charge pitometer tubes were in each case tapped into their respective pipes as close to the suction and discharge flanges of the pump as possible, and care was taken to see that the inner tips of the tubes did not project beyond the inner surfaces of the pipes. In determining total head, correction was always made for the vertical distance between the center of the pressure gauge and the point at which the suction gauge was tapped into the suction pipe. Where a mercury manometer was used on the pressure side, correction was made for the water column in the manometer. The variation of head was obtained by the use of a gate valve in the discharge line of the pump, the throttling effect giving the equivalent of increased head. The speed of the pump was measured by a Schaeffer and Budenberg Tachometer belted directly to the shaft of the pump. The power for driving the pumps was a three phase induction motor located on a track on the surface near the edge of the pit, so that the drive was in all cases directly from the motor to pump without the use of a jack shaft. The power input to the pump was determined by the use of two Western Electric single phase indicating wattmeters and multipliers connected in the usual way. The power output of the motor was determined by putting a friction brake on the motor pulley and determining for different brake loads the indicated wattage from which a curve was drawn with indicated wattage as one ordinate and brake horse power of motor as the other thus enabling a knowledge of the power being delivered by the motor to be obtained immediately from the readings of the wattmeters. There was thus provided a most efficient and accurate means of measuring the power input to the pump, the loss by belt transmission being regarded as negligible and because of the construction of the pumps entirely unavoidable. The measurement of the pump discharge was based upon the flow over a standard trapezoidal weir cut in a sheet of No. 16 galvanized iron. The weir notch was located at the front end of the galvanized iron tank into which the water was discharged by the pump through a flume leading to the rear end. A series of baffles erected vertically and a number of large pieces of wood floating behind the baffles and first receiving the impact of the water discharged into the tank were found ample to reduce the disturbance back of the weir so that the depths on the crest of the same could be determined by a hook gauge. Such precautions insured the determination of flow to well within the recognized limits of accuracy of weir measurements, in other words the flow of water was determined to within probably 2 per cent. or at the outside 3 per cent. of accuracy. The water after passing over the weir was discharged directly into the suction tank, so that no variation of level in the suction tank could occur and the only variation of suction head was that resulting from the increased friction head as the discharge of the pump increased.

Table 2.

Plant No.	Size and Type of Pump.	Rated Capacity. G.P.M.	Actual Measured Maximum Capacity G.P.M.
1	5 inch—vertical two stage.......	700	350
2	6 inch—horizontal single stage..	1000	800
3	3 inch—horizontal single stage..	225	250
4	5 inch—horizontal single stage..	700	272
5	5 inch—vertical single stage.....	1000	830
6	4 inch—vertical single stage.....	400	325

After being overhauled, cleaned and packed, each pump was mounted securely upon timbers spanning the suction tank, and suction and discharge piping of size suited to the pump was attached. Suction and discharge pressure gauges were tapped in as before described. The tachometer was belted directly to the pump shaft by pulleys giving proper speed ratios. Using a belt of constant length and shifting motor on its track, different sized pulleys were placed in succession on the motor shaft and pump shaft so that the pump could be run at several constant speeds, the motor speed being constant and invariable except, of course, with the slight changes in frequency. For each speed the gate valve in the discharge pipe was first opened wide, thus giving the lowest total head and maximum discharge obtainable, after which the valve was closed tight to secure the head which the pump could maintain without discharge. Between these two limits several runs were made in each case to give the various discharge heads by different openings of the gate valve. Upon the completion of such a series the pump speed was changed by changing the motor pulley and the foregoing repeated. Previous to and after each run at a given speed the power was measured which was required to drive the pump empty or without priming. This was designated as mechanical friction loss or the power lost in the pump bearings and in windage.

Each pump was operated under identically similar conditions and all measurements were made with the same apparatus. The results should, therefore, it would seem, give a reasonably accurate idea not only of the absolute but also of the comparative merits of the different makes and types of pumps tested.

The conclusions reached may be stated as:—

(1) The capacity of a centrifugal pump is a variable, depending upon the speed at which it is run and the total head against which it operates. Conversely, every centrifugal pump when run at a certain speed will give a certain discharge at a certain head. If the speed be increased with the head constant, the discharge will be increased according to a definite law, and if the speed be constant and the head decreased, the discharge will generally increase. But every pump has certain conditions under which it works best, as shown in the following conclusion:

(2) Every centrifugal pump has a definite head for different speeds at which it operates most economically from the standpoint of fuel cost, and in order to force the water to this head this speed should be used if, as is frequently the case, the cost of power is the most important factor in the total cost of operation.

(3) The ratings of centrifugal pumps as given in the manufacturers' catalogs or circulars are incomplete and often misleading in the determination of the proper size of a centrifugal pump for a given lift and capacity. In some cases the rating is apparently based on the maximum quantity of water the pump will discharge which may be at a very high speed and low head. Very frequently the rating is given in terms of "economic capacity," which is probably a term of doubtful meaning. Instead of rating pumps by the so-called "economic capacity," it would greatly add to the advantage of the prospective purchaser if the manufacturer should publish tables or exhibit curves based on reliable tests from which one might choose the size of pump and determine the speed which would give the greatest economy or highest efficiency for the desired discharge at the given head.

(4) Centrifugal pumps of the types and sizes used in small irrigation pumping plants are machines of markedly low efficiency as usually operated, and in figuring on the power requirement with ordinary stock pumps, one must expect that from one-half to two-thirds of the power of the engine or motor will be wasted in water friction and churning effects within the pump and in mechanical friction in its bearings and stuffing boxes.