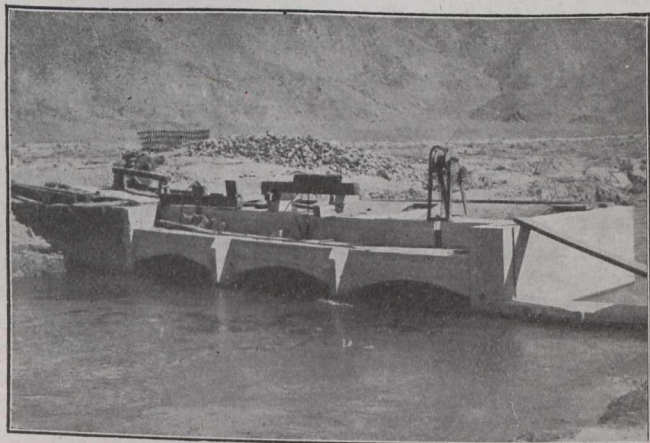


large reservoir sites have been surveyed as a part of the general plan of irrigation, but no work has as yet been undertaken on their construction.

The most important phase of the work, in fact one of the controlling factors in the completion of the aqueduct, was the Elizabeth Tunnel. This tunnel was "holed" March 1st, 1911, nearly a year in advance of the estimated time required for its excavation. This tunnel, the second longest water tunnel in the United States, was driven 26,870 feet through the hard gneiss rock of the Sierra Madre range in



The Intake of the Los Angeles Aqueduct, Eleven Miles North of Independence, California.

the short space of 1,240 working days. The average rate of progress from each portal was approximately 12.36 feet per day. United States tunnel records were repeatedly broken, that of 449 lineal feet in a thirty-day month from a single heading being advanced to 604 feet for the same interval. The work was carried on continuously in three eight-hour shifts from opposite sides of the range, the excavation being accomplished with Leyner drills driven by compressed air, and the muck handled by electric motor railways. Throughout the task, the work, excepting at the very start, when crude methods were adopted until the arrival of proper machinery, the most modern electrical equipment was used. The underground and surface forces at each portal averaged 100 men throughout the drilling. From the north portal the progress was made exceedingly difficult by water pockets and swelling earth, and heavy timbering was required. From the north portal 13,500 feet were driven and from the south portal 13,370 feet. The centre lines of the tunnel met within 1 1/8 inches and the grades checked to five-eighths inches. The estimate of cost for the completed tunnel was \$75 per lineal foot, or \$2,015,250. The actual cost of boring and concreting has been \$50.69 per foot, or a total of \$1,362,040, which is \$653,210 below the amount set aside for the purpose. Concreting is now nearing completion.

Including the construction of the Elizabeth Tunnel, the tunnel work of the aqueduct until the first of this year has progressed at an average rate of one mile of tunnel excavation per month.

The mechanical excavating equipment for conduit and canal excavation consists of two powerful electric dredges which have now completed their work in the Owens Valley, 13 steam and electric power shovels and one giant excavator. The labor force has ranged from 2,500 to 4,300 men, during the summer season it being difficult to obtain laborers who were willing to go out on the desert.

The hospital department, as well as the commissary were let by contract, the city receiving no financial return and having the privilege of terminating the contracts upon 30 days notice if the city's standard of board, medical and

sanitary care of men and camps is lowered. The men pay \$1 per month for medical attendance and board is furnished at the rate of 30 cents per meal. Rates of pay for day labor have ranged from \$2 to \$2.75 for eight hours' work, depending upon the labor market as well as the character of the labor. Miners and mechanics have received from \$3.50 to \$3.75 for eight-hour shifts and formen \$3.50 to \$4.50 per day.

With the exception of one small contract representing three per cent. in point of distance and which was in easy construction, all the work has been done directly by city forces from engineers down to day laborers.

On this work, also, the city of Los Angeles for the first time in American municipal history inaugurated the bonus system of payment. Its success surpassed the most sanguine expectations of the city's engineers. Whether it is in conduit excavation, concrete lining, tunnel boring, siphon building or whatnot, the chief engineer sets as a basis of bonus payment, dependent upon the classification of the particular piece of work, the average progress that should be made by the crew or gang in a ten-day period. For all in excess of this amount, each man participating in the work, in addition to his daily wage, is paid an established sum proportionate to the progress made. On the Elizabeth tunnel, for example, miners were accustomed to receive monthly pay-checks which, with their bonus, ranged from \$140 to \$170, and muckers and other laborers' checks were in proportion.

This system has brought out the best that was in every man because, in the hope of personal reward, there has been an incentive for him to do his best. Moreover, it created a rivalry between each of the fifty camps and brought an organization of unusually high efficiency. As drones retarded



Showing Completed Tunnels.

the work, delayed progress and so cut down the bonus payment, the workers of their own accord drove out the drones. The working out and development of the system has excited a great amount of interest from engineering publications, engineers and municipal officials throughout the United States.

Another phase of unusual municipal activity in connection with this enterprise has been the building and operation of cement mills and the introduction and use of tufa cement. In this phase of the undertaking, \$875,000 of the public