minimum weight, dropped in place from a cableway stretched across the stream.

In construction, a diversion channel was first excavated, and then two separate lines of fill were extended across the river about 150 feet apart, the upper one of earth, the lower of rock. By this means the natural channel was gradually contracted and the water forced through the by-pass channel. When the rock-fill was thus carried across, the leakage through it was estimated at 1000 second-feet, but this was gradually cut off by dumping gravel and earth on the up-stream slope

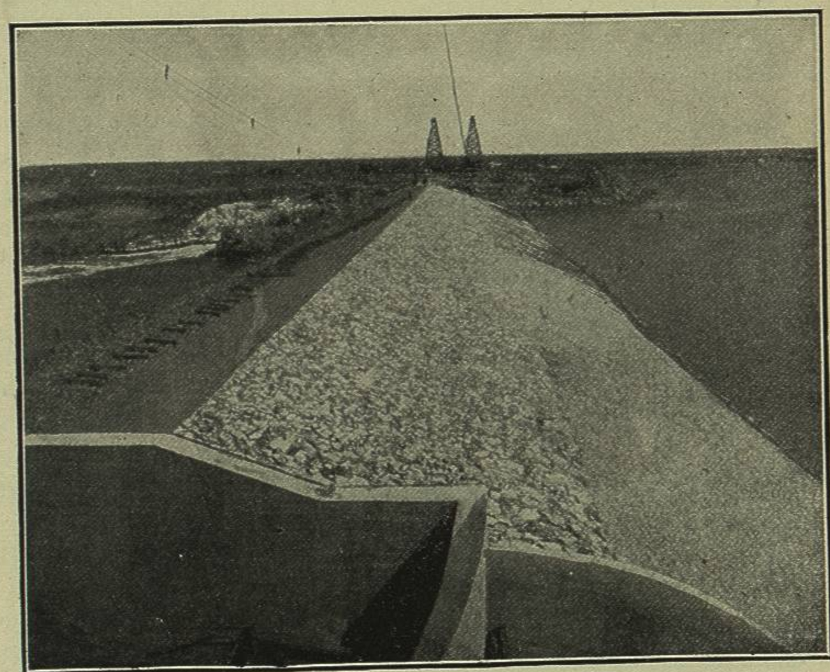

Fig. 61.—Minidoka Dam, Idaho, looking North.

from cars running on a track laid across the rock-fill. The earth-fill was then made by a second cableway and by cars, and the core-wall was built in the trough between them. Upon its completion the fill was carried up on both sides and over the top of the core-wall until the required dimensions of the dam were made. The earth and gravel used in the fill were loaded into cars by means of a steam-shovel. The closure and diversion by the rock-fill were made in April, 1906, and the entire flow discharged through regulating gates, and the dam was completed Sept. 14, 1906, under the supervision of F. C. Horn, construction engineer. The dam was planned by John H. Quinton, M. Am. Soc. C.E.

The dam is provided with a concrete spillway of irregular alignment, built on solid lava rock, and having a maximum height of 14 feet and a crest length of 26,000 feet, containing 4000 cubic yards of concrete. The crest of the spillway is 10 feet below the top of the dam, 7 feet above the sill of gates of the north side canal, 6 feet above the grade of the south side canal, and 48 feet above the bottom of the diversion sluice-way, in which a concrete dam is built with five Coffin sluice-gates, each 8 feet wide, 12 feet high. This structure is provided with penstock openings for the future development of power to be utilized for pumping water to higher lands above the south side gravity canals. It is estimated that 10,000 to 30,000 H.P. may be so developed.

About 70,000 acres of land are irrigable by the gravity canals, mostly on the north side, and 80,000 acres may be watered by pumping to higher levels on the south side.

The entire project is estimated to cost $2,600,000.

The Alfred Dam, Maine.—The highest dam in the State of Maine was completed in December, 1905, at Alfred, Maine, to provide storage

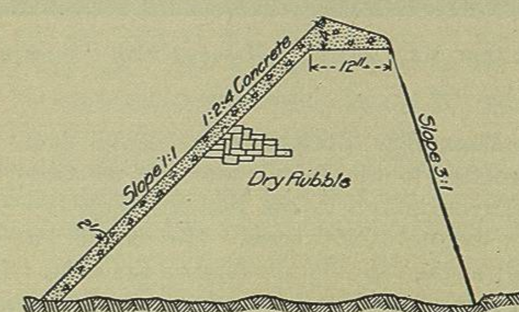

Fig. 62.—Section of Alfred Dam.

to equalize the flow of the Mousam River for power purposes for the Alfred Light & Power Co. The dam is of rather novel design, as it consists of dry rubble, built with split stone, the three lower courses laid in Portland cement and the up-stream face and crest covered with concrete 2 feet thick. See section Fig. 62.

The dam is 39 feet high, 995 feet in length, with a spillway section in center 580 feet long. It contains 12,150 cubic yards of dry rubble, and 2790 cubic yards of concrete. The stream was handled during construction by diversion through the penstocks of the power plant, by a coffer-dam thrown across the entire river.

The rock being dimension stone, laid by hand, the dam is not strictly to be classed as a rock-fill, but is interesting as a cheap type of permanent construction of a better grade than the ordinary rock-fill.

The dam was completed in 90 days after stone-laying began, and in 105 days from the beginning of clearing.

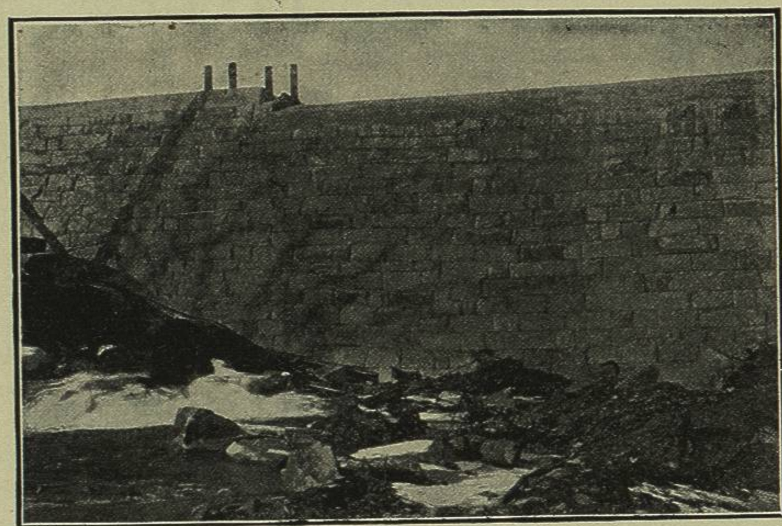

FIG. 63.—ALFRED DAM, ME. DRY ROCK MASONRY WITH CONCRETE FACING AND CREST.

The Idaburn Dam, New Zealand.—An overfall dam, 50 feet high, of similar construction to the Alfred dam just described, was built in 1904, across a canyon known as the Idaburn gorge, for the formation of a reservoir to irrigate 10,000 acres. The dam is but 42 feet thick at the base, 6 feet at the top, 100 feet long on the crest. The up-stream face batter is 1:24, while the down-stream face forms a series of tangents as points on a vertical curve of long radius. The structure is laid up as a dry wall, with a face of 2 feet thickness of concrete on the crest and down-stream slope, while the base and up-stream face are roughly squared blocks of stone laid in mortar to a thickness of 2 to 4 feet. This is the extreme of economy in dam construction, and must be regarded as having an exceedingly small factor of safety. (See Plate 3.)

The Roswell Rock-fill Dam, Georgia.—Sometime before the Civil War a rock-fill dam was built at Roswell, Georgia, for power purposes, having a height of about 28 feet, and a base width of 30 feet, the down-stream face being vertical, while the up-stream face was laid a few inches depth in Rosendale cement or lime mortar. This was used continuously until 1892 when the dam was repaired and the water slope covered with cement mortar, on which a plank face was laid. Ten years later the dam was raised about 6 feet above its former crest level, by the addition of dry rubble to the down-stream face, resting on a masonry base, laid

on bed-rock, with the upper face sloping toward the crest at a ratio of 2 on 1. This base reaches to an extreme height of 9 feet, and is 12 feet wide. On this the dry rubble wall was laid in courses with a batter of 1:3.5. The up-stream slope and crest are faced with 3″×6″ yellow pine planking. The length of the spillway is 138 feet and its depth 5 feet. The total length of the dam is 251 feet, and its extreme height 38 feet.

The original dam was laid of flat stratified rock, the interior of the fill being made up of a very poor quality of slate. The last construction on the down-stream face was done while the water filled the reservoir to the top of the dam, the level being kept below the spillway by means of sluicing gates. The crest and up-stream facing was built with the pond drained during a time when the mill was shut down for repairs.

The Victor Rock-fill, Steel-faced Dam, Colorado.—In 1901 the Pike's Peak Power Co. built a unique dam on the West Fork of Beaver Creek, 5½ miles east of the town of Victor, and 10 miles south of the summit of Pike's Peak, to form a storage reservoir for power purposes. The dam is a rock-fill, with a facing of steel plates as a water-tight skin on the reservoir side. It has a maximum height of 70 feet, is 220 feet long at the bottom, 405 feet long at top, 20 feet wide on the crest, and has a base width of 148 feet. The up-stream slope is 30° from the vertical (0.577 on 1), while the down-stream slope is 50° from the vertical, or 1.22 on 1. The foundation is a granite bed-rock.

The novel feature of the dam is the use of sheet-steel plates to form the facing, the first structure of this type that has ever been constructed. The plates are uniformly 15 feet long, 5 feet wide, laid horizontally, their thickness being ½ inch for the lower 30 feet, then diminishing to ⅜ inch and ¼ inch at the top. The horizontal seams are riveted with butt-straps, while the vertical seams are riveted to angle-bars, 5″×½″, which are placed in pairs at the seams and riveted together, with a ⅜″×2″ filler placed between them. The seams were all calked as thoroughly as in boiler work by the use of pneumatic riveters and calkers. At the base is riveted to the plate a pair of 5″×8″ angle-bars, and a foot above another pair, both of which are imbedded in the concrete toe-wall. The ends are treated in a similar manner, with angle-bars riveted on up the slope. The plates are painted with a protective coating to protect them from rusting.

The granite back-fill against which the steel plate rests is a dry wall of granite blocks, of 20 to 80 cubic feet each, chinked with fine quarry sprawls. A space of 6 inches was left between the plates and the back wall, which was filled with sand and gravel packed with water and thoroughly drained before water pressure was applied.

The outlet of the reservoir is a 24-inch wood-stave pipe, built in concrete through the base of the dam and extending into the reservoir for 240 feet. The reservoir formed by the dam covers an area of 130 acres, with a capacity of 102,000,000 cubic feet (2340 acre-feet). The surface elevation of the water is 9018 feet, giving a maximum depth of 63 feet to be drawn upon.

The dam was designed and built by Mr. R. M. Jones, Engineer and General Superintendent of the company.

Power generated with a drop of 1160 feet to the extent of 1600 K.W. is transmitted to Victor over a line of 8 miles in length. The wood-stave pressure-pipe is 23,400 feet long, the limit of pressure being 220 feet, below which a 29-inch steel pipe, $\frac{1}{4}$ inch to $\frac{3}{4}$ inch thick, 2900 feet long, is laid to the power-house.

The Animas Dam, Colorado.—In 1906 a large rock-fill and timber crib dam with plank facing was built for the creation of a storage reservoir of 960 acres, to be utilized for power development in San Juan County, Colorado, 25 miles from the city of Durango, by the Animas Canal Reservoir and Water Power Investment Company. The dam is 750 feet long, 55 feet high above the original surface, the foundation being carried down a depth of 33 feet through loose material to bed-rock. The cribs on the down-stream side are stepped in five benches or steps, from the bottom up, formed of logs and filled with rock. The dam is to be replaced eventually by a concrete dam, 100 feet high, 1400 feet long, increasing the reservoir to 1161 acres. Water is fed to the reservoir by a flume, 6×8 feet, $3\frac{1}{2}$ miles long, leading from Cascade Creek. Water from this reservoir is conveyed through a flume 8800 feet long to a penstock reservoir, formed by a small earth dam with concrete core, 30 feet high, from which a riveted steel pressure-pipe 2844 feet long leads to the power-house, where an effective head of 960 feet is utilized. Power is transmitted to Durango and Silverton at 50,000 volts pressure. The works were built by Geo. M. Peek, M. Am. Soc. C. E.

CHAPTER II.

HYDRAULIC-FILL DAMS.

THE forces employed in hydraulic mining for tearing down banks of sand, gravel and rock, by means of a large volume of water issuing at great velocity from a nozzle under high pressure, have been utilized in the evolution of a novel and interesting type of dam-construction, called the "hydraulic-fill dam," which is becoming recognized as the most economical method of handling earth, as well as the most positive and satisfactory means of compacting it in a solid and immovable mass. By the skillful direction of the currents of water by which the material is conveyed, the disintegrated earth is assorted and deposited where it is desired to perform the required functions of stability and water-tightness in the dam, thus reversing the destructive process of mining and converting it into an upbuilding of great structures serviceable to mankind.

This development of hydraulic mining doubtless originated in the Pacific Coast, where many new and peculiar methods of mining auriferous gravel on a large scale were evolved by necessity, and the ready inventive genius of American miners. It was first employed for making small storage reservoir dams in and around the mines, with the detritus from which the contained placer gold had been washed. These dams were used either for impounding mining tailings, or for water.

Subsequently the principles involved in the utilizing of water of varying velocity for loosening, conveying, assorting, distributing, depositing and consolidating the materials were more carefully studied and scientifically employed in the design and construction of higher and more important dams. These principles are adaptable to the building of dams of any desired height, provided suitable materials are available and the conditions permit of economical construction.

The only limit of feasible height for dams of this class is one which is fixed by the cost, for if the embankment to resist water pressure be made sufficiently wide and massive, and with materials which may be so consolidated as to become impervious to water, there is no reason why dams of 300 feet or more in height should not be built, if justified by the cost. There are innumerable instances in different parts of the world where nature has built hydraulic-fill dams, which form lakes of great depth. The dimensions of such dams, built as glacial moraines,