mile, and 500 sec.-feet at the 100th mile. The total length will be about 168 miles, and the area to be irrigated will be about 282,000 acres.

The Upper Otay Dam, California.—Next to the Bear Valley dam, which has been the marvel of the engineering world for twenty-four years, and still in service, the slenderest dam in California or any other part of the globe, is undoubtedly the concrete structure erected in 1900, sixteen miles southeast from San Diego, California, in connection with the other storage works of the Southern California Mountain Water Co. Although it has an extreme height of 84 feet, it is but 14 feet thick at the base, 4 feet thick at top, and 350 feet long on the crest. It is curved up-stream with a radius of 359 feet (Fig. 249).

The dam site is in a porphyry rock gorge, on the west fork of the Otay creek, at such an elevation that the full water line of the Lower Otay res-

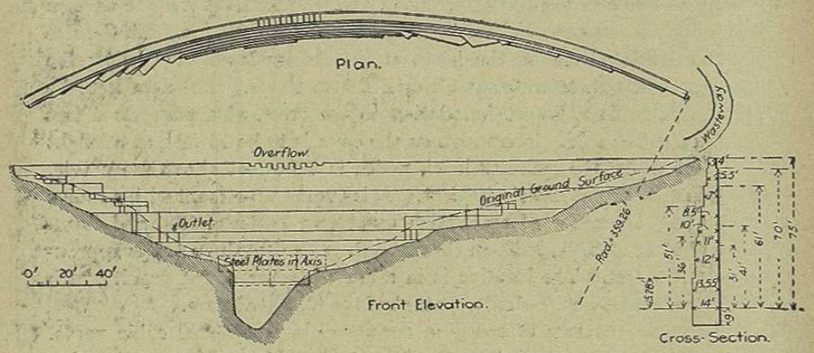


FIG. 249.—UPPER OTAY DAM, CALIFORNIA. PLAN, SECTION, AND ELEVATION.

ervoir will touch the base of the upper dam. The width between solid rock wall at the stream bed is but 20 feet. The dam was started as a masonry structure, and was first built to a height of 34 feet (See Fig. 250).

Beginning on this foundation subsequently two tiers of steel plates, riveted together, and bolted to the masonry, were first erected, extending from side to side of the canyon, reaching to within 40 feet of the top. These were enveloped in concrete on both sides. Above the top of these plates a line of old railway cables, 1¼ inch in diameter, was placed in the center of the concrete wall every two feet in height to the top the entire length of the dam. No other reinforcement was used. The wall was built vertical on the up-stream face, and stepped off on the down-stream side, with seven square offsets of 1 to 1.5 feet at irregular intervals. The reservoir has a storage capacity of nearly 2000 acre-feet, but the watershed area is so small that it is never expected to be filled from its own run-off, and

will be supplied by a conduit from the Barrett dam, on Cottonwood creek.

If the dam should break under full reservoir pressure no very serious consequences could ensue, on account of the large size of the Lower Otay reservoir, into which the water would be discharged. Neither of the reservoirs have ever been filled.

The dam must be regarded as one of the most interesting of modern structures in that line, whose ultimate fate will always be looked upon with curiosity by the profession.

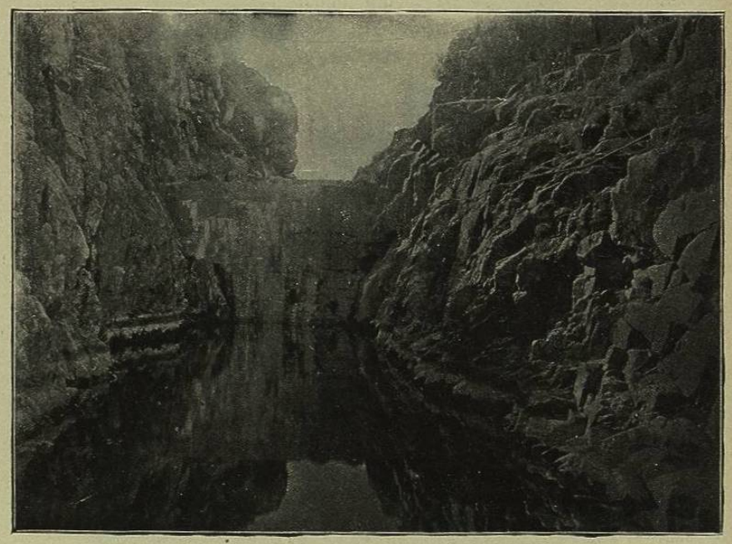


FIG. 250.—UPPER OTAY DAM. FOUNDATION MASONRY.

Fig. 251 is a recent photograph of the dam, for which the writer is indebted to Mr. N. L. Hall, one of the engineering staff of the company. Fig. 252 was taken shortly after the completion of the dam.

The Mariquina Dam, Manila, P. I.—The new water supply of the City of Manila, Philippine Islands, is to be taken from the Mariquina river, about sixteen miles northeast of the city, in connection with which a masonry dam was erected in 1906, in a narrow gorge of the river, creating a reservoir of about 2,000,000,000 gallons capacity (6100 acre-feet). The dam is 400 feet long on the crest, and has a maximum height above the stream bed of about 75 feet. The central portion of the dam for 160 feet is designed as an overpour rollway, the crest of which is 15 feet lower than the re-

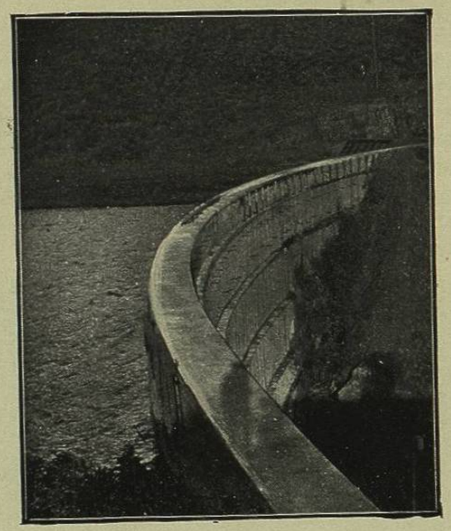


FIG. 251.—UPPER OTAY DAM, IN JANUARY, 1908.

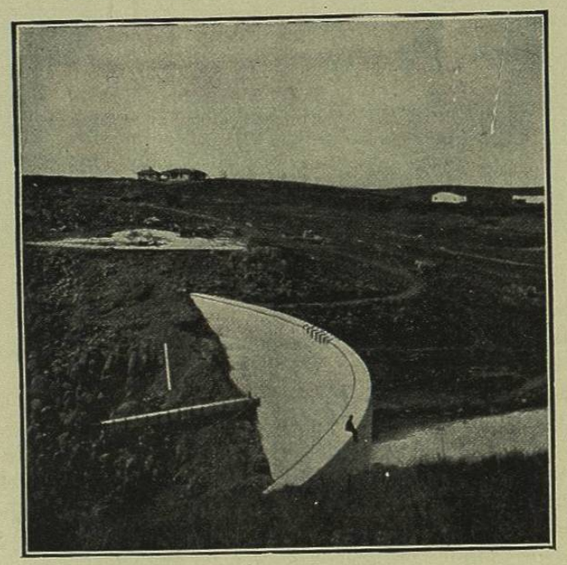


FIG. 252.—UPPER OTAY DAM.

mainder of the dam. The dam is 17 feet wide on the crest. The section (Fig. 253) shows the profile of the structure and its principal dimensions. The dam is founded on solid bedrock, to which it is bonded by stepping and grooving the rock after all unsound and fissured portions had been removed.

The body of the dam is built of rubble concrete masonry containing about 50% of large stones, laid so irregularly as to avoid continuous joints or courses. The stone used is a hard crystalline limestone or marble. The concrete is a 1:2½:5 mixture, the aggregate being gravel and broken stone up to two inches diameter. The faces are built of coursed rubble, the

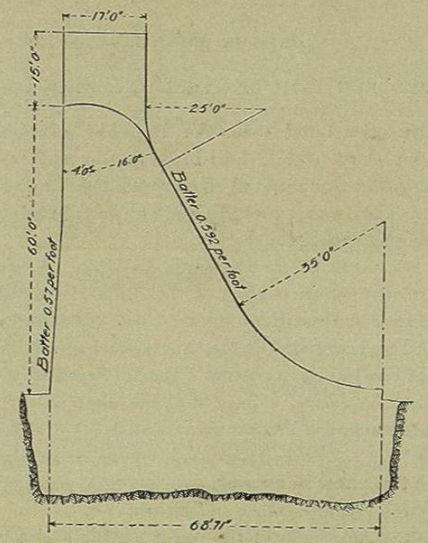


FIG. 253.—PROFILE OF MARIQUINA DAM, MANILA, P. I., WATERWORKS.

stones being dressed so as to make ¾ inch joints for a depth of at least 4 inches. These were raked out and pointed with 1:1 mortar. The total volume of the dam is about 28,000 cubic yards.

The gate house controlling the flow from the reservoir to the pipe line is built as a part of the dam at one end of the spillway section. It is 27×40 feet in size, the longest dimension being parallel with the dam. Two pipes pass through it, one of which is 42 inches in diameter, carrying the supply to the city and the other 36 inches in diameter, serving as a waste pipe.

The main pipe line from the reservoir is 42 inches in diameter, of riveted steel, 10½ miles long, discharging into an aqueduct built on a hydraulic

grade to its terminus in the city distributing reservoir of 112 feet above sea level. This reservoir is excavated largely in rock, and has a capacity of 50,000,000 gallons. The flow into and out of the reservoir is controlled by a gate house with semi-circular ends, 47′ 8″×26′ 8″, quite similar in design and detail of controlling tank and gates to the four reservoir gate houses in the distributing system of Portland, Oregon.

The works were built under the direction of Maj. J. F. Case, M. Am. Soc. C. E., chief engineer of the Department of Sewers and Waterworks Construction, formerly assistant engineer on waterworks construction in Portland, Oregon.

Dams in Mexico.

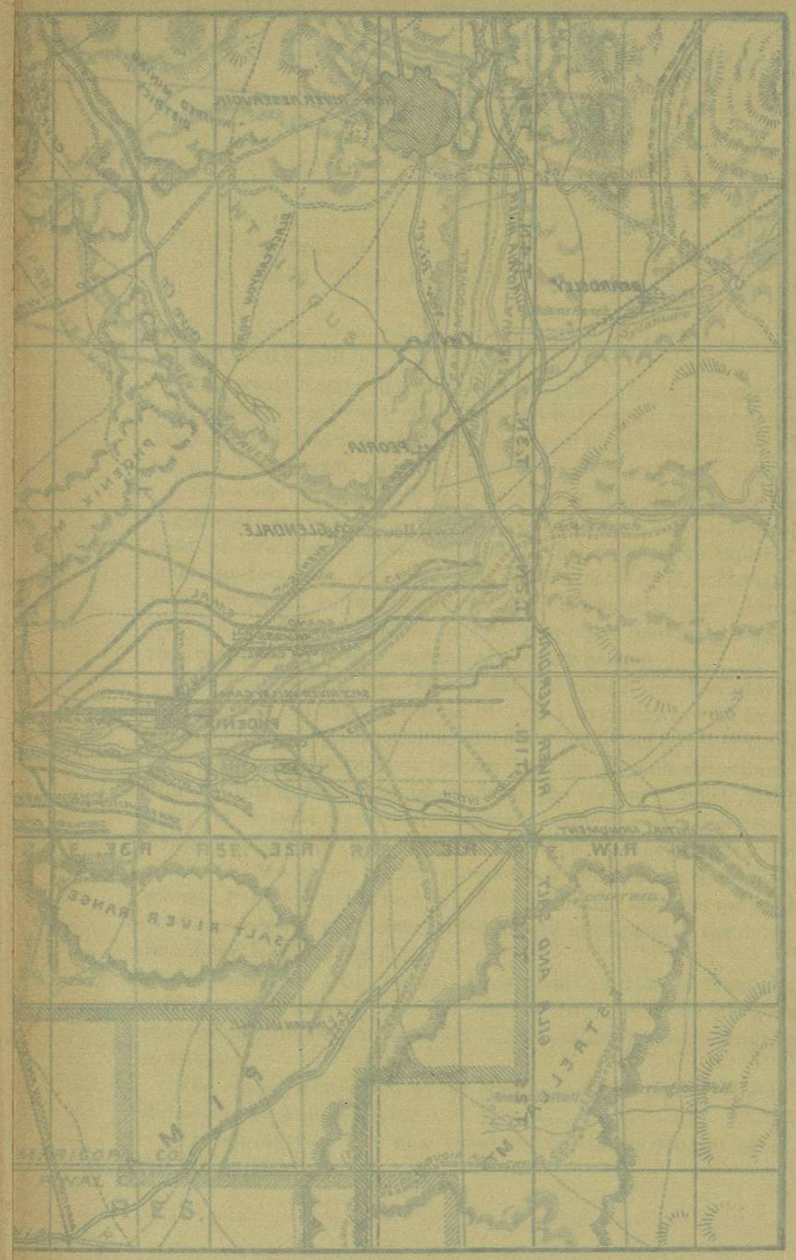
THE OLD AND NEW DAMS OF LA JALPA, GUANAJUATO, MEXICO.

The Old Dam.—Scattered over the Republic of Mexico are many venerable masonry dams which date back to the Spanish régime, whose history and description would make an entertaining chapter were complete data obtainable. They were generally built on private estates or haciendas to store water for irrigation.

One of these is situated on the Hacienda La Jalpa, 25 miles from the city of Leon, in the northwestern portion of the State of Guanajuato, now the property of Mr. Oscar J. Braniff, of Mexico City. The dam was built about 250 years ago, and was regarded at the time as such a notable structure that the King of Spain created for its owner a special hereditary title, called the "Conde de la presa La Jalpa"—the Count of Jalpa dam. Unfortunately it was not as permanent a structure as anticipated, and was destroyed seventy years ago by a tremendous flood, which stripped the country, so that there are no trees now in its path over seventy years of age. The dam was immediately rebuilt, and is now in service.

The New Dam.—Alongside of the old reservoir site where Mr. Braniff is building a new and more important masonry modern dam of gravity type after the Wegmann profile. The two watersheds are quite independent, but the overflow from the old reservoir is taken into the new one by an artificial channel through the ridge. The new dam is nearing completion, and is expected to be dedicated within a year with appropriate ceremonies by President Diaz and his wife. It is located on the river Turbio, a tributary of the Lerma river, and intercepts a watershed area of 116 square miles, on which the average annual rainfall is about 30 inches, yielding a run-off about double the reservoir capacity.

It was projected over fifty years ago on a small scale, and work begun on the foundations in 1888, but after working a year operations were suspend-



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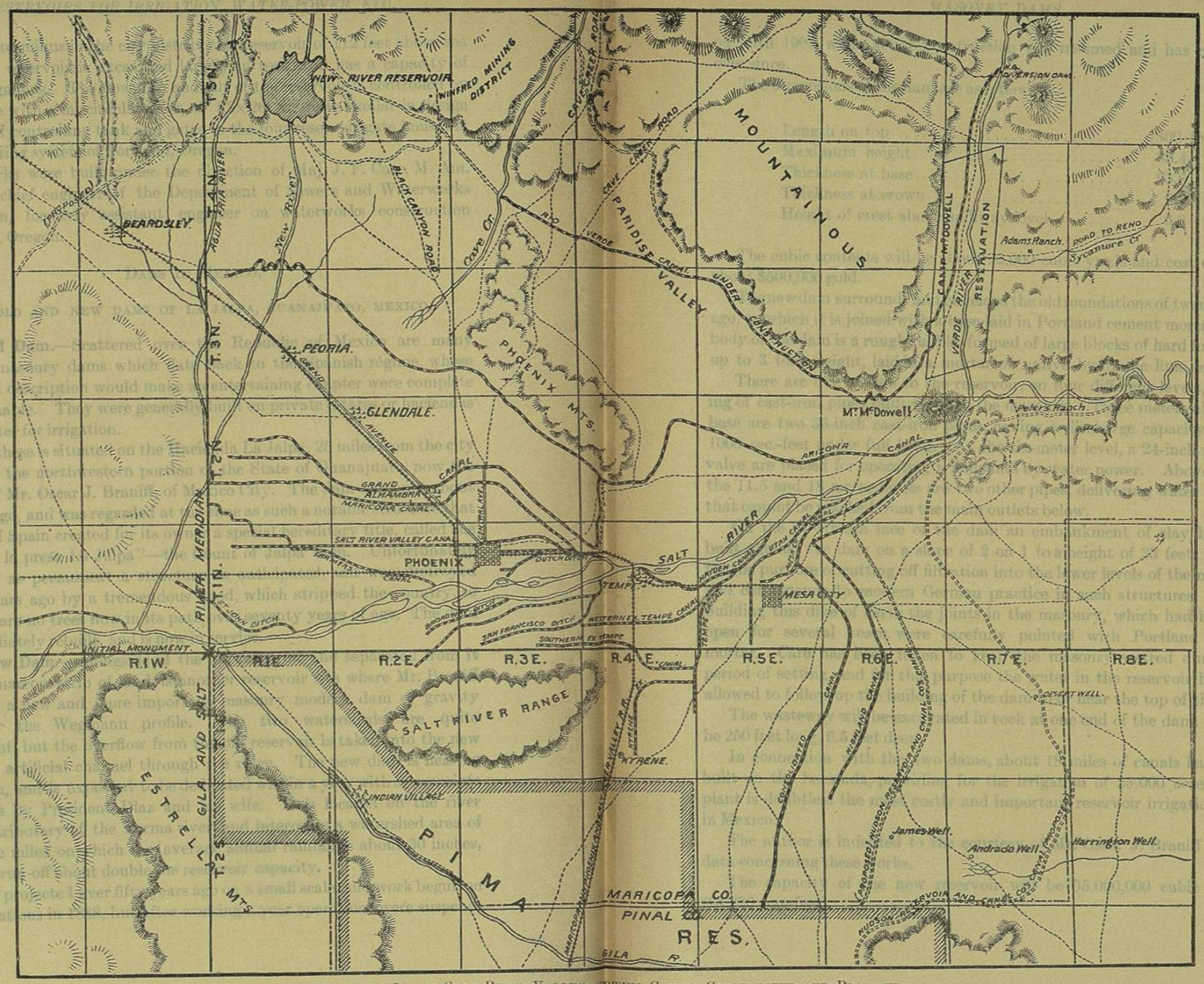

FIG. 164.—MAP OF SALT RIVER VALLEY, SHOWING CANALS CONSTRUCTED AND PROPOSED.

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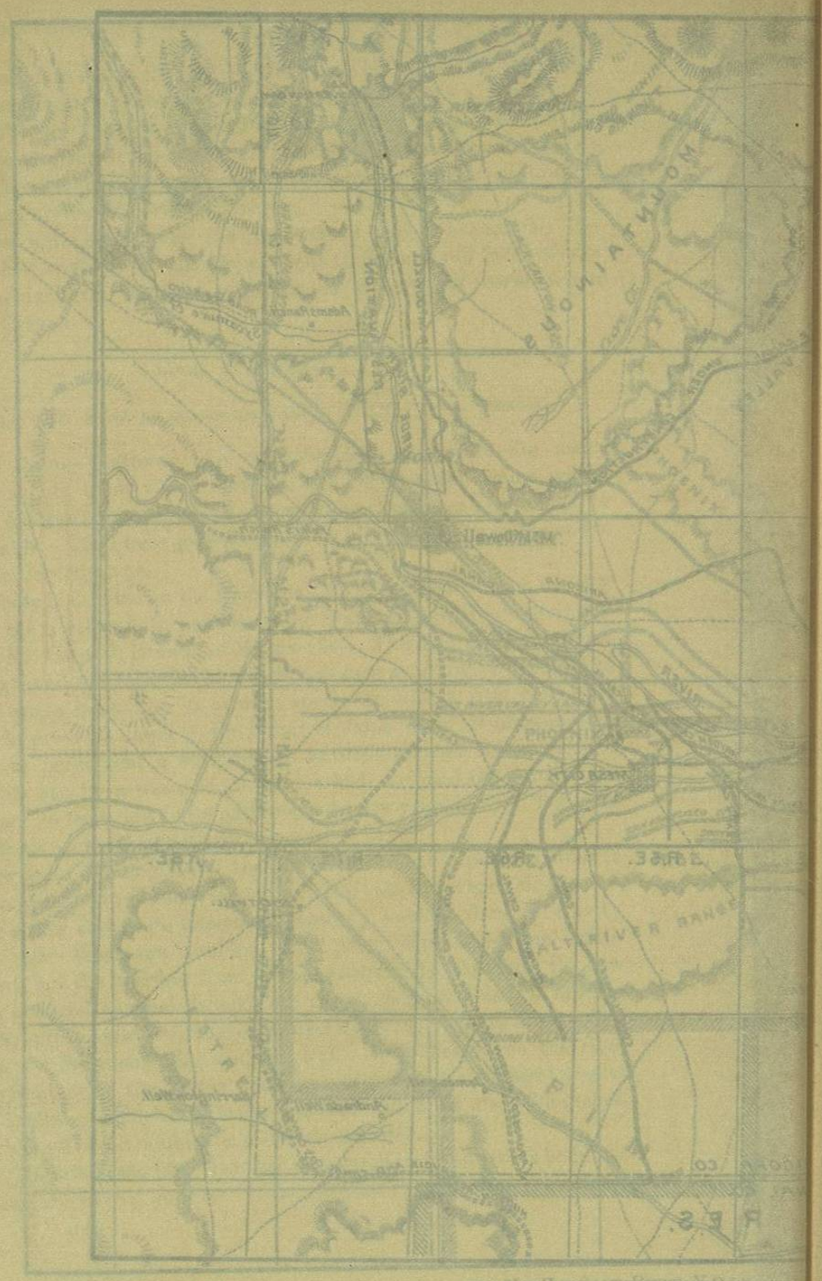

ed until 1902, when active construction was resumed and has continued ever since.

The dimensions of the dam are as follows:

Length on top	1800 feet
Maximum height	85.4 "
Thickness at base	65.6 "
Thickness at crown	9.1 "
Height of crest above spillway level	6.6 "

The cubic contents will be about 92,000 cubic yards and cost complete about $500,000 gold.

The new dam surrounds and envelops the old foundations of twenty years ago, to which it is joined with a base laid in Portland cement mortar. The body of the dam is a rough rubble, formed of large blocks of hard limestone, up to 3 tons weight, laid in a mortar of native hydraulic lime and sand.

There are five outlets to the reservoir, on four different levels, consisting of cast-iron pipes built through the masonry. Three meters above the base are two 36-inch cast-iron pipes, having a discharge capacity of over 1000 sec.-feet under full head. At the six-meter level, a 24-inch pipe and valve are placed for operating a flour mill by water power. Above this at the 11.5 and 18 meter levels are two other pipes, delivering water to lands that cannot be reached from the main outlets below.

On the up-stream face of the dam an embankment of clay has been built against the dam on a slope of 2 on 1 to a height of 33 feet. This is for the purpose of cutting off filtration into the lower levels of the masonry, and corresponds to modern German practice in such structures. Before building this dike of earth the joints in the masonry, which had been left open for several years, were carefully pointed with Portland cement mortar. Care has been taken to keep the masonry wetted during the period of setting, and for this purpose the water in the reservoir has been allowed to follow up the building of the dam to or near the top of the work.

The wasteway will be excavated in rock at one end of the dam. It will be 250 feet long, 6.5 feet deep.

In connection with the two dams, about 18 miles of canals have been built on the hacienda, providing for the irrigation of 25,000 acres. The plant is doubtless the most costly and important reservoir irrigation work in Mexico.

The author is indebted to the courtesy of Mr. Oscar J. Braniff for the data concerning these works.

The capacity of the new reservoir will be 35,000,000 cubic meters (28,370 acre-feet).

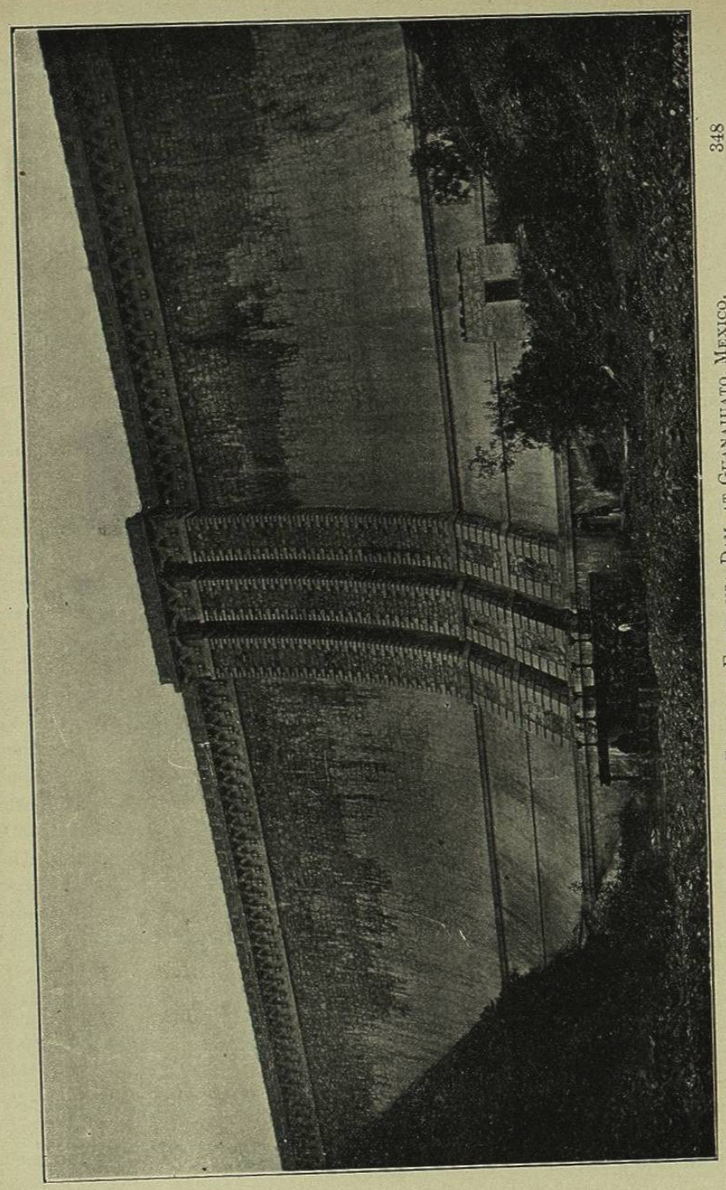

FIG. 254.—FRONT OF ESPERANZA DAM, AT GUANAJUATO, MEXICO. 348

By courtesy of *Modern Mexico*, of St. Louis, Mo., the accompanying views of two notable masonry dams at Guanajuato, Mexico, are incorporated in this work, as types of reservoir construction in our neighboring republic. Fig. 254 shows the upper dam, from which water is supplied to the higher portion of the city through a stand pipe that is shown in the view of the lower dam, or the "Presa de la Olla," Fig. 255 (frontispiece).

The upper dam is evidently a massive, ornate structure that would do credit to any country of the world, as far as exterior appearances can lead one to judge, although the precise dimensions are unfortunately lacking. Estimating from the proportions of the figures in the foreground, the height of the dam must be at least 80 feet.

The view of the lower dam was taken on St. John's Day, the 24th of June, which is celebrated annually by a function called the "Fiesta de la Presa," or the feast day of the dam.

Sharply at 12 o'clock noon of that day, the people congregate to witness the opening of the gates, bringing refreshments and musical instruments for a picnic, and thus commences a fortnight of gayety, gambling, bull-fights, cock-fights, theater and dancing. The object of letting out the water is to clear the reservoir preparatory to the advent of the rainy season, which usually begins about that day.

The water thus released washes out the river-bed below, which is the main drainage of the city.

Mercedes Dam, Mexico.—One of the large landed estates of Mexico, in the State of Durango, is the Hacienda de Santa Catalina del Alamo y Anexas, which includes five minor haciendas, or centers of administration, embracing more than one million acres, and belongs to Señor Pablo Martinez del Rio, of Mexico City. While a large part of the estate consists of rugged grazing lands, there are extensive valleys of fertile soil where cotton can be profitably grown. The Nazas river is the source of irrigation supply or a large and extremely fertile territory known as the Laguna District, stretching eastward from the line of the Mexican Central railway for 50 miles or more. A large part of the cotton crop of Mexico is produced in this district. It has developed into such a profitable industry as to give a high value to all the water supply available for irrigation.

The property of Mr. del Rio adjoins the Laguna District on the west, from which a number of small tributaries of the Nazas river drain the mountainous portion of the hacienda in a northeasterly direction from the region broadly known as the Yerbanis Sierra. One of these tributaries, called Zorrillo creek, drains an area of 120 square miles before passing through a narrow box canyon known as the Boquillo del Zorrillo. Below this canyon, there are many thousands of acres of fine land, in a large valley of a stream called La Vieja, which only require sufficient water