13th September, 1917.

NOTES ON AN ELECTRICALLY DRIVEN HYDRAULIC PUMPING PLANT.

By H. Kidd.

At the request of the President to write a short paper for this session, I thought it might interest members to have a description of the Electrically-driven Hydraulic Pumping Plant installed in Messrs. A. Hordern & Sons, Ltd., Palace Emporium Building, George-street, for supplying power water for working fourteen passenger and eleven goods lifts, also two hydraulic whips.

It will interest members to know that this hydraulic pumping installation was designed by the late Norman Selfe, an esteemed past-president of this Association. The pumps and accumulator were made by Messrs. Henry Vale & Sons, engineers, Auburn.

The first set of pumps was installed in February, 1913, and has been in constant use since that date. The second set of pumps, from the same design, was installed and tested about two months ago.

The complete plant consists of two sets of Duplex Pumps, each having two pairs of single acting plungers working back to back, connected by wrought iron crossheads and side rods. The No. 1 set of pumps is driven by a Lancashire Company's Open Type Motor, Compound Wound, fitted with interpoles, and arranged for variable speed work from 300 to 900 R.P.M., the compound winding after starting being cut out when the motor reaches minimum speed.

The motor is capable of developing 100 B.H.P. on a 480 volt D.C. circuit, one hour rating, and is connected with pinion shaft by a flexible coupling, and geared to pump crankshaft by single reduction double helical gear—Citroen type. The motor pinion is machine cut from a solid forging of vanadium steel, and contains 12 teeth $1\frac{3}{4}$in. circumferential pitch and $7\frac{5}{8}$ face. The main wheel on pump crankshaft, into which the pinion gears, is of cast iron, and contains 154 teeth.

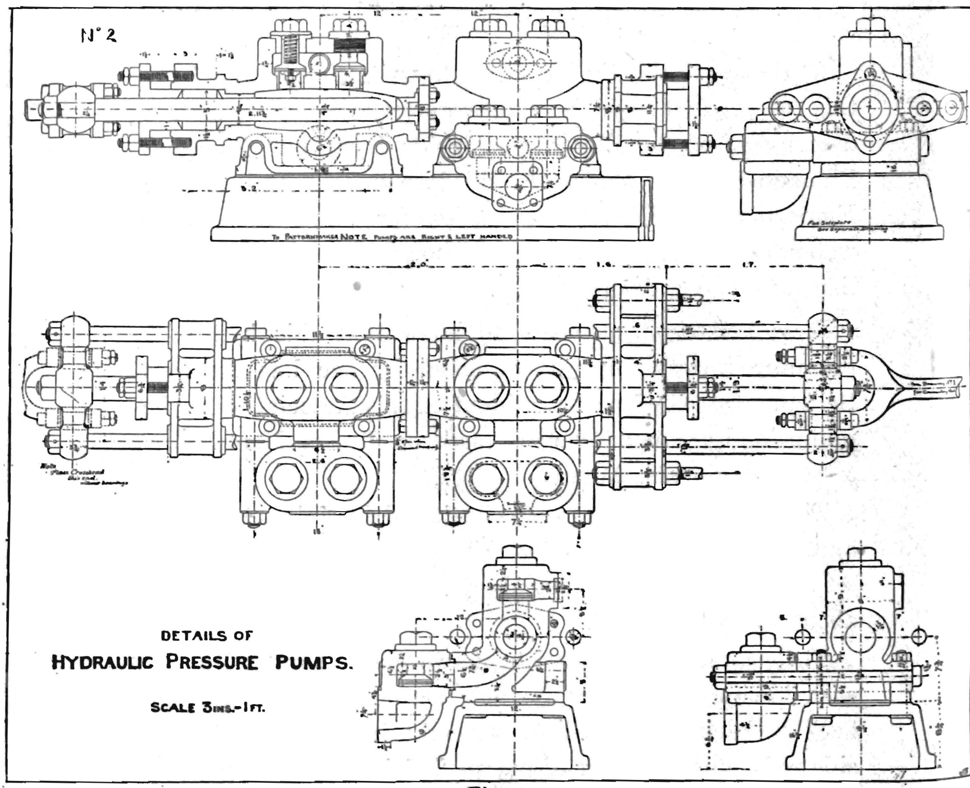

Fig. 1

The No. 2 set of pumps is driven by a Phoenix Co.'s Open Type Motor, Compound Wound, fitted with interpoles, and arranged for variable speed work from 300 to 900 R.P.M., the compound winding after starting being cut out when the motor reaches minimum speed. The motor is capable of developing 110 B.H.P. on a 480 volt D.C. circuit, one-hour rating, and is connected with the pinion shaft by a flexible coupling and geared to pump crankshaft by single reduction double helical gear—made by David Brown & Sons, Huddersfield. The pinion is machine cut from a solid

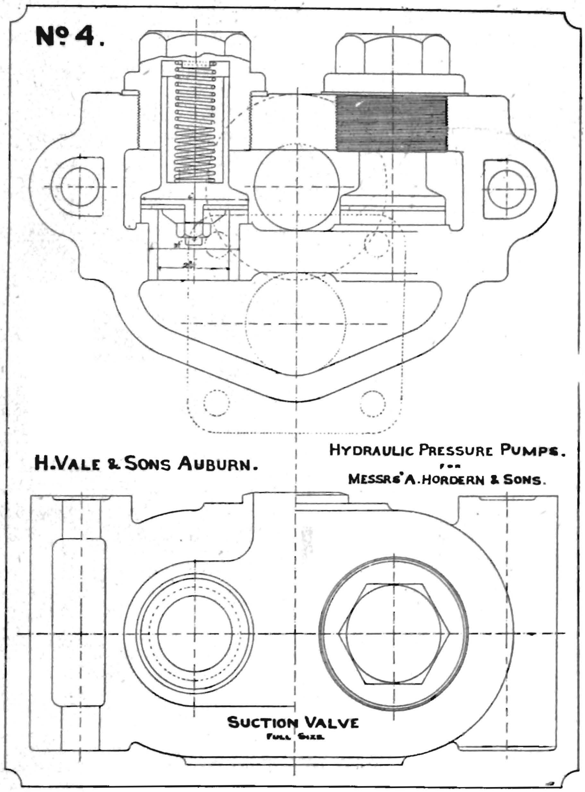

Fig. 2

forging of high carbon steel, and contains 12 teeth $1\frac{3}{4}$in. circular pitch x $8\frac{3}{4}$in. face. The main wheel on pump crankshaft into which the pinion gears is of cast iron, containing 154 teeth.

The ratio of speed variation is the same in both sets of pumps, and gives a maximum speed of 70, and a minimum speed of 23.4 R.P.M., the corresponding plunger speed being 175 and 58.5 feet per minute.

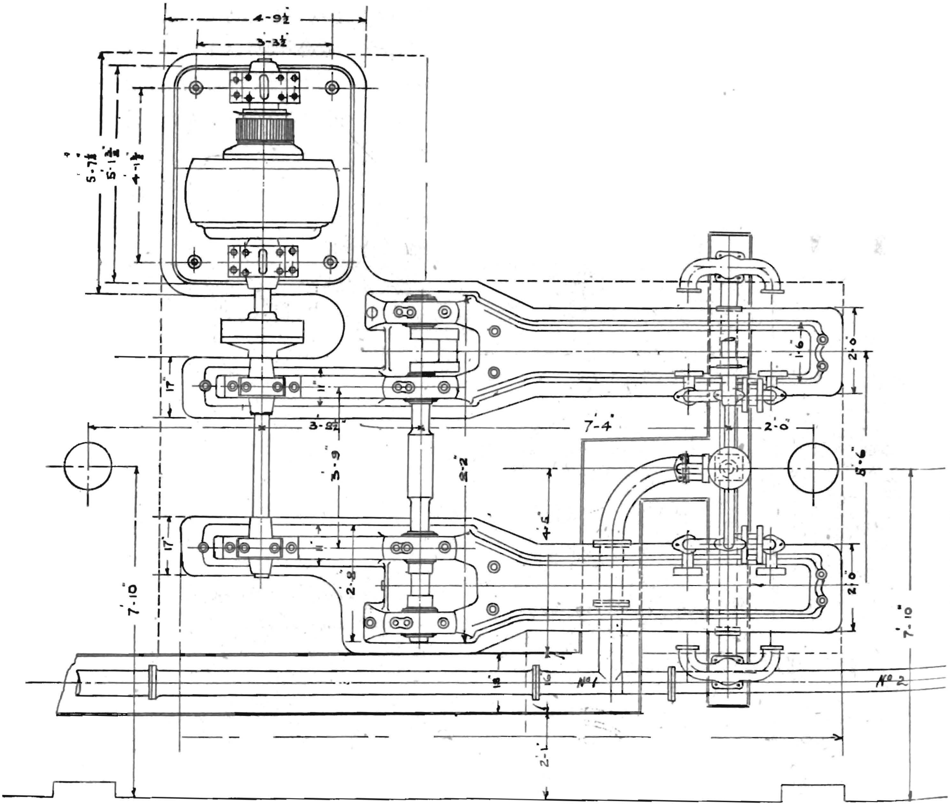

Fig. 3

The pumps draw their water supply from an overhead tank of 1,000 gallons capacity, situated in engine-room. The pressure water, after being used to actuate the lifts, is returned to the overhead supply tank, and is circulated through the system as required, being used over and over again. The pumps deliver the water at a pressure of 750 lbs. per square inch into the accumulator, which is 14 inches diameter x 20 feet stroke, loaded with cast-iron weights, and fitted with guides and the necessary safety and stroke limit valves.

REGULATION AND CONTROL.

The motor starters are automatic, and are designed for use with the 100 and 110 B.H.P. motors on 480 volt D.C. circuit. They are designed to permit of being operated frequently; the resistance and contacts are large enough for starting the motors against full load, and are arranged to cut out compound winding when motors are up to minimum speed.

The shunt regulators are designed to give the specified speed variation for continuous working, and are fitted with sprocket wheels for moving the brush over the contacts. The sprocket wheels are actuated by a rope wheel on the end of the main sprocket wheel shaft, the rope being arranged to make contact with the crosshead of accumulator by suitable tappets.

For speed regulation purposes the stroke of the accumulator is divided into three parts. The first contact is 5ft., the second contact 15ft., and the third contact 20ft. from bottom. When the accumulator ram rises to the full 20ft. stroke from the bottom, it opens a bye-pass valve and allows the pumps to run without load; but as soon as the accumulator ram falls about an inch the bye-pass valve is closed, and the pump discharges into the accumulator.

When starting the pumps to work the accumulator ram is at the bottom of its stroke, and switch and controller are cut out, the main switch is closed, and the motor is run at the slowest speed while pumping up the accumulator. When the ram reaches the limit of its stroke it automatically cuts in the speed controller, and the pumps continue to work at their bottom speed until the lifts commence to work.

When the demand for power water by the lifts is greater than the pumps can supply at bottom speed, the ram descends until it reaches the 15ft. point. The regulator then comes into action, and steadily increases the speed of the motor and pumps to meet the increasing demand for water by the lifts.

The resistance in the controller is divided into 60 sections with corresponding contacts, and as the speed variation is from 300 to 900 R.P.M., $\frac{900-300}{60}=10$ R.P.M. variation for each stop; or an increase of 10 R.P.M. for each two inches of the descent of the ram until it reaches the 5ft. point, when the motor and pumps are running at top speed, and continue to do so until the pumping capacity of the pumps overcomes the demand and raises the accumulator ram above the 5ft. point, the controller again comes into action, and controls the speed of the motor and pumps to correspond with the demand made by the lifts.

There are two speed controllers, one for each motor and set of pumps; both are driven from the main sprocket shaft, and worked simultaneously, but only one of them is in electrical operation, controlling the speed of the motor and pumps that are supplying the demand for power water. The other controller is arranged so that it can be switched on to start the other set of pumps when the demand for power water is greater than one set of pumps can supply at maximum speed.

The maximum demand for power water during the busy part of the day is at the rate of about 7,500 gallons per hour, and the average daily demand is about 4,200 gallons per hour. When a sudden demand for power water occurs, the pumps accelerate in speed rapidly. To obviate severe shocks to the pumps and discharge pipes, caused by the rapid acceleration of speed, a cushion chamber is connected with the discharge pipe close up to the pumps; the plunger of the cushion chamber is spring loaded to a pressure of 750 lbs. per square inch, and is free to move under severe shock.

Dimensions: Plungers, 3¼in. diameter, 15in. stroke.
Accumulator, 14in. diameter, 20ft. stroke.

Careful records are kept of each day's work, a Watt meter records the quantity of current consumed, and the quantity of water pumped is measured by a water meter fitted on the return water pipe. A revolution counter is fitted and connected with the crankshaft of pumps to record the number of revolutions made during the day's run. As a check on the accuracy of the water meter the pumps are occasionally calibrated by noting the number of revolutions required to pump a given quantity of water into the accumulator.

The records of the years 1916 and 1917 show an average of 120 gallons of power water pumped per unit of current consumed.

With current at 1½d. per unit the cost of pumping 1000 gallons of power water is 12½d.

The average quantity of current used per day for years 1916-17 is 358.6 units: $\dfrac{358.6 \times 1.5}{25 \text{ lifts}} = 21.5\text{d. lift per day.}$

The principal feature of the installation is the method of regulating the speed of the motors and pumps to meet the varying demand for power water, so that little or no water is allowed to circulate through the bye-pass valve.

It is a difficult matter to shew the working of the controller arrangement diagramatically, but Mr. S. Hordern will be pleased if any of the members who are interested in the subject will visit the engine room after the present labor unrest has settled down and the plant is again in operation.

I have to thank Mr. Samuel Hordern for permission to present these notes, and Mr. Noel, the Chief Engineer, for his assistance in preparing them.

Mr. TOURNAY-HINDE said: I have listened with considerable interest to the description of the electrically-driven hydraulic pumping plant at Messrs. Anthony Hordern & Sons' engine room. As stated by Mr. Hector Kidd, this plant was designed by the late Mr. Norman Selfe, M.I.C.E., shortly before his death. I have also had several opportunities of seeing the plant in operation, and the way in which the plant responds to the varying calls upon it is remarkable, and can only be appreciated properly by inspection. When one considers that when designing the plant Mr. Norman Selfe must have had to forecast the probable consumption of water to operate the lifts at various periods of the day and loading, and that such forecasts would have to be compiled from human estimates and records instead of from actual charts, the remarkable accurate proportioning of the motors and pumps to the work to be done reflects the greatest credit on the genius of Mr. Norman Selfe.

In many hydraulic plants of the above class it is quite common to see them running on the by-pass a considerable portion of the day, but in the plant under discussion the Watt-meter records, which we have had shown us this evening, show that this does not occur except perhaps for a moment or two during the first half-hour of the day. The plant thus must be very economic in operation.

I would also like to refer to the notable smoothness of working, and would say that when the pumps are running at their maximum speed they are nearly silent, and the only sound audible is that of the gearing and the hum of the motor brushes. There would also appear to be an entire absence of breakdown, and this is shown more clearly from the fact that the first set of pumps appear to have been in operation for four years before it was considered necessary to instal a duplicate as a stand-by, and the fact that no alteration in design was considered necessary when constructing the duplicate plant is, to my mind, the best proof of the excellence of design and proportion as laid down by the late Mr. Norman Selfe.

I have no criticism to offer, the paper being a plain statement of fact. There is no room for criticism. It is a fine thing for us, as an Association, to be able to bear testimony now to the skill of one of our most famous past Presidents.

Mr. Snashall: I have seen some records of these pumps and units taken, and it is remarkable the similarity of the readings on different days of the week. The number of units is nearly the same throughout the year, the notable exceptions, of course, being upon special occasions such as sale time.

Mr. Sinclair asked a question re the overall efficiency of the pumps, and in reply Mr. Kidd said that the efficiency is about 76 per cent. at maximum, and 69 per cent. at minimum speed. The modulus of the pump was about 96 at all times. They had gone into the matter of H.P. developed by both motors, and found it about the same, the speed accelerates more rapidly with the Phoenix motor. It is a difficult matter to get the exact number of units at a given moment; when a test is made the number of revolutions is counted, and the Watt-meter carefully noted, the H.P. and efficiency are then calculated from that data.

Replying to a question asked re the position of accumulator and action of the controlling gear on the economical working of the plant, the author said that they had merely carried out the instructions of the late Mr. Norman Selfe, and could only say that, taking records day by day, the units do not vary more than one unit per day.