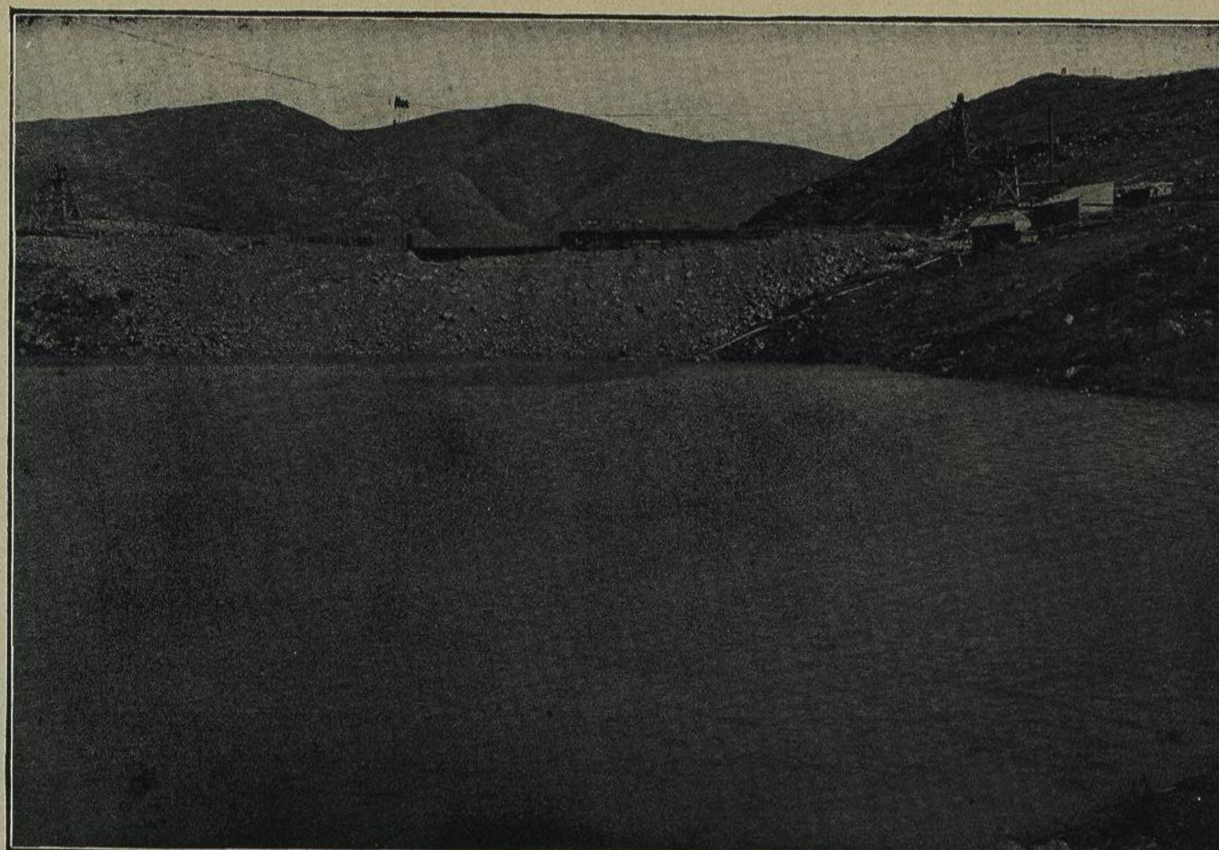

Fig. 12.—Otay (Cal.) Rock-fill Dam—Steel Core.

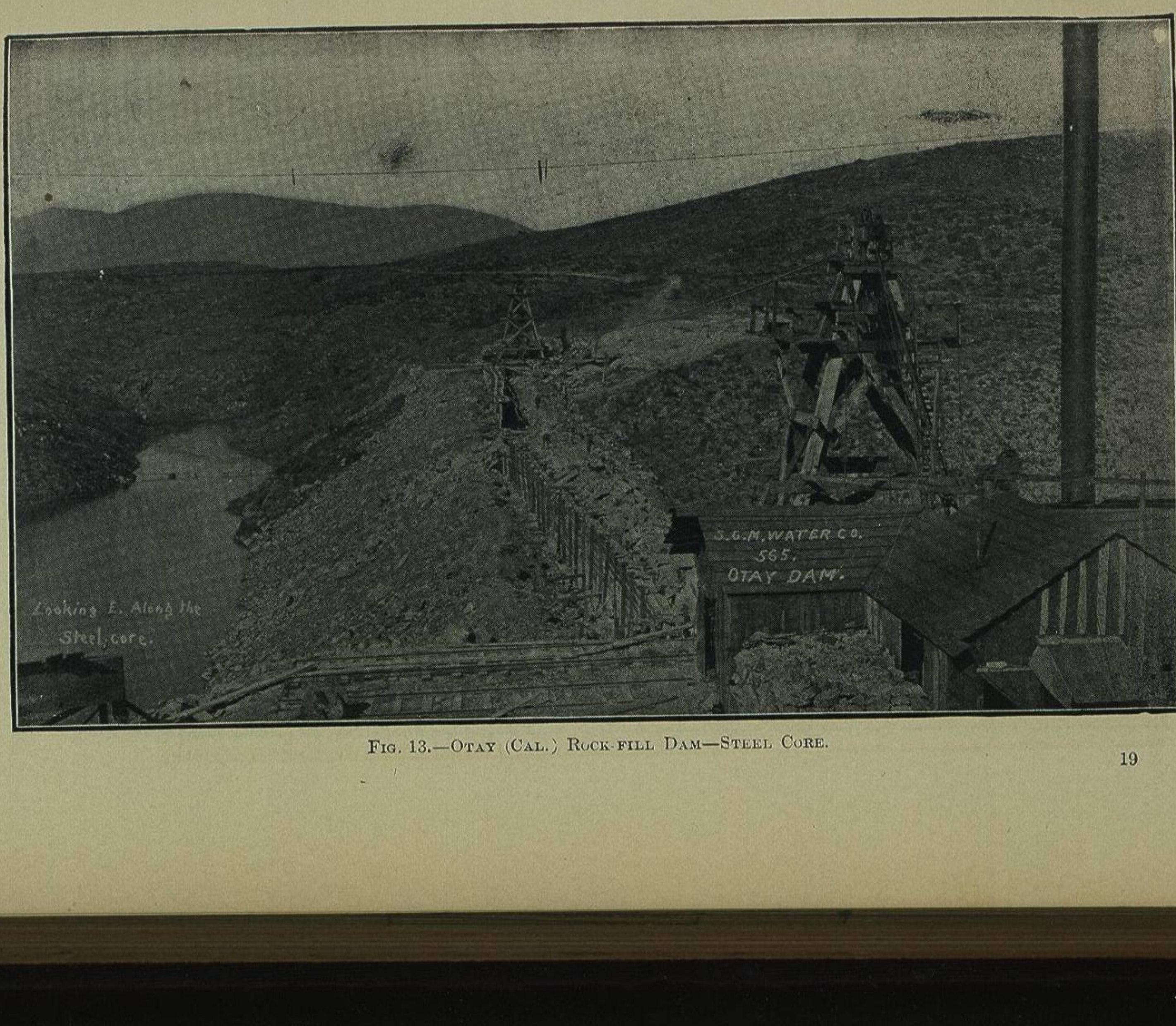

Fig. 13.—Otay (Cal.) Rock-fill Dam—Steel Core.

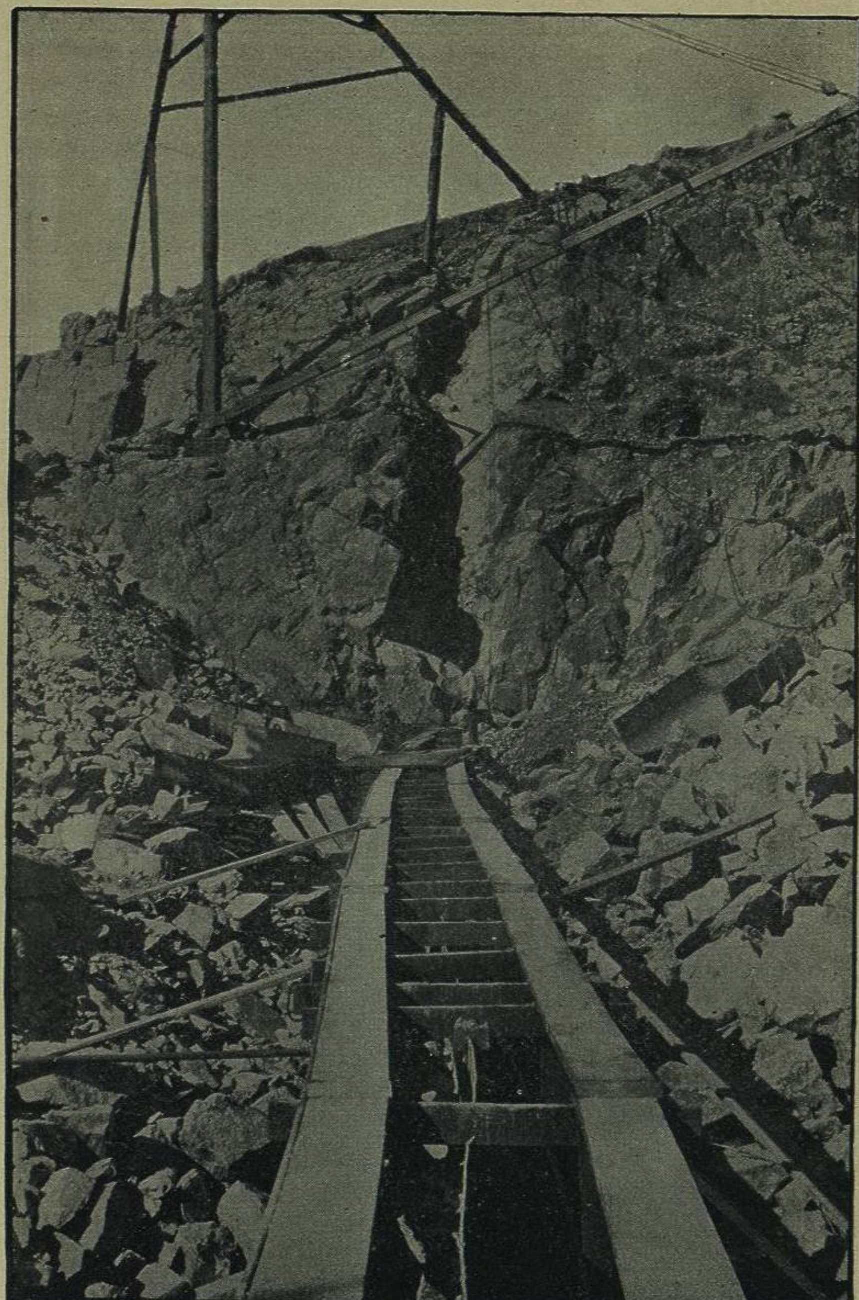

Fig. 14.—Steel Web-plate and Anchor-trench at West End of Lower Otay Dam.

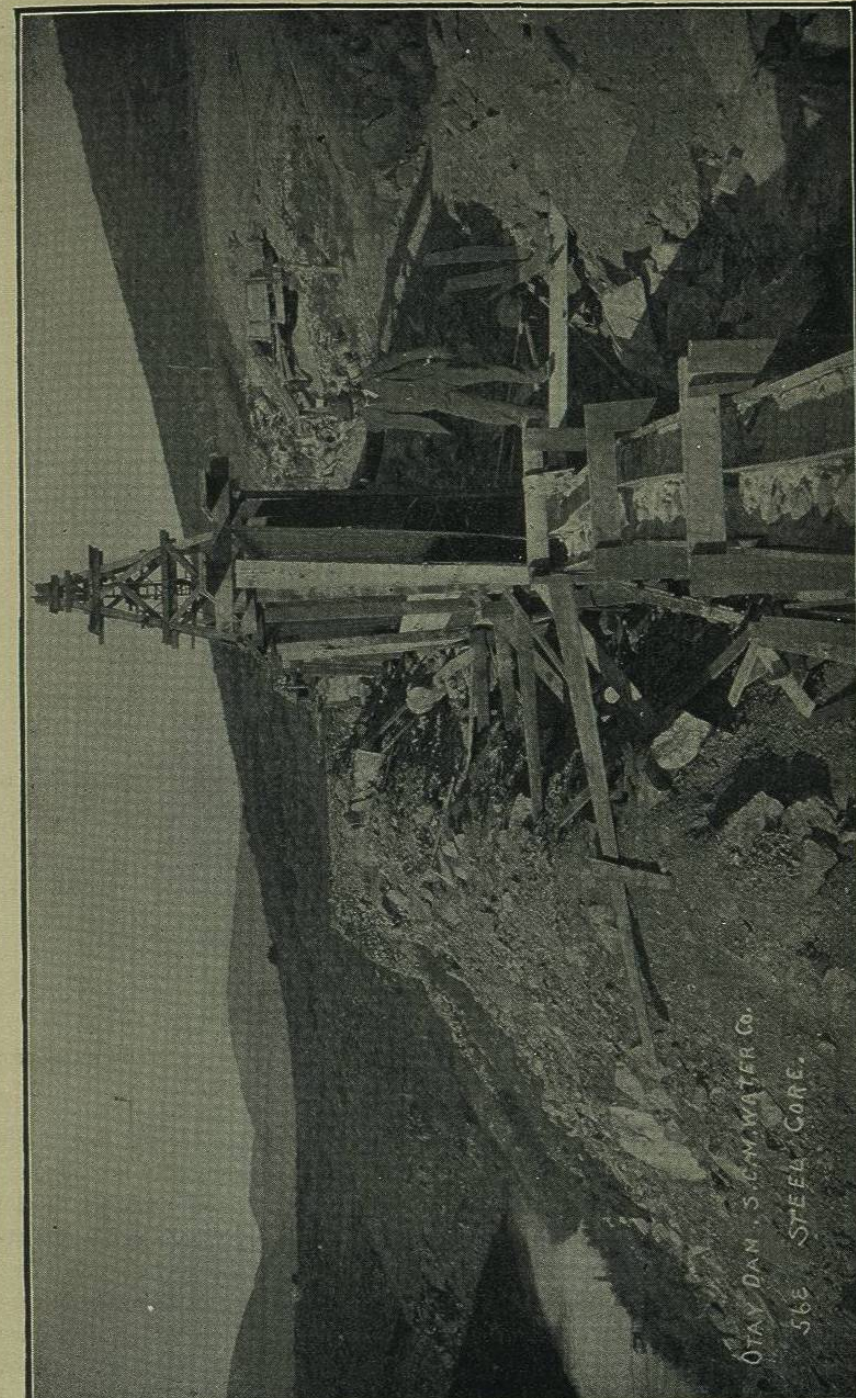

Fig. 15.—Otay (Cal.) Rock-fill Dam—Steel Core.

towers, crossing the canyon diagonally, at an angle of about 60° with the axis of the dam. The head tower was 130 feet high, the tail tower down-stream 60 feet high, the tops being practically level, and a direct line between them crossed the axis of the dam 260 feet above the bed of the stream. The cableway had a guaranteed capacity of 10 tons, center load, under which its deflection was 88 feet, or 42 feet higher than the top of the

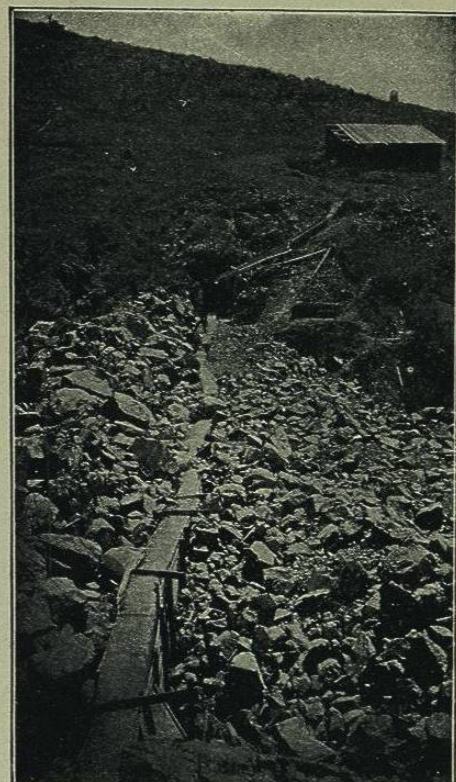

Fig. 16.—Crest of Lower Otay Dam, showing Web-plate of Steel embedded in Concrete. Dam nearing Completion.

dam. Up to the height of 75 feet the rock dumped under the line of the cable was distributed by means of derricks, but subsequently a secondary cableway was erected parallel with the line of the dam, underneath the main cable. This was anchored at each end to heavily ballasted cars resting on tracks, which permitted the cable to be shifted 30 feet, or 15 feet either side of the center of the dam. The loaded skips from the quarry brought to the dam by the overhead cable were picked up by the secondary cable and carried to any point desired along the line of the dam. Tools, materials, derricks, 35-H. P. hoisting-engines, and all other articles required

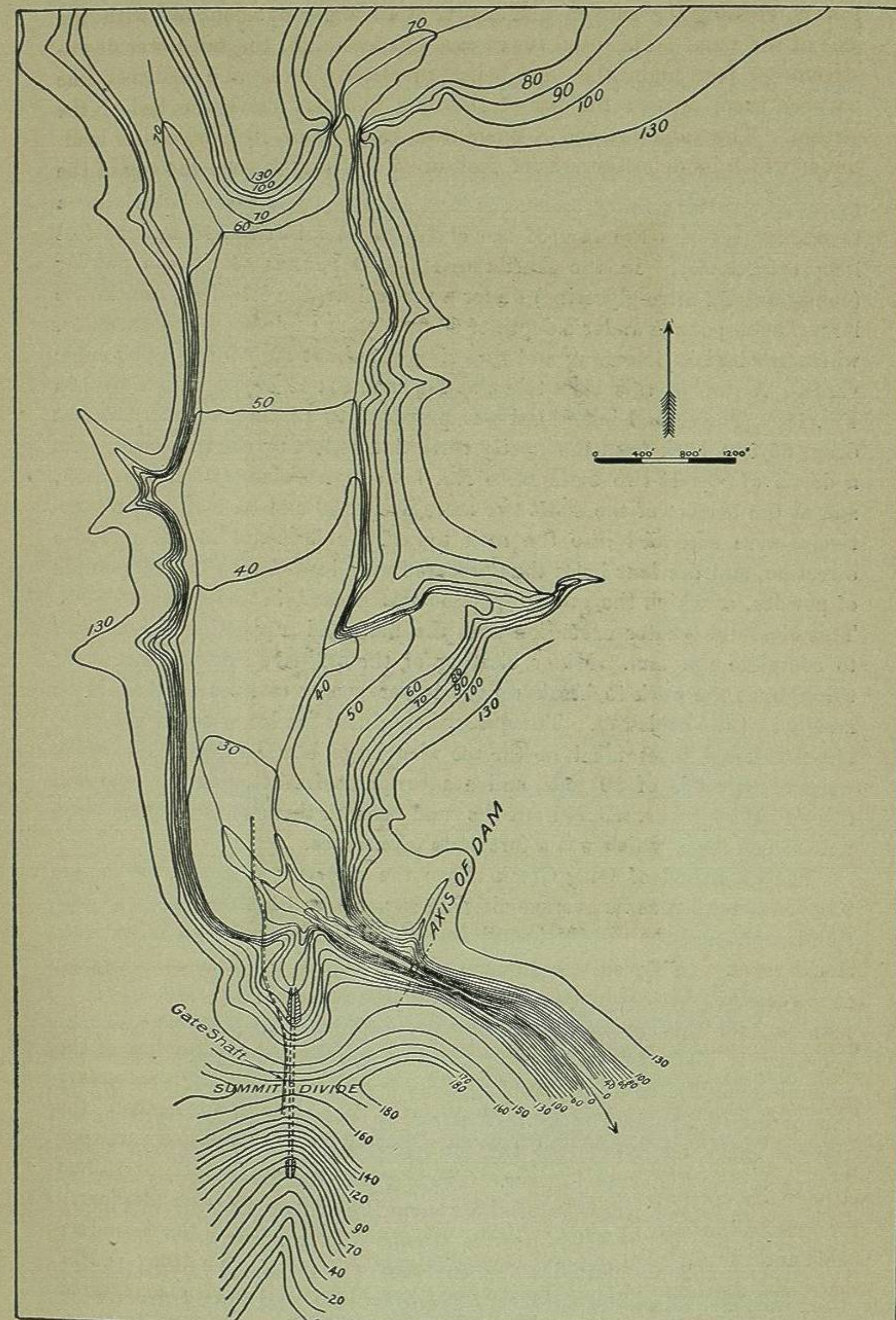

Fig. 17.—Map of Lower Otay Reservoir.

to be moved from one position to another were hauled rapidly and safely by means of these cableways, and not infrequently the employees preferred the aerial journey across the canyon by the cableway to the more laborious climb over the trails. Fig. 18 illustrates the general plan of the dam, with a cross-section of the site and details of the outlet tunnel.

Quarry.—All or the greater portion of the rock used was loosened in the quarry by very heavy blasts, the first of which was made by driving a tunnel 50 feet into the face of the cliff with lateral drifts, 18 and 28 feet long respectively. In the shorter drift, 4000 pounds of Judson powder (containing 5% nitro-glycerine) under a vertical depth of 70 feet, and in the larger, 8000 pounds under a depth of 85 feet, were exploded simultaneously, which resulted in loosening and throwing out about 50,000 to 75,000 cubic yards. A view of this blast taken at the moment of explosion is shown in Fig. 19. The second large blast was prepared by sinking a shaft 115 feet deep, 85 feet back from the nearly vertical face left by the first blast. At a depth of 50 feet two drifts were run laterally a distance of 25 feet each, and at the bottom of the shaft two more drifts, 30 and 35 feet long respectively, were extended into the rock toward the face and in the opposite direction, and the four holes thus prepared were loaded with 30,000 pounds of powder, of which the greater portion was located in the bottom drifts. This blast did greater execution than the first, and supplied sufficient rock to complete the dam. Minor blasting of the ordinary class was necessary throughout the work to break up the larger masses to sizes that could be handled by the cableway. The quarry being near the lower toe of the dam, the first large blast filled in the toe with large bowlders, some of which weighed upwards of 50 tons, and a subsequent freshet, pouring over and through these rocks, scoured out the sand beneath them so as to settle them well to bed-rock, which was a fortunate occurrence.

The watershed of Otay Creek above the reservoir is about 100 square miles in area, but as its average altitude is not over 1600 feet the precipitation is light and the run-off insufficient to fill the reservoir except in occasional years. In dry seasons there is no flow whatever. The catchment in four years prior to September, 1899, did not exceed 5000 acre-feet. To make up for this shortage in supply and to fill the reservoir regularly the company is planning to divert water from Cottonwood Creek, a stream adjoining on the south which drains an extensive region of the highest mountains of the main range. This stream enters Mexican territory and returns again, emptying into the sea near the boundary-line, where it is known as the Tia Juana River. The conduit for diverting its flow will start at the second reservoir of the system, known as the "Barrett dam," at an elevation of 80 feet above the stream-bed, or about 1650 feet above sea-level, and be supported along the southerly slopes of Lyon's Peak to Dulzura Pass, where the divide will be crossed by a long tunnel, from which

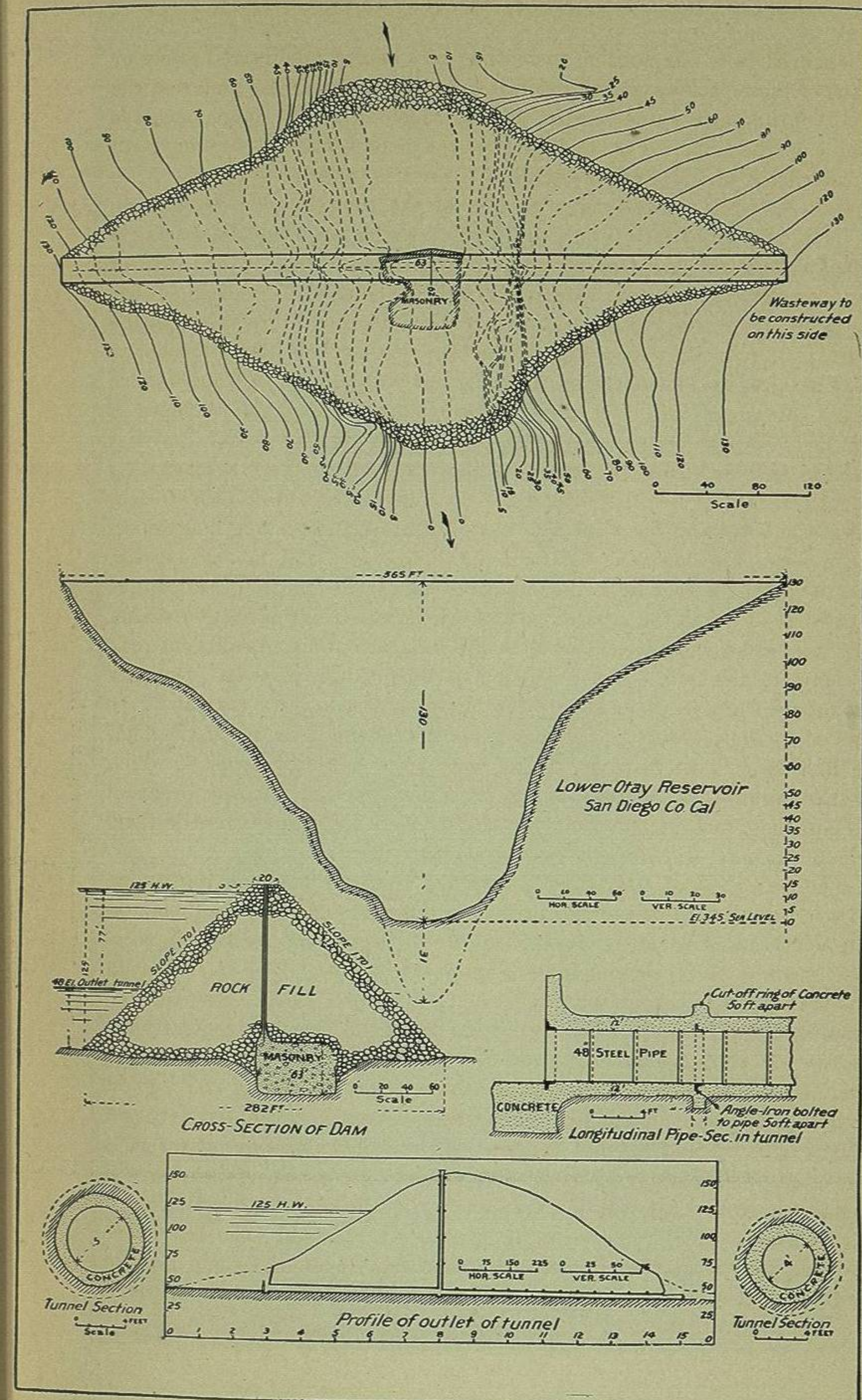

FIG. 18.—PLANS OF LOWER OTAY RESERVOIR.

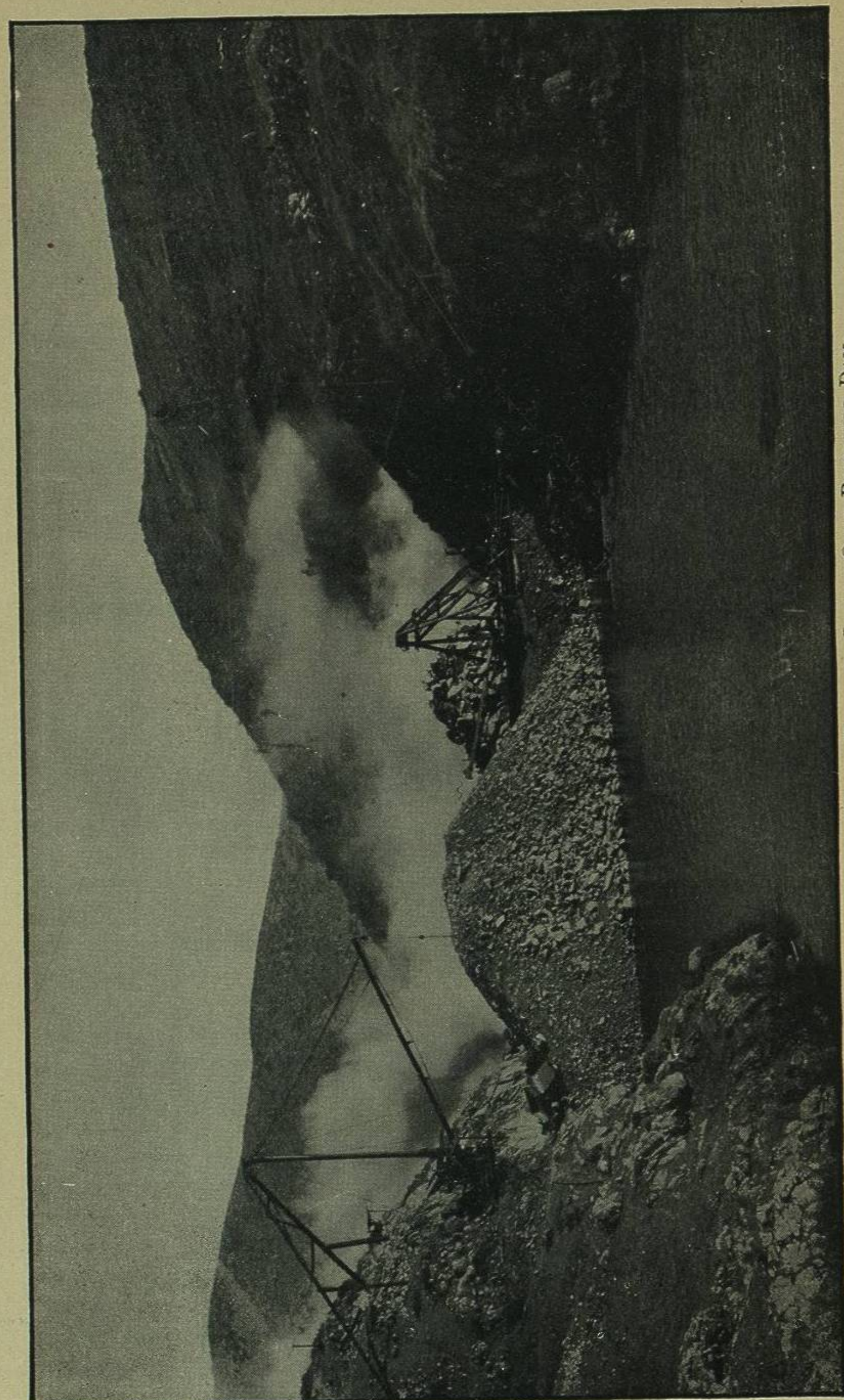

FIG. 19.—EXPLOSION OF GREAT BLAST AT LOWER OTAY ROCK FILL DAM.

the water will drop into the east fork of Otay Creek and thence to Otay reservoir. The conduit will be a trifle over 8 miles in length, and consist of a succession of cement-lined tunnels in granite. To regulate the flow of the stream and store additional water the company have under construction two dams of mammoth size—the Barrett and Morena, the latter having been projected as a rock-fill dam, while the former is to be a concrete structure of gravity type.

Spillway.—The spillway excavated at the east end of the dam is of liberal dimensions considering the limited run-off of the stream. It is cut in solid rock for a distance of 400 feet, is 40 feet wide, 6 feet deep, lined with concrete. The reservoir has never filled higher than within 15 feet of the spillway level, or 109 feet above base. This height was reached during the winter of 1906–7. The storage at that height is about 24,000 acre-feet, or 64 per cent of the full capacity to the overflow (37,460 acre-feet). When the water reached the maximum stage a small leak appeared below the dam, on the west end, 20 feet above the base, measuring about 225,000 gallons per day.

Outlet Tunnel.—There are no pipes or outlets through or under the dam proper, and the only outlet provided is a circular tunnel through a narrow part of the enclosing ridge 1000 feet west of the dam. This tunnel is 1150 feet long, the bottom of which is at the 48-foot contour. Below the tunnel-level, therefore, as will be seen by reference to the table of reservoir capacities in the Appendix, there remains a volume of water of approximately 2000 acre-feet (652,400,000 gallons), covering nearly 160 acres of surface which can never be drawn off. The material encountered in this tunnel was a brown hard-pan, resembling marl, and cemented gravel, both bone-dry. The western limit of the porphyry dike is between the tunnel and the dam. For 500 feet from the inner heading the tunnel was lined with concrete to a clear circular diameter of 5 feet, the lining being 12 to 18 inches thick and plastered with cement mortar. At the end of this section a shaft, 104 feet in depth, reaches to the surface. Below this shaft a 48-inch riveted steel pipe is laid to the outside, and the entire annular space between the pipe and the walls of the tunnel is filled with concrete, with a minimum thickness of 12 inches. This pipe was put together in sections of 38 inches in length, stovepipe fashion, the insertion at each joint being 2 to 3 inches. The joints were driven as closely as possible, but owing to the sag of the pipe and the absence of careful ramming of the concrete at the bottom of the joint it was found on completion that there were cavities which rendered it impossible to calk the joints from the inside and make them water-tight. As it was desirable to utilize the full depth of the reservoir pressure on the conduit outside the tunnel, it was essential to stop the leakage in the pipe lining of the tunnel, and a plan was devised by H. N. Savage, M. Am. Soc. C. E., consulting engineer of the