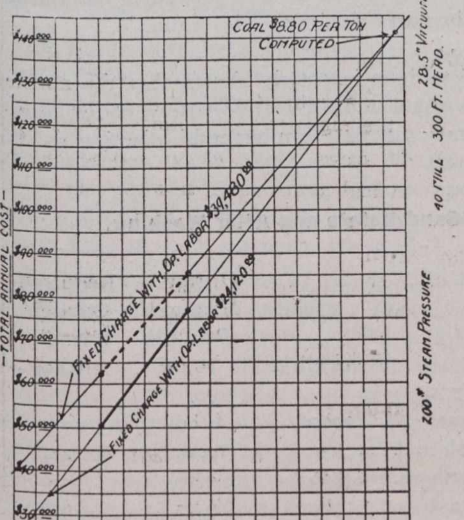
Tabulation "B."

20,000,000 Gallons per Day, 280-ft. Head, 981 w.h.p

Item.	Vertical C. & F. W. Triple Expansion, 165,000,000 Duty, 3 225-h.p. Boilers.	Steam Turbine Centrifugal, 120,000,000 Duty, 3 300-h.p. Boilers.
Cost, pumping unit	$120,000	$26,000
Interest, depreciation, etc., 10%	12,000	2.600
Cost, boilers	20,250	27,000
Interest, depreciation; etc., 17%	3,700	4,590
Labor, three shifts—		
Engines	2,700	2,700
Boilers	1,800	1,800
Total int., depreciation, etc., and labor	19,940	11,690
Fuel cost, $2 coal	13,570	18,630
Fuel cost, $3 coal	20,335	27,945
Fuel cost, $4 coal	27,140	37,260
Total annual cost, $2 coal	33,510	30,320
Total annual cost, $3 coal	40,275	39,635
Total annual cost, $4 coal	47,080	48,950

We believe it can be assumed safely that the development of pumping machinery in the future will be along somewhat the same lines as the development of power-producing machinery. At the present time one of the most noticeable features in the development of power machinery is the increasing favor with which larger units are being adopted. In large central station work five years ago, the ordinary size of unit was from 10,000 to 15,000 k.w. Now, not only in European practice, but also in American practice, 25,000 k.w. units are being installed in the larger stations. There are two reasons for this development, the first being the continual endeavor to obtain better economy, not only in actual steam consumption, but in capital charges, including first cost, buildings, real estate, etc. The second reason for the development along this line comes from the fact that engineers of to-day seem to have more initiative than formerly, and where before the development of a 15,000 k.w. turbine would have seemed an impossible task, now the installation of 25,000 k.w. turbines is becoming a matter of course.



Comparisons of Cost of Steam Turbine and Triple Expansion Engines, Large Plants.

We have assumed that there will be progress along this line in waterworks pumping machinery, and that installations of very large units will be made in the future. We have evolved a comparison between two units of the types under consideration, each having a capacity of 40,000,000 gallons per 24 hours, against a total head of 300 feet. This comparison is based on utilizing the greatest range of steam temperature which the best modern practice has established as commercially practicable, and which at the same time is not too intensely theoretical. We refer here to European practice, in which steam pressures of 200 pounds, 275 degrees superheat and 28.5 inches vacuum are successfully and commercially utilized. Especially important in this connection is the item of high vacuum, since in the case of waterworks large quantities of water are always available for condensing purposes.

Extremely large capacities and high heads present no difficulties nor disproportionate costs in the construction of steam turbine-driven centrifugal pumping units, since it is an inherent characteristic of the centrifugal pump that the larger the capacity, the greater the efficiency for a given head.

There is practically no development necessary on the turbine to take advantage of these conditions, as the turbine of almost exactly the same characteristics that would be necessary for this installation is now in successful operation in hundreds of power-producing plants to-day. We have had to assume no steam consumption, as this is a matter of test, and practically have had to assume no pump efficiencies, as we have taken the minimum which we know can be obtained on this size pump.

Further, the turbine is well adapted to take advantage of the improvement in steam conditions as mentioned above, and reciprocating engines can also be designed as to take advantage of the initial and terminal conditions favoring high economy.

The results of this comparison are shown in Table "C." It is apparent from these tables that the point at which the two curves of overall economy of the two units cross is at a cost of approximately $8.80 per ton for coal.

It would appear, therefore, that the field of these large capacities at high heads for ordinary coal costs belongs to the turbine-driven centrifugal pump exclusively.

Tabulation "C."

40,000,000 gallons per day, 300-ft. head, 2120 w.h.p., 200 lbs. steam pressure. 275 deg. F. superheat. 28.5 in. vacuum.

Item	Vertical C. & F. W. Triple Expansion, 223 000,000 Duty, 3 350 h. p. Boilers	Steam Turbine Centrifugal, 193,000,000 Duty 3 400 h. p. Boilers.
Cost, pump	$210,000	$55,000
Interest, depreciation, etc., 10%	21,000	5,500
Cost, boilers	31,500	36,000
Interest, depreciation, etc., 17%	5,360	6,100
Labor, three shifts—		
Engines	7,200	7,200
Boilers	5,320	5,320
Total int., depreciation, etc., and labor	39,480	24,120
Fuel cost, $2 coal	23,265	26,800
Fuel cost, $3 coal	34,897	40,200
Fuel cost, $4 coal	46,330	53,600
Total annual cost, $2 coal	62,475	50,920
Total annual cost, $3 coal	74,377	64,320
Total annual cost, $4 coal	85,810	77,720

In conclusion, if the above data are correct—and it has been our sincere endeavor to present only such figures as are fair for both types of machines—it would seem that the steam turbine centrifugal pumping unit must be conceded a place of primary importance in the field of waterworks engineering.