funds were expended. The Portland cement mill was erected at Monolith, close to the line of the aqueduct, about equidistant from the intake and outlet, adjacent to large deposits of limestone and clay and with transportation facilities that have reduced freight rates to a minimum. This mill was first fired in March, 1909, and with a capacity of 1,000 barrels per day, to January, 1, 1912, had ground 575,000 barrels.

It was found that at Monolith and two other points in close proximity to the aqueduct line there were large deposits of tufa strikingly similar to the Italian tufas used in

**Building a Concrete Siphon.**

the construction of the Coliseum and the Roman aqueducts. Tufa is a volcanic ash metamorphosed by volcanic heat and water into a white, brittle, porous rock. A year of tests and experiments demonstrated that an excellent cement could be manufactured by taking equal amounts by volume of Portland cement and ground tufa and regrinding them to a fineness of not less than 90 per cent. passing a 200 mesh screen. The seven-day test shows to the advantage of the Portland, but after that the tufa cement surpasses the Portland in breaking strength and at the end of one year, exceeds Portland by about 20 per cent. In 1909-10, therefore, tufa grinding mills with an aggregate daily capacity of 2,600 barrels were erected on the sites of the deposits.

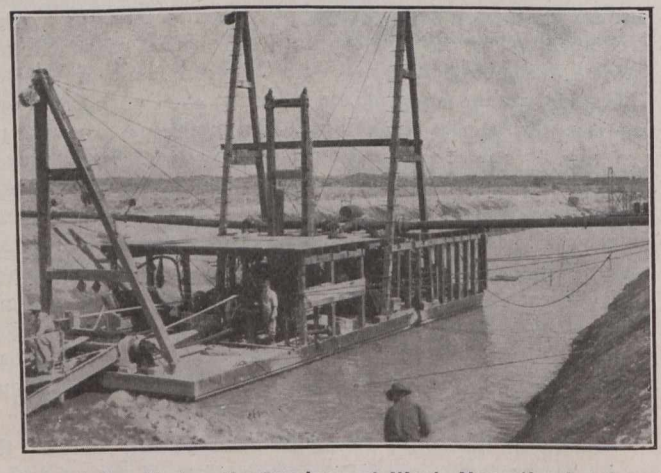
The advantage of this municipal move will be seen in a comparison of cement prices. At the time aqueduct work was started, commercial cement sold in the Los Angeles market at $2.25 per barrel. The city has been able to manufacture her own Portland cement at a cost of approximately $1.30 per barrel and the tufa cement at from 83 cents to 86 cents per barrel, besides reducing freight charges fully fifty per cent. by having two of the tufa mills directly on the aqueduct where the material was to be used. Now that the aqueduct is nearing completion the tufa mill machinery will probably be disposed of to the federal government, while it is possible that the Portland mill may be retained to furnish cement for other large public works now underway.

At the time this is being written, the most interesting phase of construction is the fabrication of the inverted steel siphons by which the waters of the aqueduct are to be carried across canons and valleys. So far as the writer knows, these huge steel pipes are the largest and longest in existence. They range in length from 611 to 15,596 feet, and in diameter from 8 feet 6 inches to 11 feet. The thickness of the steel varies from one-fourth inch to one and one-eighth inches. The aggregate length is 49,576 feet, the cost of which installed represents an expenditure of $1,400,000. The total tonnage amounts to 14,500 tons. These siphons will be under heads ranging from 75 to 450 feet.

The siphons are all of single plate construction. The material is furnished under contract and the work of erection is performed by the city. No foundry on the Pacific Coast was equal to the magnitude of the task. The plates are therefore rolled, punched and bevel-sheared, under the eyes of Los Angeles inspectors, in the steel foundries of Pittsburgh, Pa., and Camden, N.J. There they are erected section by section, given a number on a diagram showing the exact location of every plate and rivet hole in the completed structure, are then taken apart, nested on flat cars and dispatched to the railroad station nearest the point of their destination on the Mojave Desert. From here they are freighted by twelve mule team wagons from 5 to a maximum of 30 miles to the point of erection where the diagrams have already preceded them. Here they are lifted by aerial trams to their place along the canon wall and are riveted into place. Twenty-four-inch double disk gate valves are placed at the lowest points of the siphons, first, for cleaning purposes, and secondly, to divert the flow of the aqueduct into natural water channels should a break occur in the conduit high along the mountainside to the south of them. This work is proceeding simultaneously at seven different points and should be completed during the second week in January.

Where the head is low, concrete siphons are used in place of steel on account of the cheaper cost. These pipes, used also in the approaches to the steel siphons, are 10 feet in diameter, strongly reinforced with steel and constructed of very rich cement. The illustration shows the manner of reinforcing.

For the partial development of the hydro-electric power, the city voted $3,500,000 in the spring of 1910. While the aqueduct is being built primarily for a domestic water sup-



**One of the Hydraulic Dredges at Work Near the Intake of the Aqueduct.**

ply this feature in point of revenue is by far the most important. The Board of Electrical Engineers reported in 1910 that a maximum of 99,000 kilowatts, or 120,000 horse-power, can be generated from the aqueduct with all conditions present for reliability of service and favorable low costs of operation. Owing to the regular and assured flow through the aqueduct, they reported that in their opinion no reserve steam plants are necessary and that from this and other favorable conditions, one of which is that the major part of the electric energy can be developed in close proximity to