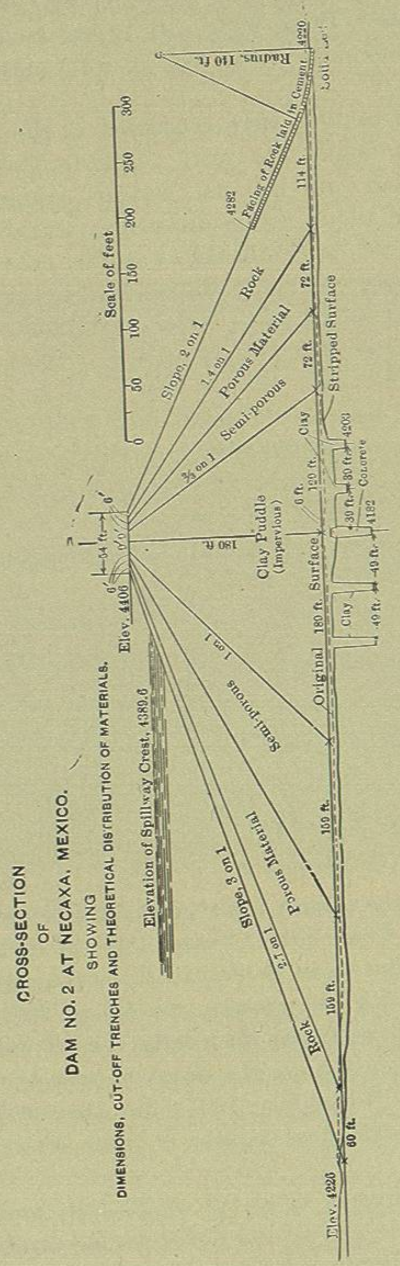
Hydraulic-fill Dams in Mexico.—The Mexican Light & Power Co., Ltd., a Canadian corporation, organized by F. S. Pearson, Dr.Sc., has installed a power-plant at the foot of the falls of the Necaxa River, State of Puebla, 100 miles northeast of the city of Mexico, where a maximum drop of 1400 feet is utilized, developing 40,000 H.P. which is transmitted to the capital of the Republic and to the mining camp at El Oro, a total distance of 170 miles. To equalize the flood flow of the streams and store water for use in the dry season, the company has been engaged since 1904 in the erection of five storage-reservoir dams of earth, which when completed will create an aggregate storage capacity of 123,000,000 cubic meters (100,000 acre-feet). Two of these dams, at Necaxa and Tezcapa, are to be of unprecedented height, and of enormous volume, 190 and 175 feet respectively, while a third, on the Los Reyes River, is to be 100 feet high. The hydraulic-fill process is being employed on all but one of these dams, for the adoption of which the responsibility rests with the author, who was called upon in January, 1905, to report on the subject, and has since been retained as consulting engineer to supervise their construction.



CROSS-SECTION OF DAM NO. 2 AT NECAXA, MEXICO. SHOWING DIMENSIONS, CUT-OFF TRENCHES AND THEORETICAL DISTRIBUTION OF MATERIALS.

Fig. 112.

The highest and most important dam of the group is that at Necaxa, whose chief function is to serve as a penstock reservoir at the head of the pressure-pipes, and afford a storage of over 43,000,000 cubic meters (34,850 acre-feet) on the main Necaxa River, a stream which fluctuates between extremes of 2 and 200 cubic meters per second.

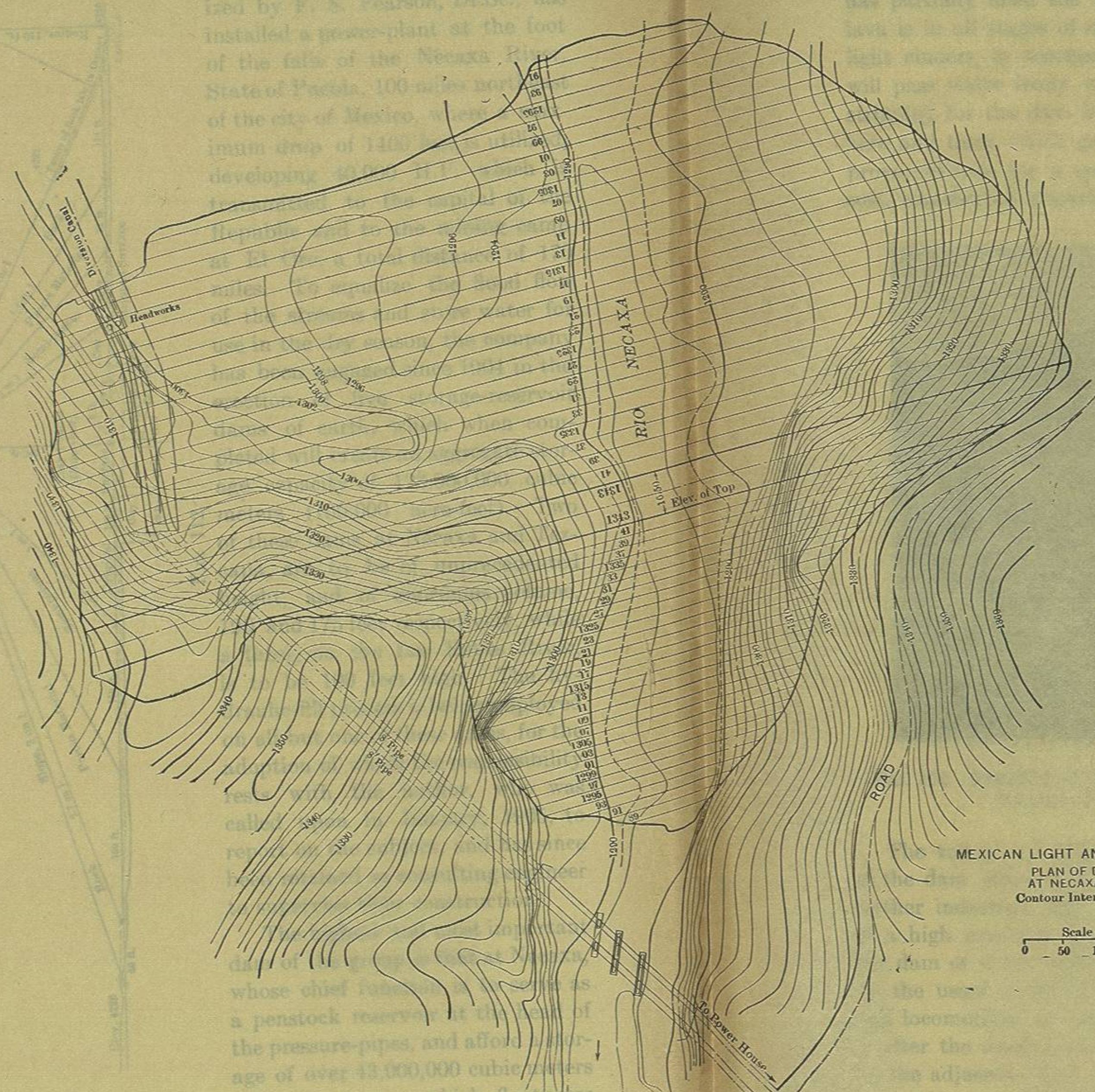


FIG. 113.

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The dam-site is of peculiar geological formation at the line of juncture between the original limestone and the succeeding lava flow which has partially filled the valleys between the limestone mountains. The lava is in all stages of decomposition, varying between hard basalt and light cinders, in successive layers, some of which are very porous and will pass water freely while other layers are firm and impervious. In stripping for the dam irregular masses of hard basalt were encountered here and there which gave rise to the hope that the foundation would prove suitable for a masonry structure, but these were underlaid by soft, treacherous material at slight depth.

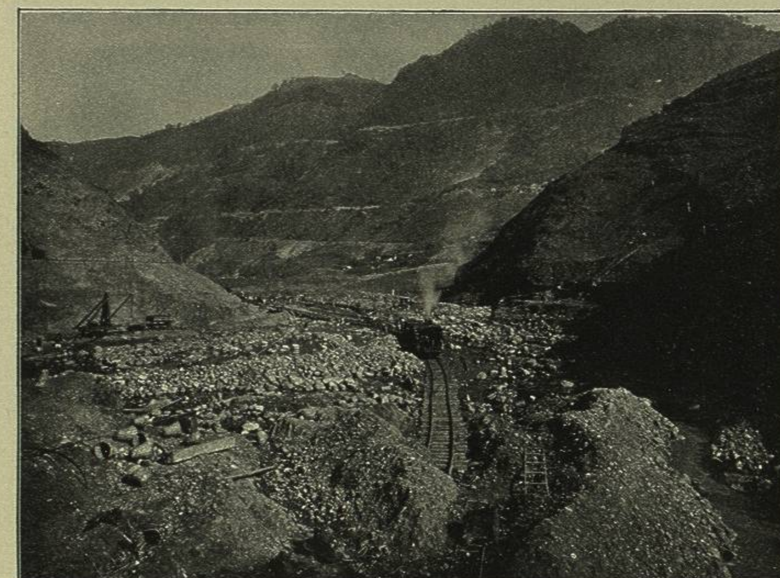

Fig. 114.—Looking up Stream at Site of Dam No. 2, at Necaxa, showing Stripped Abutments for the Dam on each Side.

The tunnel excavated through a spur against which the south end of the dam rests revealed the existence of pockets of quicksand, which further indicated that it was unworthy of confidence as the abutment of a high masonry dam. The only apparent alternative was to build the dam of earth, and plans had been prepared to build the earth dam by the usual methods, excavating with steam-shovels, hauling by cars and locomotives, spreading the earth in layers, and wetting and rolling it after the usual fashion. There was an abundance of clay to be had on the adjacent mesa, of purely volcanic origin, but the enormous quantity to be moved and the cost of building as high a dam as was required for necessary storage, caused the management to hesitate. The solution of the difficulty was afforded by the existence right at hand in the slopes of the high limestone ridge to the northwest of the dam of a sufficient mass of broken fragments of stone of all sizes intermingled with pure yellow clay of superior quality to build the dam by the hydraulic-mining process, using powerful jets of water under high pressure to be brought to the site by a ditch. This material could not be handled economically or sorted and deposited in a way to produce stability and drainage of slopes, and compact imperviousness to the core of the dam in any manner except by the hydraulic method.

FIG. 115.—NECAXA DAM, MEXICO. HYDRAULIC MONITOR WORKING UNDER 180 POUNDS PRESSURE, 6-INCH NOZZLE, 30 SECOND-FEET OF WATER.

Somewhat similar arguments applied to all of the other dams of the group.

The proportions of rock and clay are about equal, and their distribution can be so controlled and regulated by the varying velocities of the water as to permit of the formation of two rock dams at either slope resting against and confining an enormous mass of dense, impervious clay between them. In this manner the dam when completed cannot fail by slipping or sliding, and must be proof against leakage.

The dam will contain 1,639,690 cubic meters (2,143,520 cubic yards), and will have the following dimensions:

Length on crest	1220 feet
Height above lower toe	190 "
Height above up-stream toe	178 "
Width of crest	54 "
Super-elevation above spillway	16.4 feet
Up-stream slope	3 on 1
Down-stream slope	2 on 1
Base width	975 feet

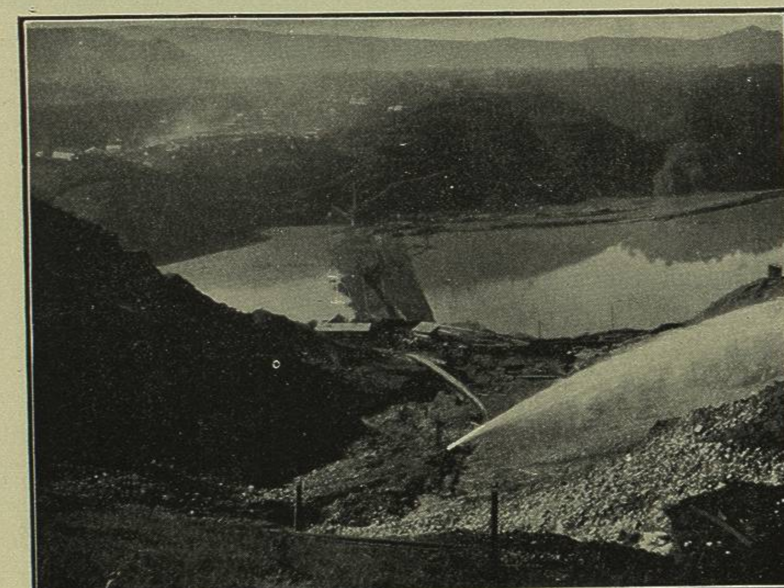

FIG. 116.—HYDRAULIC MONITOR IN ACTION, WITH 30 SECOND-FEET UNDER 180 POUNDS PRESSURE, 6-INCH NOZZLE. UP-STREAM TOE OF DAM SHOWN, WITH TAILING POND AT LEFT.

Sluice Ditch.—The supply-ditch for sluicing is 17.5 km. long, and as it passes the site of Dam No. 3 on Necaxa River, 6 miles above Dam No. 2, will furnish water for building both dams. It has a capacity of 70 second-feet as far as Dam No. 3, and 53 second-feet, the remaining distance, delivering water to Dam No. 2 at a height of 728 feet above its base. The elevation gives most effective and powerful cutting-jets at all working levels, above the crest of the dam as well as below. The ditch was extremely difficult to construct, as it was excavated on steep mountain sides in rock, requiring cement lining in many places and one long siphon with head of over 400 feet. Its total cost was about $250,000 gold, but as it can be utilized to generate 1700 H.P. after the dams are finished, its cost is not entirely chargeable to the building of the dams. The drawing, Fig. 113, illustrates the location of the dam and the general process of construction. Fig. 112 is an ideal section of the dam, showing the cut-off core-trenches, two on each side of the concrete core-wall.

Stripping Foundations.—The preparatory work of stripping at Dam No. 2 consisted of the removal of all surface soil to a depth of 2 to 3 feet over the entire base of the dam, and the excavation of all loose, pervious material over the middle third down to hard-pan or bed-rock. The hard-pan is a species of soft lava, locally called "tepetate," and

Fig. 117.—Hydraulic Monitor Working on Line of Contact between Limestone and Lava in Spillway Cut. Necaxa Dam, Mexico.

the rock is basalt that was encountered in the form of thin layers, or kidneys, disconnected and of irregular masses. The depth of this stripping in the valley was from 10 to 15 feet. It was a tedious work, occupying more than two years, part of the time with two steam-shovels and two locomotives and trains of dump-cars. Part of the material was placed at the upper and lower slopes of the dam, to the extent of 75,000 cubic yards, but the greater portion was wasted. It amounted in all to 272,487 cubic yards. The trench for the concrete core-wall was excavated to a depth of 40 feet below the stripped surface across the valley portion and from 5 to 20 feet deep on the slopes. It cut through various strata of porous, rotten tepetate, and finally ended in a hard, impervious layer. It was about 6 feet wide and filled with concrete made of

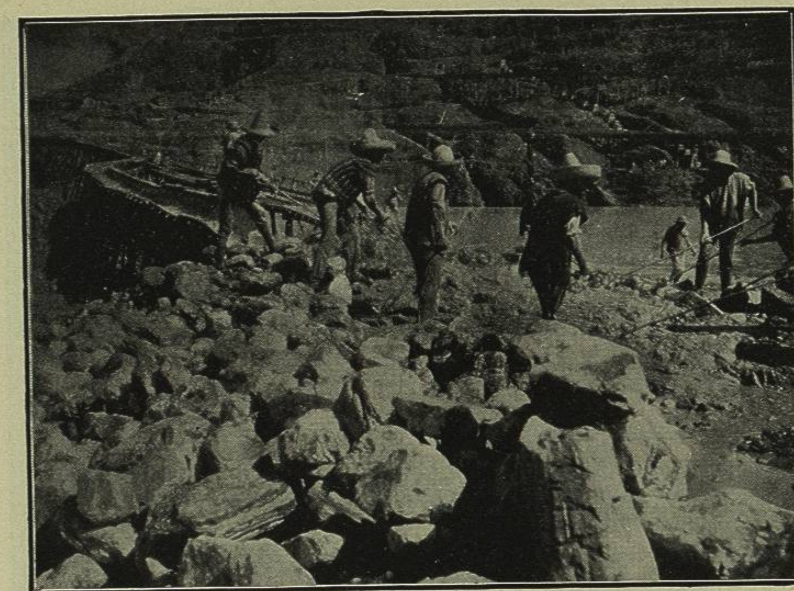

Fig. 118.—Stone Carried through Flume to Up-stream Slope of the Necaxa Dam.

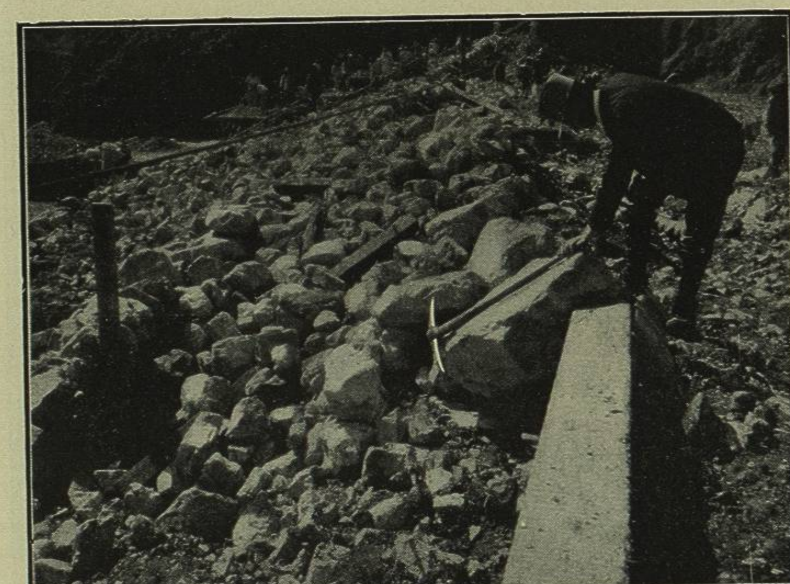

Fig. 119.—Illustrating the size of Stone delivered by Flume to the Necaxa Dam. The largest One Measured contained 18 Cubic Feet.