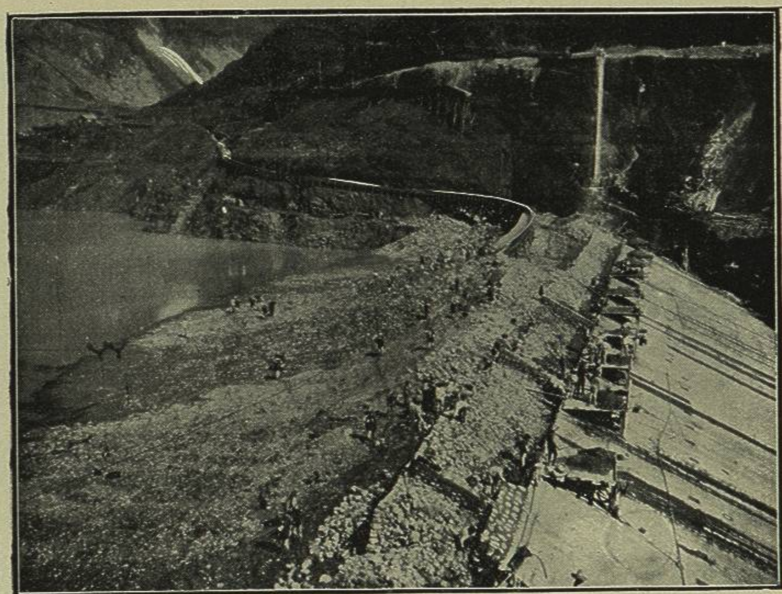

Fig. 120.—Lower Toe of Necaxa Dam, looking North, showing Delivery of Rock and Clay by Flume.

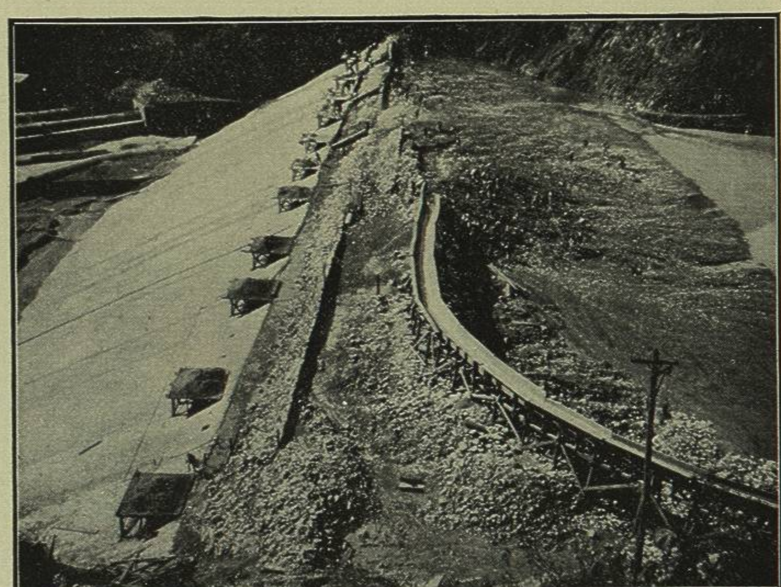

Fig. 121.—Down-stream Slope of Necaxa Dam, showing Masonry Pavement on Face and Character of Sluiced Material.

Portland cement and hydraulic lime in proportions to insure water-tightness. It was carried about 2 meters in height above the stripped surface, finishing with a width of 1 meter on top. It contains in all about 5600 cubic yards of concrete. The exterior of the exposed part of the wall which is enveloped in clay puddle was made very rough by projecting small stones to form a bond and to avoid the smooth surfaces which water may follow. The two trenches up-stream from the core-wall, and parallel with it, were excavated to the clay floor of the valley, and were refilled after sluicing began with the clay puddle that forms the heart of the dam.

The preliminary plant for the delivery of material to the dam con-

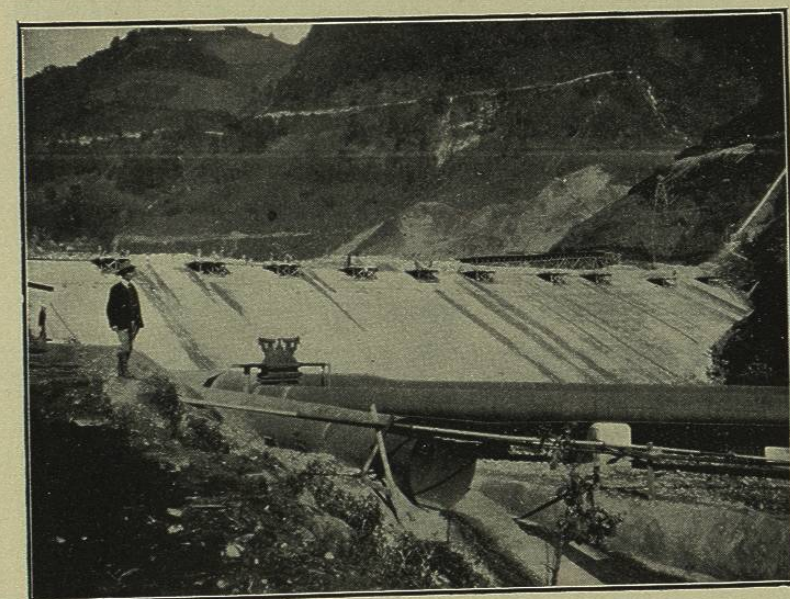

Fig. 122.—Necaxa Dam from Below, at Height of 85 Feet. January 1, 1908.

sisted of two trestles, 40 to 60 feet high, built parallel with the center line and supporting two lines of 20-inch riveted steel pipe laid on a grade of 5% from the borrow-pits on the mountain side, opened by the hydraulic "giants." These trestles were located about 100 feet in from either toe, and the material carried was delivered to the outside by branch pipes, 16 inches in diameter, which were supported by cables suspended across the dam between the exterior footings and the trestles. As a larger quantity of rock was desired on the down-stream slope, one of the pipes was laid to the lower trestle from borrow-pit No. 2, yielding about 95% of broken stone, while the other pipe to the up-stream face was taken from borrow-pit No. 1 where the material consisted of clay to the extent of 60% to 70% mingled with stones of all sizes. The photographs, Figs. 118, 119, 120, 121, and 124 show the nature of the materials delivered to each and the manner of delivery.

A striking feature of this work, as illustrated by the photographs, Figs. 118 and 119, taken by the author in January, 1908, is the large size of rocks which have been transported through the flumes and deposited on the dam. Many of these contain upwards of 15 cubic feet and weigh over 1 ton. In this respect the magnitude of the operation exceeds any hydraulic sluicing ever before attempted. The down-stream slope is being covered with 2 feet of masonry laid in Portland cement, using

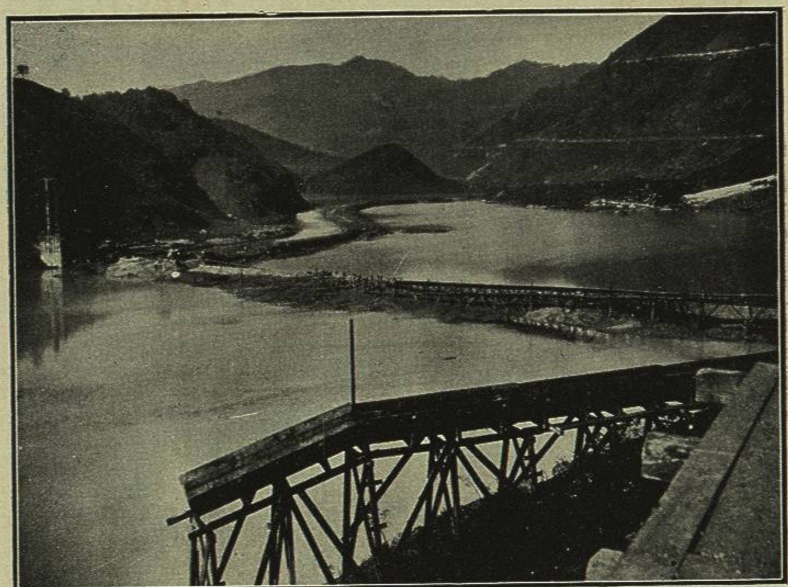

Fig. 123.—Necaxa Dam and Reservoir. Sluice Ditch in Upper Right-hand Corner of Picture.

the larger stones brought down by the flume. The purpose of this is to protect the work from the consequence of a sudden freshet, which might exceed the capacity of the flood discharge outlet-pipes provided. These are two in number, one of which is of steel 8 feet in diameter, in the main outlet tunnel, the other is 10 feet in diameter of concrete, built for construction purposes only and to be plugged when the dam is finished. Two overflow towers 8 feet diameter are built at the head of this pipe in successive layers, as the lake across the dam rises, permitting of storage following up the construction. The solidity of the rock-fill is attested by the lack of settlement cracks in the masonry facing built on the slope of the fill.

The rocks transported by the water are carried along at a velocity of about 20 feet per second, and as they drop in place they act as powerful rammers to consolidate the embankment. The material leaves the end of the raceway at such a velocity as to pile up several feet higher than the top of the flume. It has been the practice to build up the dump from the extreme end of the flume, retreating and removing section by section as the embankment is formed until the ridge is made entirely across the valley along the slope line, to be followed by another line of flume, 15 to 20 feet higher, built a little nearer the center line. There

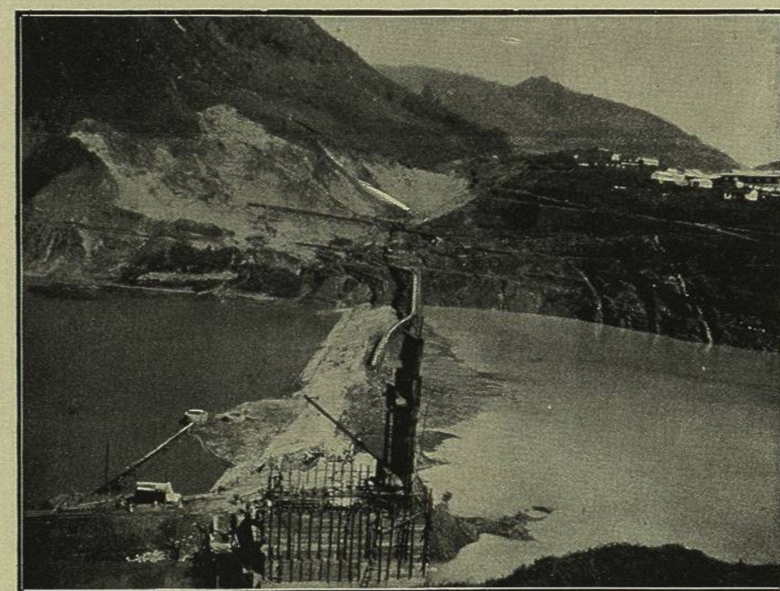

Fig. 124.—Necaxa Dam, Up-stream Slope, looking toward Sluicing Pit and Spillway Gap.

is great wear and tear in the flumes and linings, but the material is used over and over until worn out.

When working in clay the ratio of solids carried to water used has reached as high as 70%, but in rock the ratio is as low as 3%, and the average falls below 10% of solids.

The cost for labor alone averages from 3 to 10 cents gold per cubic yard.

Sluicing began in April, 1907, and continued throughout the year, with many interruptions due to drought and shortage of water, breaks in the ditch, etc. By May 1, 1908, a total volume of 622,990 cubic meters had been delivered, and it is estimated that the dam may be entirely completed before the end of the year.

After the borrow-pits had been well opened, it was found that a much greater percentage of large rock would have to be handled than was anticipated, and to save the cost and delay involved in breaking the rocks to a size that would pass through the sluice-pipes, it was determined to substitute open flumes. Two lines of flumes were accordingly built on 8% grade, crossing the dam about midway between the first lines of trestle and the outer slopes. When these were put in service they were able to carry rock of a maximum size of 12 to 18 cubic

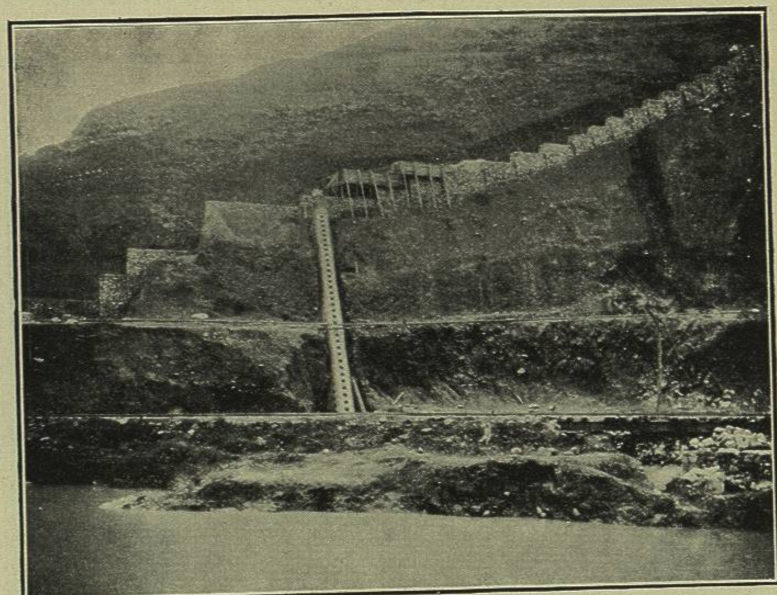

Fig. 125.—Necaxa Dam. Inclined Pipe with Perforations for Drainage of Water after Settlement of Sluiced Material on Dam. Also Core-wall as Completed.

feet weighing a ton or more. The velocity of the water through the flumes was about 20 feet per second. They were made rectangular, 4 feet wide with V-shaped bottom, lined with sheet steel and T-rails. The maximum volume of water carried is about 30 second-feet. The hydraulic monitors, or "giants," discharge varying amounts, according to the pressure and the size of nozzle used. The nozzles employed vary from 4 to 6 inches, according to the work required, and discharge from 15 to 30 second-feet. Experienced hydraulic miners from California are employed to manipulate the monitors. Visitors to the work find a peculiar fascination in watching these powerful jets of water, issuing at a velocity of 200 to 300 feet per second, tearing down the mountains, ripping up the ledges of stratified limestone, and tossing

about huge stones weighing tons as though they were pebbles. The greater portion of the material for the dam will come from the excavation of the spillway, which requires a cut over 150 feet deep. The surplus

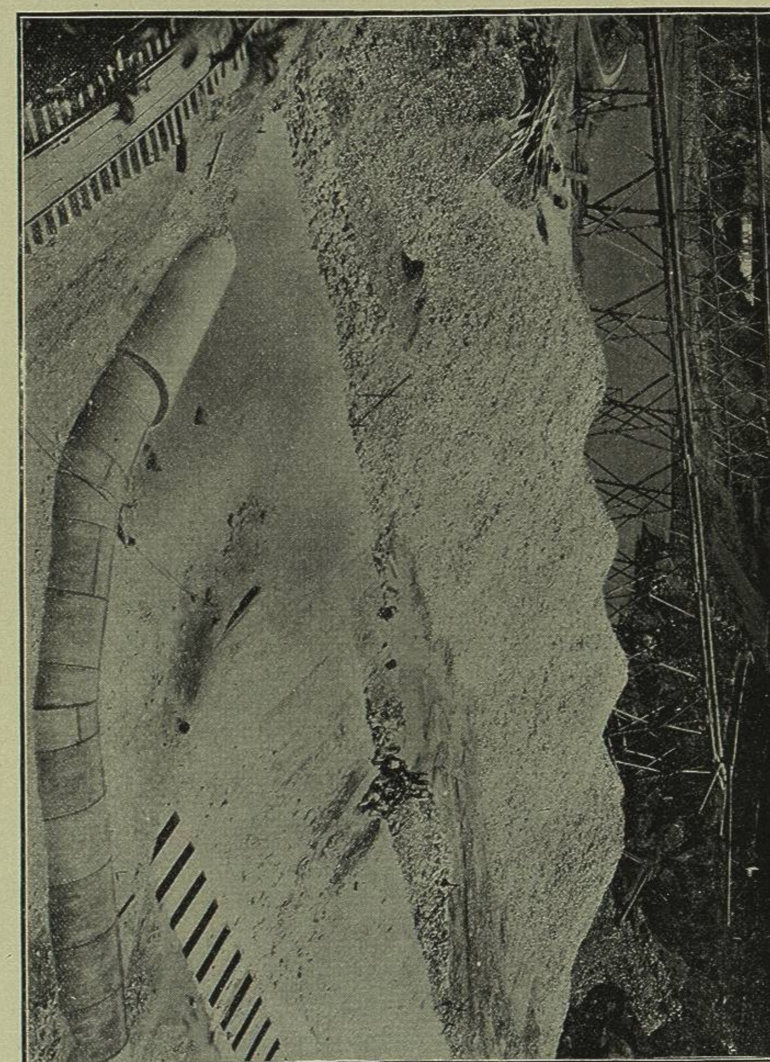

Fig. 126.—Lower Toe of Necaxa Dam, Mexico, showing Character of Hydraulic-fill Material. Pipe in Foreground is 10 feet in Diameter, used Only for Flood Discharge during Construction.

water, draining from the pond, which is maintained on the center of the dam, is carried off through holes in an inclined concrete pipe (Fig. 125), built up the steep slope near the south end of the dam on the opposite side from the borrow-pits. To raise the pond it is only necessary to close the lower of these holes with wooden plugs. In this manner,

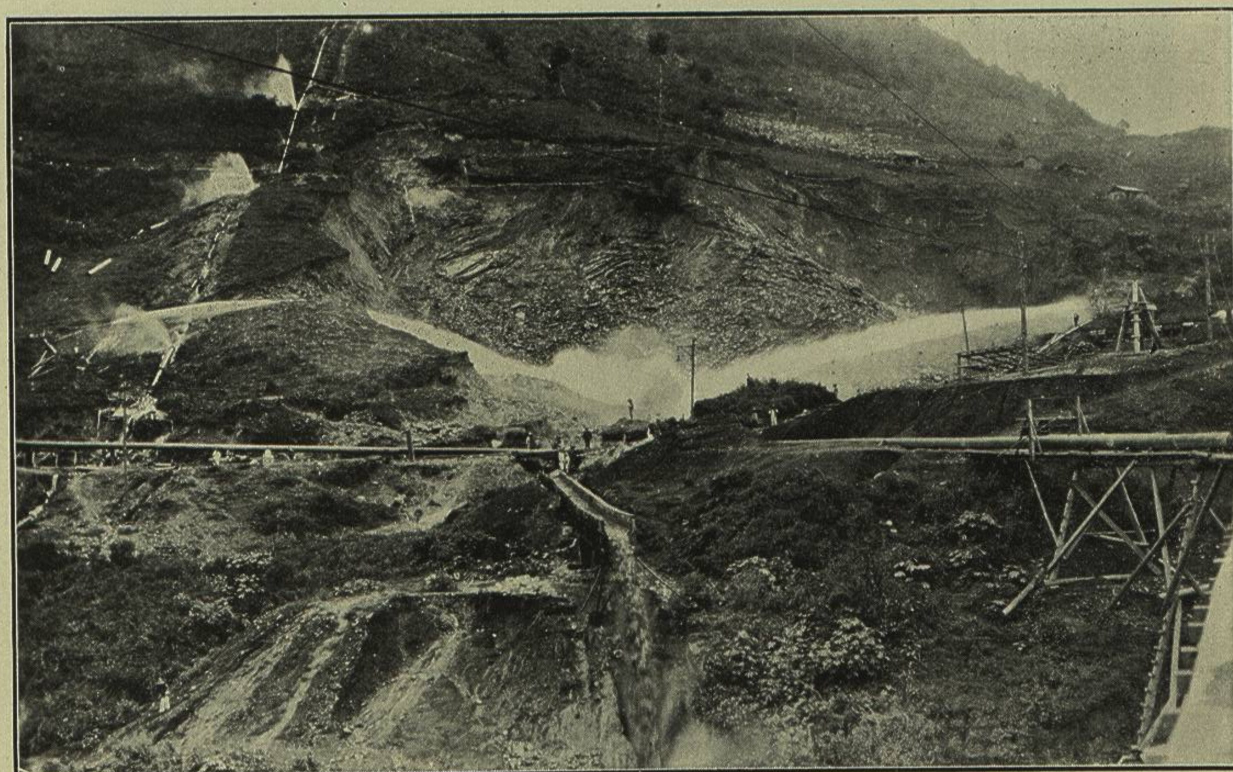

Fig. 127.—Hydraulic Sluicing at Necaxa, June, 1907. Showing Tilted Limestone Ledges in Pit No. 1, overlaid by Clay and Loose Rock.

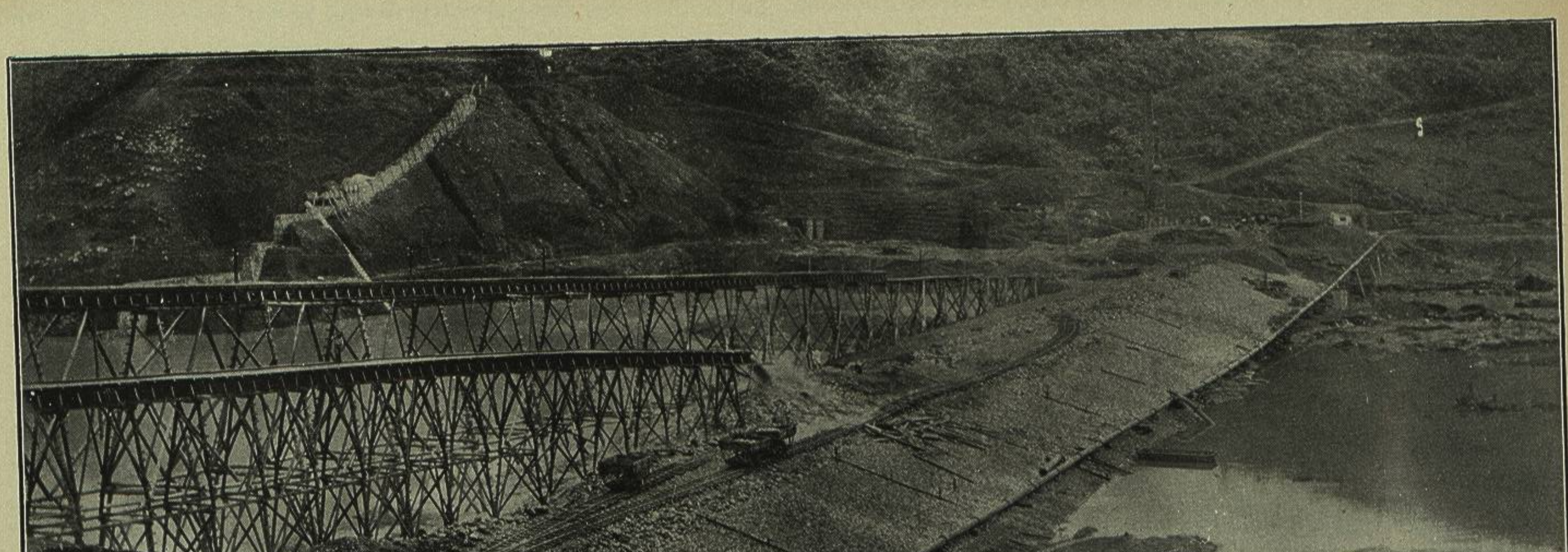

Fig. 128.—Necaxa Dam, Mexico, Oct. 26, 1907, showing Material being Deposited by Flume. Also Hydraulic Elevator Operating under 700 Feet Head, Lifting Water from Pond into Power Canal at Headworks at End of Pipe.

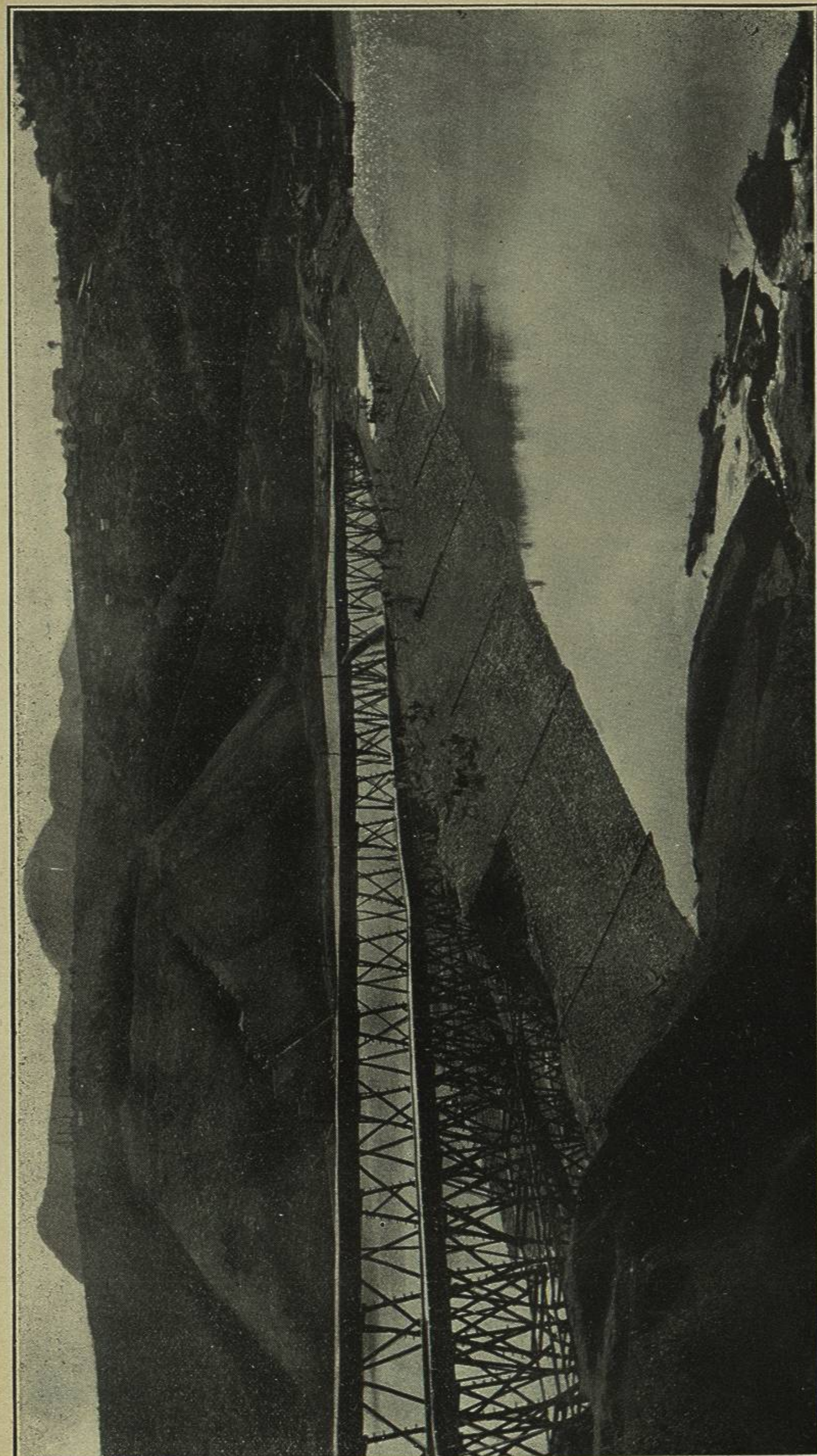

Fig. 129.—Up-stream Toe of Necaxa Hydraulic-fill Dam, Dec. 9, 1907, showing Delivery of Materials by Flumes. The Core-wall is shown in Center of Dam.

the line separating the central clay puddle, from the semi-porous mixture of clay and rock can be controlled, as it is found that the deposit drops off under water at a slope of 1 on 1. Under the water of the pond, the fine clay is deposited almost absolutely level. The water in the pond is usually from 12 to 15 feet deep over the bed of clay beneath. In this manner two stable dams of rock are being built up with an enormous core of clay, having a maximum thickness of 500 to 600 feet between them.

Dam No. 1, at Acatlan.—This structure was completed in June, 1906. It serves as a diverting weir to turn the water of the Tenango River to the Necaxa, through a 3000 foot tunnel. Its extreme height is about 30 feet and it was built of earth by the ground-sluice method, with water taken from the stream through a short ditch. Figs. 130, 131, and 132 illustrate the construction of the dam, and Fig. 133 shows the finished dam viewed from the tunnel portal. It is divided into two sections by a concrete weir located in the stream channel at the deepest portion. When examined with an earth auger to a depth of 20 feet below the crest six months after completion the core material was found in a plastic but compact condition. The dam has shown no sign of leakage or seepage and but very slight settlement.

Dam No. 3, at Tezcapa.—This dam, the second in height of the series, is located six miles above Necaxa, and will form a reservoir of 19,000,000 cubic meters, or less than half the capacity of Necaxa reservoir. After the site had been partially stripped, work was suspended pending the completion of the Laguna and Los Reyes Dams, Nos. 4 and 5, where subsequent surveys proved that greater storage can be secured at less cost and in shorter time. For this reason it will probably be the last of the group to be finished. In many respects it will present fewer difficulties of construction than any of the others, and can be completed with the plant in use at the Necaxa dam.

Laguna Dam.—A large natural basin near the end of one of the tributaries of the Necaxa River was acquired by the company and utilized as a storage-reservoir by building a long low dam across its outlet. It is fed by a 5-mile canal of 10 second-meters capacity from Necaxa River. This site is 20 miles distant from Necaxa, and 3000 feet higher. The dam was planned to have an ultimate height of 66 feet with a crest width of 25 feet and slopes of 3 on 1 and 2 on 1 respectively, and was to have been made as a hydraulic-fill, with water pumped from the lake. The urgent necessity for securing a storage of 12 to 15,000,000 cubic meters in the shortest possible time, led to the adoption of a plan for building the up-stream toe of the large dam to the height of 40 feet of the material chiefly obtained from stripping the middle third of the main dam. As there was a large amount of loose