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Design of Motor-Driven Centrifugal Pumps

Typical Characteristic Curves for Different Types Under Identical Conditions—Non-Overloading Pump Shows Maximum Efficiency When Motor Is Under Maximum Load—Induction Motor Designed Under Full Load Conditions Is the Most Economical Drive

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WATER works engineers who have to prepare specifications for pumping units consisting of centrifugal pumps direct-connected to electric motors, have many problems to solve which are not clearly understood by either young electrical engineers or young hydraulic engineers.

The quantity of water required per day and the pressure required at the pump have first of all to be decided upon.

The quantity of water required is controlled by the size of the population to be served and is easily ascertained.

TYPICAL CHARACTERISTIC CURVES OF DIFFERENT TYPES OF PUMPS

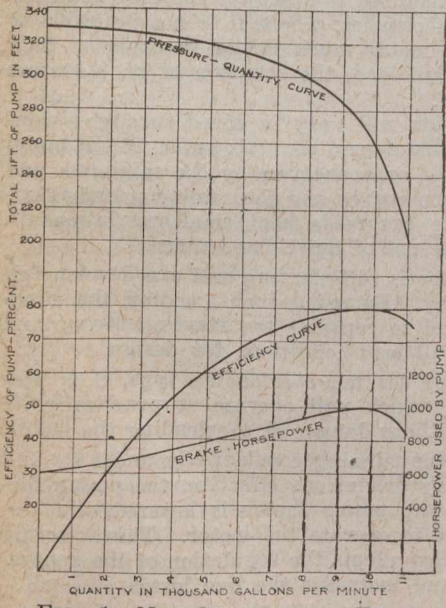

FIG. 1—NON-OVERLOADING TYPE

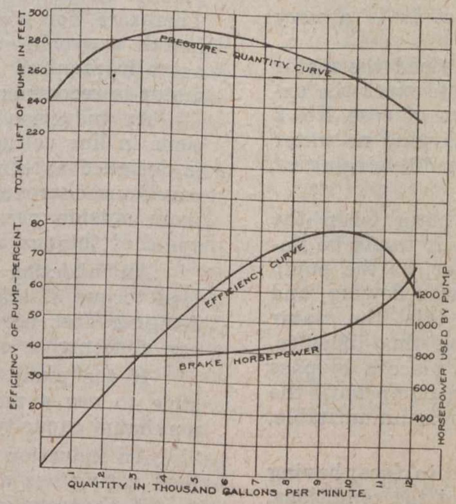

FIG. 2—RISING CHARACTERISTIC TYPE

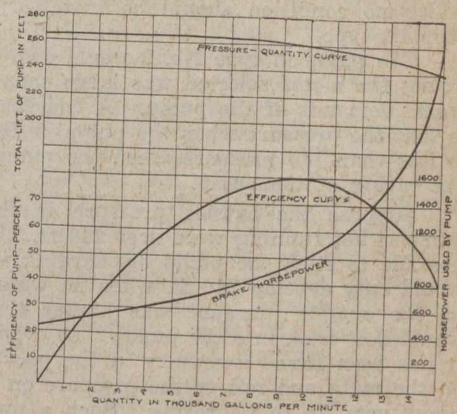

FIG. 3—FLAT CHARACTERISTIC TYPE

The pressure required at the pump should be selected to supply water at sufficient pressure at the most remote or highest point on the service under conditions of maximum consumption over the service. This is a problem of pipe friction and other losses. Where a reservoir exists on the service, the reservoir acts as a governor and the pressure developed at the pump must be sufficient to overcome all friction losses in the main or mains, and maintain the level of the water at normal elevation in the reservoir.

In a city where several pumping units serve one reservoir through certain mains, and it is desired to place an additional unit in the service, it is essential that a new main be also installed of sufficient capacity to carry the additional water pumped by the new unit, otherwise the existing mains would require to carry the additional water from the new unit as well as that from the existing units. This condition would create a much larger friction loss in the mains and the pumps would require to develop a larger pressure to overcome this loss. However, these are well-known facts and do not require to be discussed in this paper.

It is supposed that the water works engineer has decided on the rate of flow required and on the head to be developed. He has now to decide whether he shall specify the motor and pump in separate specifications. If he does so, he is accepting all responsibility that the two will work in harmony, and unless he is familiar with the characteristic curve of the pump and his specifications are rigid enough to force the manufacturer to adhere to the curve, he will run into difficulties.

Let Figs. 1, 2 and 3 represent typical characteristic curves of different types of pumps. Suppose these pumps are running under identical conditions and discharing 10,000 gals. per min. against 260 ft. head, and that the efficiency in each case is 80% as shown by efficiency curves.

Let the pressure at each pump fall to 240 ft. head. This might be caused by a fall in level of the reservoir, caused by a sudden demand on the system. Under this new balanced condition, pump No. 1 will deliver 10,400 gals. per min. at 240 ft. head; pump No. 2, 11,600 gals.; and pump No. 3, 15,100 gals.

Under the first condition, the horsepower used in each case was $10{,}000 \times 10 \times 260/33{,}000 \times 0.80 = 1{,}000$.

Under the new conditions the horsepower used in case No. 1 was $10{,}400 \times 10 \times 240/33{,}000 \times 0.795 = 950$ h.p., where $10{,}400 \times 10 =$ weight of water in lbs. per minute; 240=feet through which water is raised; 33,000 footpounds per minute =one horsepower; and 0.795=efficiency of pump.

In case No. 2 the horsepower used was $11{,}600 \times 10 \times 240/33{,}000 \times 0.68 = 1{,}240$ h.p.

In case No. 3 the horsepower used was $15{,}100 \times 10 \times 240/33{,}000 \times 0.40 = 2{,}740$ h.p.