is now more than 100 million miles from the earth, but is still brighter than anything else in the sky.

Mars is likewise a morning star and is not far from Venus. She is moving eastward faster than he, and on the 30th she overtakes him, and passes north of him, distant little more than one degree.

Jupiter is in the morning sky too, but rises earlier than the others—about 1 A. M. in the middle of the month.

Saturn alone of the conspicuous planets appears in the evening sky. He is in Aquarius, and comes to the meridian about 9:30 P. M. on the 1st and 7:30 on the 30th.

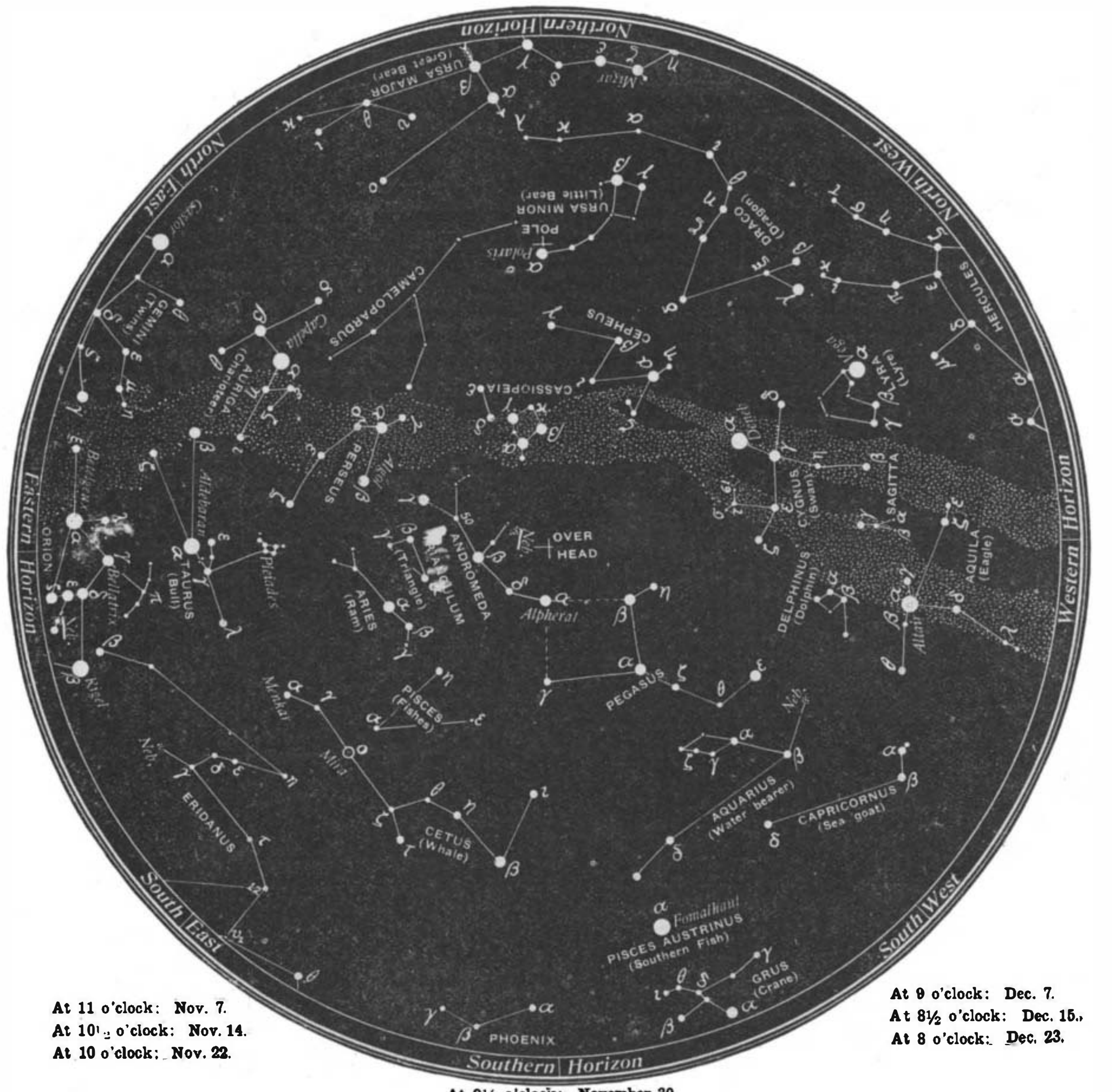
Uranus is in Sagittarius, too far south and too near the sun to be observed, though technically he would be called an "evening star." Neptune, which is in Gemini, comes to the meridian about 3 A. M. and may be observed in the morning.

THE MOON.

First quarter occurs at 9 A. M. on the 1st, full moon at 3 A. M. on the 8th, last quarter at 7 P. M. on the 15th, new moon at 5 P. M. on the 23d, and first quarter again at 5 P. M. on the 30th. The moon is nearest us on the 4th and farthest off on the 16th. She is in conjunction with Saturn on the 4th, Neptune on the 12th, Jupiter on the 17th, Venus and Mars on the 20th, Mercury on the 22d, and Uranus on the 26th.

It may be added that the Leonid meteor shower is due as usual on the mornings of November 15 or thereabout. But there is no reason to expect much of a display this year, so it will not be worth sitting up to see.

Princeton University Observatory.



At 11 o'clock: Nov. 7.
At 10½ o'clock: Nov. 14.
At 10 o'clock: Nov. 22.
At 9½ o'clock: November 30.
At 9 o'clock: Dec. 7.
At 8½ o'clock: Dec. 15.
At 8 o'clock: Dec. 23.

NIGHT SKY: OCTOBER AND NOVEMBER

THE YUMA IRRIGATION DAM.

BY DAY ALLEN WILLEY.

Within the next year, one of the most notable projects connected with the reclamation of arid lands in the Southwest will probably be entirely completed. While the work includes the storage of water on a large scale, and its distribution by means of irrigating canals, the extraordinary difficulties encountered by the engineers in building the necessary dam and in restraining the rivers in the vicinity, have made the undertaking unique among the irrigation enterprises.

In a recent issue, a feature of the Yuma project as it is termed was described in the extensive levee work required to confine the channels of the Gila and the Colorado rivers during high water, to prevent the reservoirs and canals from overflowing during floods, also to check the movement of sediment carried in such enormous quantities when the streams are at high-water mark. The formation of the embankments by means of abatis made from young trees and brushwood holding the earth embankments, also the jetty system for retarding the flow of the water, were detailed and illustrated. Another problem necessary to be solved, however, was how to create a permanent reservoir of sufficient size for irrigation purposes, strong enough to resist flood action, and so constructed that it would not be shallowed or filled with the sediment. The great variation of the volume of water in the Colorado and the depth of the mud and other detritus on its bottom above rock strata added to the difficulty. A dam across the river was essential, but the question was how to build it so that it would not be washed out, or at least partly demolished. Could it be erected on a solid foundation, and could its ends be securely anchored in the formation on either side?

Preliminary surveys for the general project were made early in 1904. Several different locations were also examined to determine the best place for this structure, and a search was made for bedrock with diamond-core drilling machinery, at all possible dam sites between Yuma and Picacho. As a result of these explorations, the Laguna weir site was selected as the most desirable one for the construction of a weir to serve the lands near Yuma, a high dam and high-line canal being considered impossible. The type of weir selected is one that has been tried during the last fifty years at numerous places in India and Egypt under similar conditions, three dams having been constructed on the Nile River within the past fifteen years, on practically this same plan, all having served their purpose efficiently and being in operation today. This type of weir consists of a loose rock structure with a paving of stones 1½ feet in thickness on the downstream slope, the structure being tied together with three parallel walls of steel and concrete run longitudinally between the granite abutments on the two sides of the river, the entire structure being further made secure by an apron of loose rock pitching 10 feet in thickness and 50 feet in width at the lower toe of the dam below the sloping pavement. The

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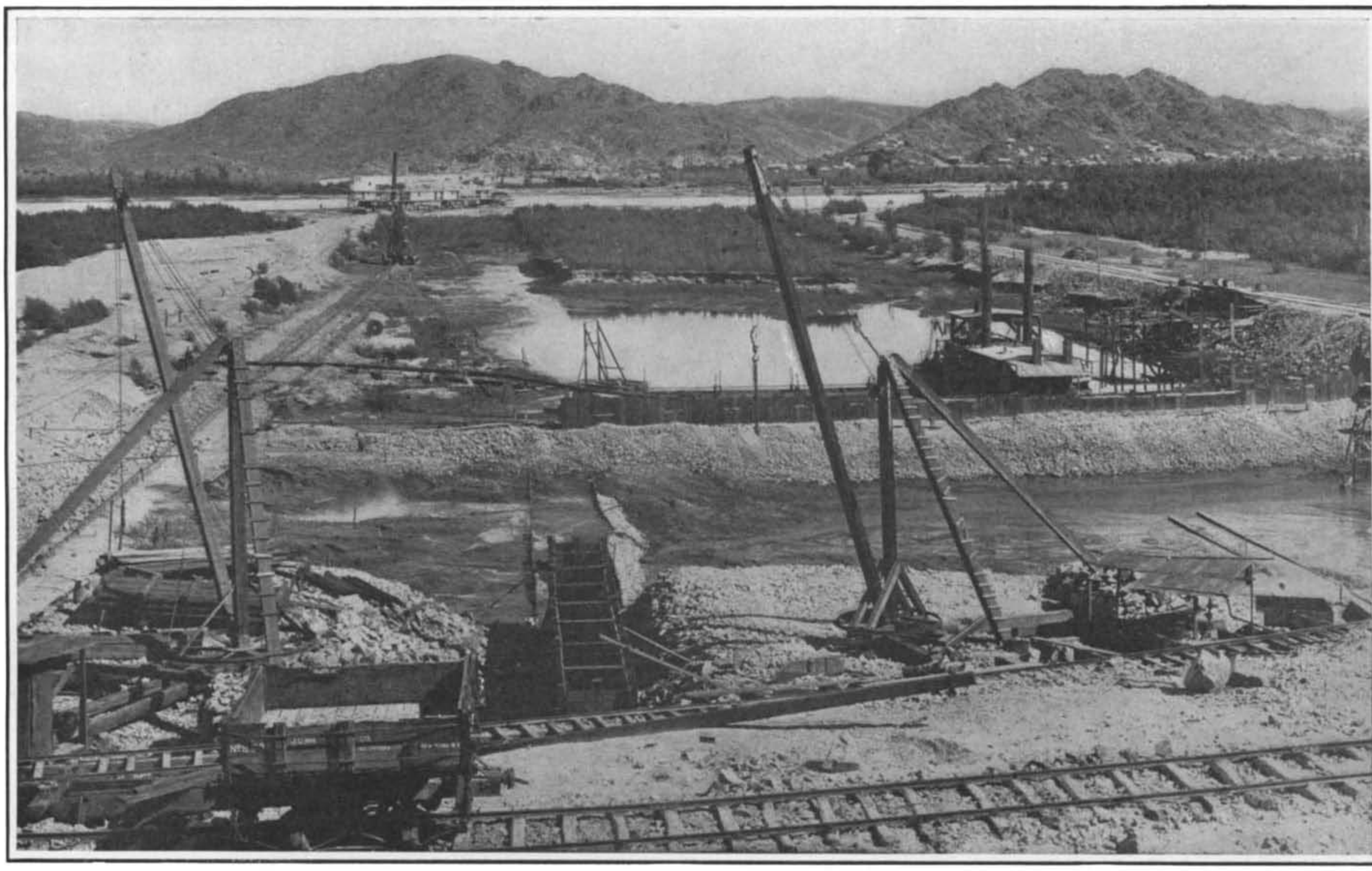
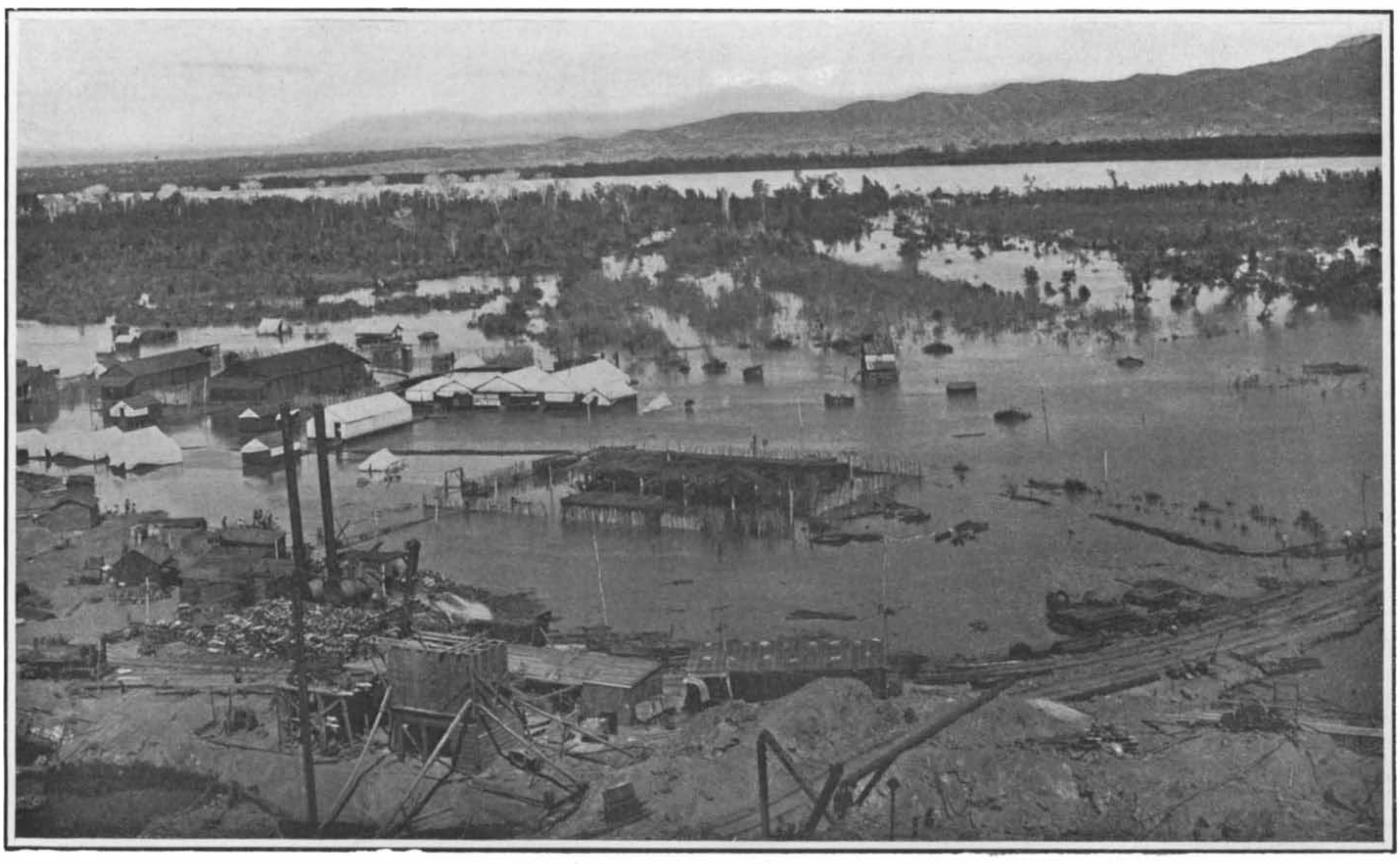


Filling in the adjacent lowlands at dam. Note tree growth to break force of current.



View below the dam, showing the river in flood.

THE YUMA IRRIGATION DAM.—[See page 302.]

height of this weir was to be 19 feet above low water, and the slope of the downstream side 12 feet horizontal to 1 foot vertical, with 50-foot apron below. The design called for the upper core wall of concrete to rest upon a row of sheet piling driven into the bed of the river.

The handling of the silt of the Colorado is one of the most difficult features of this undertaking. It is known that its amount is very large. The river is on a grade of approximately one foot to the mile above the Laguna weir site, so that this weir will make a settling basin of relatively quiet water approximately ten miles in length above it. At each end of the weir, and constructed in solid granite rock, is a sluiceway 200 feet wide excavated to the depth of low water in the river. These sluiceways are closed by large gates operated by hydraulic machinery. The diversion canals for irrigation take their water above these gates from the sides of the sluiceways. The area of the sluiceways being so great, the water movement toward the canal is slow, and most of the sediment is deposited. It is estimated that the capacity of the sluice gates will be approximately 20,000 cubic feet per second each. This great volume of water passing through the sluiceways when the gates are open, will carry out with it the sediment deposited above the intake of the canals. The ordinary low-stage flow of the Colorado River is from 3,000 to 4,000 cubic feet per second, so the capacity of each of these sluiceways will be about five times the low-water flow of the river. The figures are given for purposes of comparison only.

As the result of a number of experiments, it has been found that the principal quantity of silt is carried along near the bottom of the river, and that the surface water is relatively free from sediment. It was planned, therefore, to take the water into the canals by a skimming process over a long row of flashboards, so that the entire capacity of the canal can be furnished by drawing but one foot in depth of water from the surface of the river. As a still further precaution, it was decided to construct the first 3,000 feet of canal on each side of the river of such size that the movement of water through it will be slower than one foot per second. These settling basins, as they are called, will be either excavated from granite, or, where the section is in earth, they will be paved. At the lower end of the settling basins, gates were planned to discharge into the river, so that the water could be drawn down to the level of the stream.

The headworks as designed are of rock, concrete, or steel, with the exception of the sheet piling, which is driven entirely below the water level, and so will not decay. Every portion of the weir is of what is known as permanent construction.

The accompanying photographs show the enormous proportions of the Laguna dam and the variety of work required in the preparation of the foundation and later construction. While 4,780 feet, or nearly a mile, in length, its width is especially noticeable, the maximum dimension being no less than 272 feet, although the height as stated is but 19 feet. These proportions are necessary, however, because of the great force of the flood current, and to prevent the water from forcing its way beneath the dam and thus undermining it.

The capacity of the canals at their intakes is 1,200 cubic feet per second on the Arizona side, and 200 cubic feet per second on the California side. The amount of the silt that would be daily delivered into the Arizona canal, if diversion were made directly from the structure, would approximate 17,000 cubic yards of wet mud by volume.

Careful study was made of the existing canals in the vicinity of Yuma and Imperial, to determine the shape that they naturally assume, and the roughness of the bottom and sides, which tends to retard the velocity. Based upon these data, the new canals have been so designed as to carry water at a higher velocity throughout than will be found in the settling basins above their head, and at such velocity as will permit of a minimum loss by seepage and evaporation. The gates and drops of these canals and the Yuma bridges are steel concrete structures. One of the most difficult problems in connection with this project was the crossing of the Gila River. It was considered necessary to make this perfectly safe, and for this purpose a structure was designed that crossed beneath the bed of the river, the top several feet below the lowest point of the stream bed. This structure is of steel and concrete, and some 3,000 feet in length.

The shape of levee adopted was one that has been developed by years of experience along the Mississippi River. It has a slope of three feet horizontal to one foot vertical on the water side, it is eight feet wide on top, and built five feet above the highest water marks of the year 1903. These levees are 4,000 feet apart (one on each side) along the Colorado River, and 3,200 feet apart along the Gila River.

Because the lands are so flat, and the level of the water in the ground so near the surface, it was considered necessary, for their permanent safe irrigation, to supply a drainage system. A main drainage canal has been designed to run through the central portion of the areas to be irrigated, and when possible the natural drainage lines of the country have been utilized, deepening them with a stream dredger to such depth that they will carry off the water returning from irrigation or seeping through the levees during the high-water stage of the river. When lands in any district tend to become alkaline they may be connected, by means of local drainage canals, with this main drain, and in this manner they can be kept free from alkali by holding down the level of the ground water. During the greater portion of the year, when the river is low, this drainage water is discharged into the stream; but when the river is in flood, its elevation is such as to prevent the discharge into it from the drains. A pumping plant has, therefore, been designed to lift the drainage waters from the levees during the flood period of the river to prevent the lands becoming waterlogged.

The total cost of the works will be about $3,000,000, but they will irrigate 100,000 acres all told by means of 26 miles of main canals and 138 miles of laterals. The most interesting feature, however, from an engineering point of view is the successful control of a stream whose volume of water may rise and fall to the extent of thirty feet in a week, flowing through a channel of soft silt which it has been accumulating for centuries.

Dam partly completed. Note top of core wall, and, in right foreground, the stone paving.

THE YUMA IRRIGATION DAM.

Cement from Blast-furnace Slag.

An invention which should have far-reaching effect upon the Portland cement industry, and which incidentally will enable a hitherto useless product to be turned to commercial advantage, has recently been perfected by Mr. Sherard Cowper-Coles, the well-known English electro-metallurgist. This invention consists of the direct production of cement from blast-furnace slag. The latter is taken when still molten as it issues from the furnace, and conducted to an electric furnace, where its temperature is further increased. During this period a predetermined quantity of chalk is added to the slag, and the whole then subjected to electrolysis, which brings about certain reactions producing a Portland cement equal in strength and quality to the best grades obtained by the existing methods, at a very small cost as compared with the generally adopted process and in practically one operation.