tinuous work completed the main arch. The supplementary arches, designed as flat slabs, but having curved lower line to conform to the appearance of the arch, were poured three days later.

A strike was called the day before concrete was poured, to force salary payments to be made on Saturday night so that the money could be used in betting in the cockpit on Sunday. This Saturday happened to be the 15th of the month. The 17th was regular pay day. Although pay rolls were made out and the cash was in the safe at the office, it would not be policy to give in to their demands. Out of 250 men only 29 went to work. About 4 p.m. these 29 were paid and the others, although expecting their money too, were compelled to wait for the regular time. In order to be sure of enough men to complete the job, the presidente of the town was told that, unless he saw to it that the men were there for work on Monday a.m. we would get men of another tribe to do the work and the town would lose both the personal taxes and the wages of their own men. That settled our labor troubles for all times in that town.

The bridge was opened for traffic forty-two working days after the first gang started work, and the total cost was about $3,000. Cement hauled fifteen miles up country on bull carts, after a trip from China to Manila and Manila to Lagaspi, the port town, costs $3.33 per barrel. Oregon pine for forms cost about $36 per thousand, but as it could be used over several times on other work, it was not charged entirely to this job.

MODERN WATERWORKS PUMPING ENGINES: THEIR COST AND EFFICIENCY.

Four distinct types of engines (all condensing) have been developed to suit the various conditions imposed. Their costs, including foundations, piping and appurtenances, per million gallons per 24 hours' capacity, under average conditions, are as follows:

1.—Compound low-duty horizontal engines.....$23.00
2.—Triple expansion low-duty horizontal engines..... 28.00
3.—Cross-compound horizontal engines..... 33.00
4.—Triple expansion high-duty vertical engines..... 48.00

The first two are non-rotative or "direct-acting" machines; the third and fourth are of the crank and flywheel type.

The cost of boilers with mechanical stokers, feed pumps, etc., ready for service will be covered by $20 per boiler h.p., based on the following average operating conditions: Water load against plungers, including suction and friction, 90 lb. per sq. in (= 207 ft. head); evaporation, 8 lb. per lb. coal, with feed at 150 deg. F., coal costing $3 per 2,000-lb. ton; steam pressure (gauge) at throttle valves of engines: 75 lb. for type 1, 125 lb. for types 2 and 3, and 150 lb. for type 4; boiler pressures 5 lb. higher.

Under present circumstances of unit capacity, cost of construction, economy of operation, space required, etc., water-tube boilers fitted with automatic stokers and damper regulators take the lead as steam generators for waterworks pumping engines. The practical relation between the economic duty of a pumping engine and the amount of boiler capacity required, is shown in Table I., which is based on the fact that in good ordinary practice 1 sq. ft. of heating surface will evaporate 3 lb. of water per hour from a feed temperature of 150 deg. F. into steam at 130 lb. gauge pressure; 10 sq. ft. of heating surface evaporating 30 lb. of water per hour, which is taken as 1 boiler h.p.

Table I.—Boiler H.P. Required for Each Pump H.P., Counting 10 Sq. Ft. of Heating Surface Per Boiler H.P.

Duty in ft.-lb. per 1,000 lb. of dry steam.	Boiler H.P. per pump H.P.
40,000,000	1.63
50,000,000	1.32
60,000,000	1.10
70,000,000	0.94
80,000,000	0.83
100,000,000	0.66
120,000,000	0.55
140,000,000	0.47
160,000,000	0.41
180,000,000	0.37
200,000,000	0.33

With boilers properly constructed and arranged, the values in this table will answer all reasonable purposes. If, however, caution of some special reason should suggest an increase in heating surface, any desired percentage of increase may be readily added without disturbing the relations of the different rates of economy. For example, if an evaporation of 2 lb. per sq. ft. be taken as the limit, the values in Table I. should be multiplied by 1½.

The limits of steam economy in the pumping engine are about reached, both theoretically and practically. The highest duty record was attained in 1906, being 181,068,605 ft.-lb. per 1,000 lb. of dry saturated steam. The leading type is a vertical triple-expansion condensing engine, with outside-packed plungers, mostly of the crank and flywheel type.

Table II. gives unit costs of pumping stations which are closely approximated and largely based on records. The figures given are for the best types of modern triple-expansion engines and high-pressure boilers; well-designed buildings of brick or stone (where the latter is cheap) with steel-trussed and slate-covered roofs; adequate chimneys; and intakes properly proportioned and thoroughly screened. The figures in the table, which include the cost of everything except the land, are so closely calculated, that an engineer or contractor should hardly guarantee the production of results without investigating each case independently.

Table II.—Cost of Complete Pumping Stations.

Pressure of water load pumped against, lb. per sq. in.	Cost of plant per million gallons capacity, including reserve.
30	$ 6,750
40	7,000
60	7,500
80	8,000
100	8,500
120	9,000
130	10,000

If there was no necessity for the use of steam jackets the duty per 1,000 lb. steam would approach 200,000,000 ft.-lb., and if superheating can save jacket steam and vitalize the working steam in the cylinders, this figure may be reached in the near future, in official tests, at least. Otherwise the upper limit has about been reached.

There are only two important items which grow less by higher duty—the coal account and the fixed charges on the boiler plant. Everything else increases except the wage account for equal capacities; with large high-duty triple engines this is somewhat less in the fire-room, because less coal needs to be handled in proportion to the pumping. The items in favor of high duty are maintenance, interest and sinking fund on boilers, and the coal account. Those against high duty are maintenance, interest and sinking fund on machinery, and the cost of oil, waste, packing, etc.