PLAN OF
THREE COMBINATION HYDRAULIC-FILL AND ROCK-FILL DAMS,
MILNER, IDAHO
AT HEAD OF TWIN FALLS CANAL ON SNAKE RIVER.

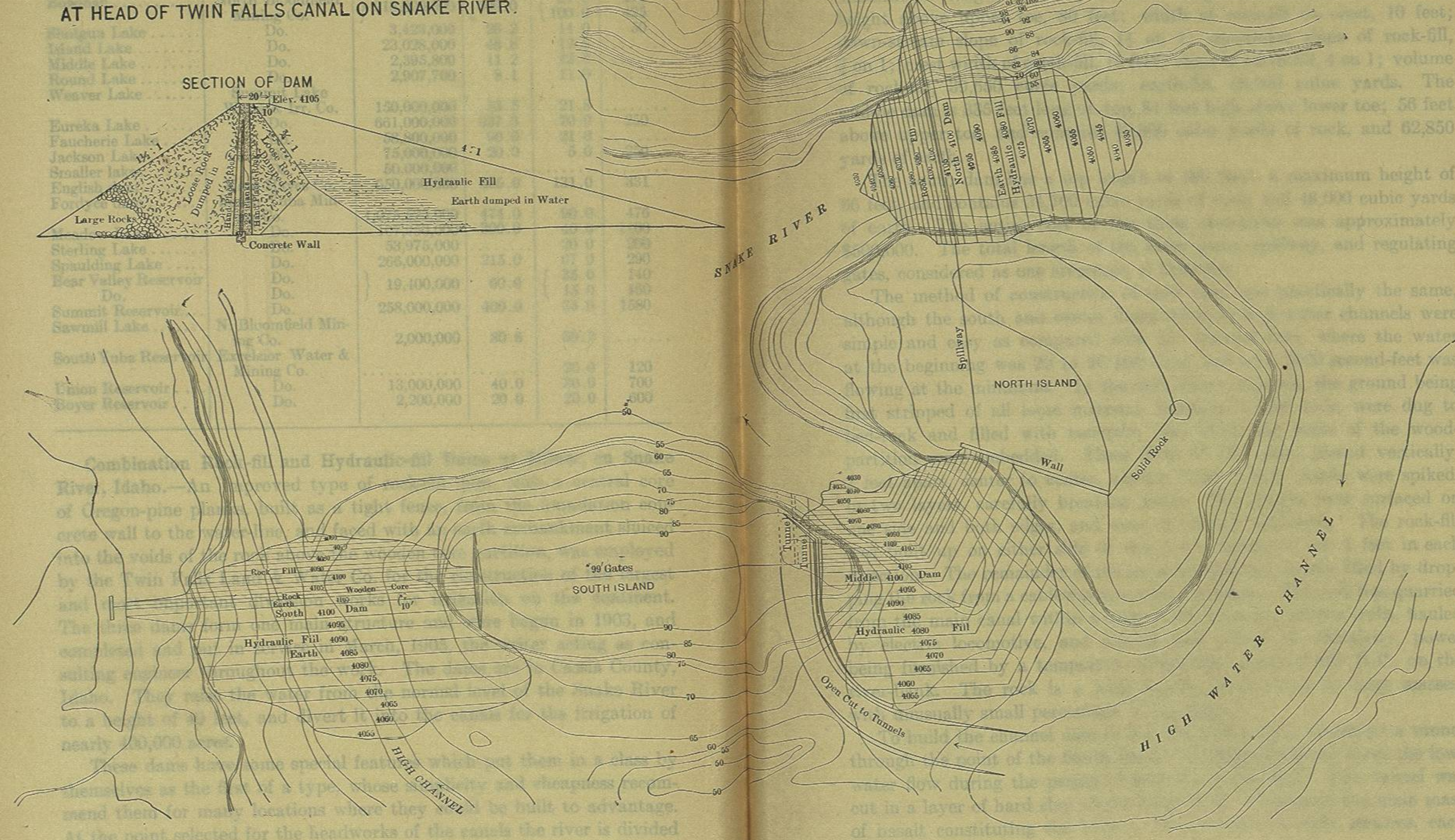

FIG.

[To face page 68.]

character and height to be utilized as spillways,—one of them taking the natural overflow when the canals are full, and the other affording a location for a battery of 99 regulating gates, by which all excess water not required for diversion could be turned back into the channel. The maximum flow of the river in flood is about 60,000 second-feet, which can be carried by the gates. The main channel dam has the following dimensions: length on crest, 340 feet; height above lower toe, 86 feet; height above upper toe, 80 feet; width of rock-fill on crest, 10 feet; down-stream slope of rock-fill, $1\frac{1}{2}$ on 1; up-stream slope of rock-fill, $\frac{3}{4}$ on 1; crest width of earth-fill, 10 feet; slope of earth-fill, 4 on 1; volume of rock-fill, 39,650 cubic yards; earth-fill, 58,000 cubic yards. The middle dam is 335 feet long on top, 81 feet high above lower toe; 56 feet above upper toe, and contains 42,800 cubic yards of rock, and 62,850 yards of earth.

The south dam has a top length of 560 feet; a maximum height of 66 feet, and contains 34,700 cubic yards of rock, and 48,000 cubic yards of earth. The entire cost of the three structures was approximately $500,000. The total length of the three dams, spillway, and regulating gates, considered as one structure, is 2100 feet.

The method of construction of each dam was practically the same, although the south and center dams being in high-water channels were simple and easy as compared with the channel dam, where the water at the beginning was 20 to 30 feet deep, and over 5000 second-feet was flowing at the minimum. In the high-water channels, the ground being first stripped of all loose material, trenches, 5 feet wide, were dug to bed-rock and filled with concrete, into which the posts of the wood-partition were imbedded. These were $3'' \times 6''$ pine, placed vertically, 2 feet apart, center to center, against which 2-inch planks were spiked, in two layers, carefully breaking joints. The planks were surfaced on one side and both edges, and were of uniform thickness. The rock-fill was built up on either side of this fence, hand-laid for 5 feet in each direction. The remainder of the embankment was loosely filled by dropping the rock from a cableway spanning the gorge. The rock was quarried from the main canal within a mile of the dams by electric drills, hauled by electric locomotive, and hoisted and placed by electricity, power being furnished by a temporary contractors' plant of 500 H.P., on the river-bank. The rock is a hard basalt, which broke in large masses, with unusually small percentage of fine spawls.

To build the channel dam it was first necessary to construct a tunnel through the point of the South Island, of sufficient size to carry the low-water flow during the period of erection of the dam. This tunnel was cut in a layer of hard clay about 9 feet thick, underneath the main mass of basalt constituting the island. It was made in eight sections, each

5 feet wide, by 9 feet high, with heavy side walls of concrete, and partitions of timber and plank between them. Heavy gates of cast iron, with powerful hoisting gear, were set at the upper vertical face of the tunnel, on line with the battery of 99 gates for river control after completion of the works. The diversion of the river was effected in the following manner: An earth embankment, or coffer-dam, was placed across the channel approaching the head of the tunnel to keep out water during its construction. At the same time rock in large blocks, was deposited in the river channel, forming two lines of embankment at the up-stream and down-stream toes of the rock-fill, leaving a space between wide enough to permit the sinking of 24′×12′ timber cribs, with the upper faces on the longitudinal center of the rock-fill crest. The water found its way through and over these parallel levees of rock, which were built up until the water-level was 13 feet higher above than below. By this time the tunnel was completed, the coffer-dam was blown up by dynamite, and as much of the river turned through the tunnel as would go. About 4000 second-feet found exit that way and 1000 second-feet passed through the loose rock of the channel dam. With the aid of divers the timber cribs were sunk on the center line of the rock-fill, and a double thickness of sheet-piling was spiked to the upper face of the cribs, which were loaded with stone. This piling was fitted to the bed-rock bottom as carefully as possible, and the joints made tight by means of concrete in bags, placed against the upper footing of the sheet-piles. This work was done in a maximum depth of 40 feet of water, and finally all the water was forced through the tunnel. The remainder of the work above the water-line was similar in plan to the other two dams—the wooden fence being built as a continuation of the sheet-piling.

Much difficulty was encountered in making the wooden core-wall sufficiently tight to prevent loss of earth sluiced into the rock-fill above it. The material used for the earth-fill was exceedingly fine in texture, free from grit, and an almost impalpable powder. It is the soil of that country, classed by geologists as loess or æolian soil. When packed it makes a water-tight embankment, but when in suspension in water would flow as freely as any liquid through a hole or crack in the fence. After final completion the dams were found to be absolutely water-tight, and have shown no subsequent leakage or settlement. The work was done by contract with the State of Idaho for the reclamation of lands granted to the State by the United States Government under the terms of the Carey Act. The project has been remarkably successful in every respect, not only from an engineering standpoint, but as a commercial and agricultural enterprise.

The main canal on the south side of the river is about 70 miles long, and has a capacity of 3000 second-feet, carrying a depth of 10 feet. It

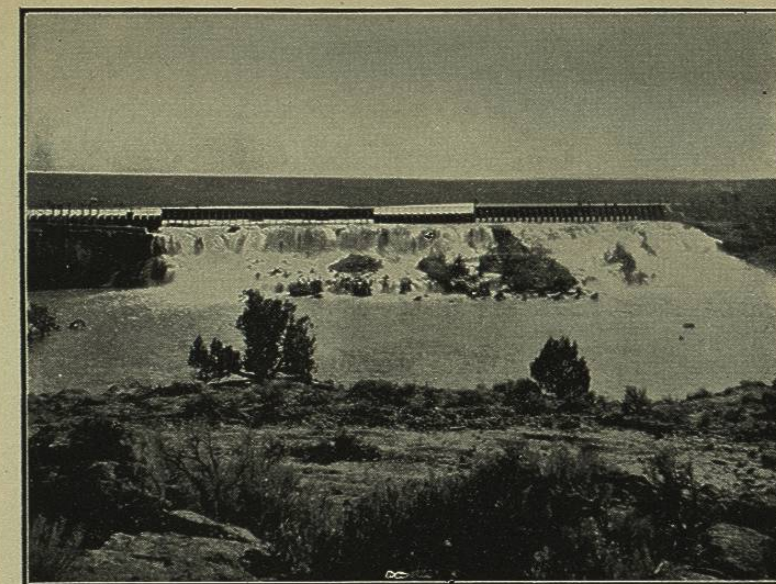

Fig. 47.—Milner Dam, Snake River, Idaho. Discharge through the Great Battery of 99 Waste-gates Forming "Irrigation Falls," 40 Feet High.

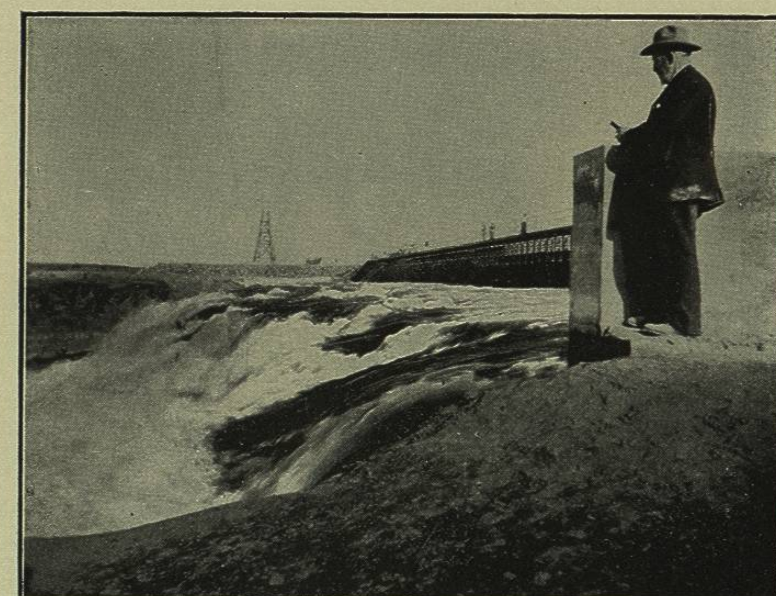

Fig. 48.—Milner Dam, Snake River, Idaho. Showing Waste-way Gates and Discharge of River Over "Irrigation Falls."

FIG. 49.—MILNER DAM, SNAKE RIVER, IDAHO. NORTH CHANNEL DAM BEFORE COMPLETION OF SHEET PILING. ABOUT 500 SECOND-FEET IS PASSING THROUGH ROCK-FILL, UNDER HEAD OF 13 FEET.

FIG. 50.—MILNER DAM. DIVERS AT WORK PLACING SHEET PILING IN 40 FEET OF WATER.

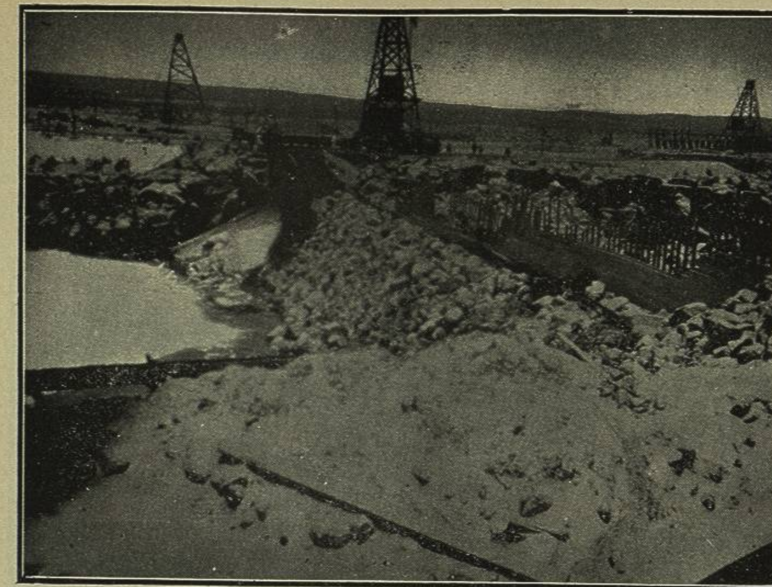

FIG. 51.—MILNER DAM, SNAKE RIVER, IDAHO. SHOWING ROCK-FILL WITH WOOD-CORE IN MAIN CHANNEL OF RIVER.

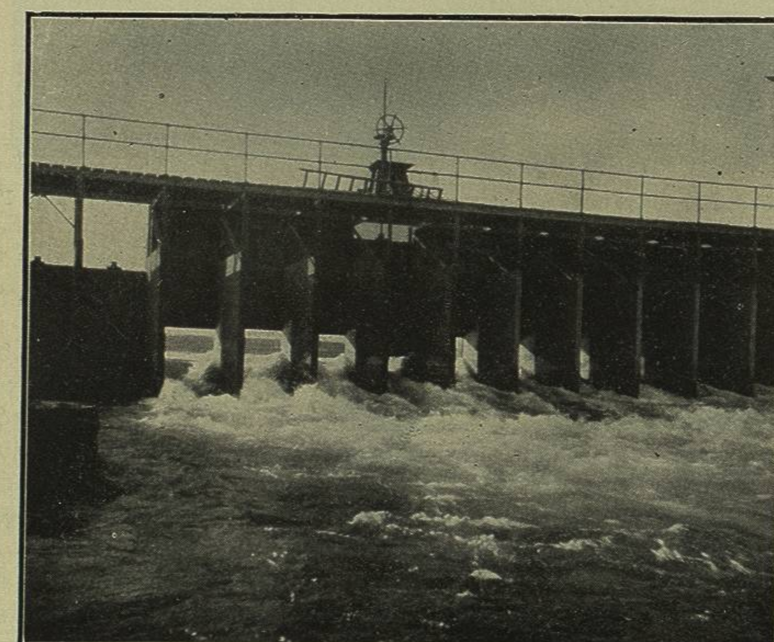

FIG. 52.—MILNER DAM, IDAHO. SHOWING A PART OF THE BATTERY OF 99 WASTE-GATES.

supplies 240,000 acres. On the north side of the river the canal has not yet been constructed, but surveys have determined the feasibility of irrigating about 150,000 acres. Two or more reservoir basins of large capacity will be utilized along the canal line for storage of water during the non-irrigation season.

Figs. 47, 48, 49, 50, 51, and 52 illustrate the construction of these notable dams, and Fig. 53 shows the type of head-gates successfully

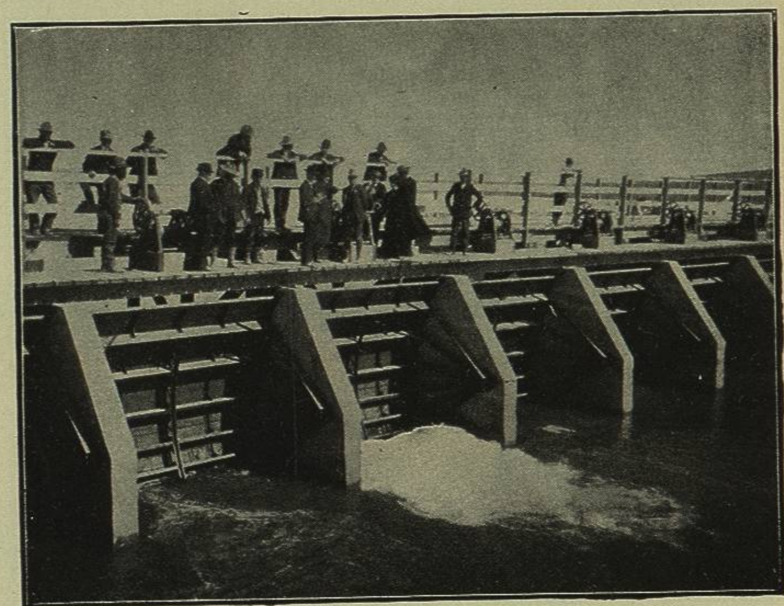

Fig. 53.—First Opening of Head-gates of Twin Falls Canal, March 1, 1905.

used in the canal. They are eight in number, each 12 feet wide and 11 feet high. For description of hydraulic filling of these dams see pages 125 and 126.

The Zuñi Dam, New Mexico.—Near the western boundary of New Mexico, on the Zuñi Indian Reservation, 45 miles south of Gallup, a coal-mining town on the line of the Santa Fé railway, the United States Indian Bureau has built a dam 70 feet in height for the storage of water to be used in the irrigation of the lands of the Indians. The work was done under the general direction of W. H. Code, Chief Engineer United States Indian Service, by J. B. Harper, C.E., Superintendent of Irrigation, the writer acting as consulting engineer. As originally planned the dam was designed to be an earth-fill throughout, the material to be placed by hydraulic sluicing. In view of the torrential character of the stream and the possible occurrence of freshets exceeding the capacity of the outlet tunnel during construction, it was finally decided to change the