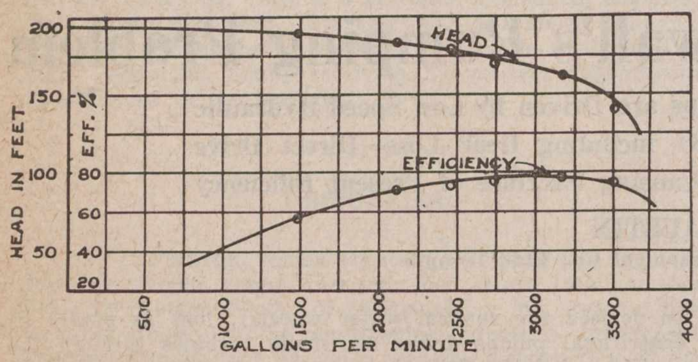
Toronto. A wall separates these pumps from the turbines and centrifugal pumps.

As an adequate supply of water was obtainable from the canal, which runs right alongside the pumping station, it was decided to have the new pump also driven by a hydraulic turbine, and in November, 1916, F. W. Stidwill, the town engineer, compiled specifications of the town's requirements and called for tenders.

Six or seven bids were received, and that of the Turbine Equipment Co., Ltd., of Toronto, was accepted for the



Characteristic Curve Showing Performance of Pump Installed at Cornwall

pumping machinery and the William Kennedy Co. was awarded the contract for the new turbine.

The successful bidder for the pumps recommended that a new shaft be installed in the existing turbine, to extend at both ends so that it could be used for driving the old reciprocating pumps in cases of emergency, and also for driving (from the other end of the shaft and through the medium of double helical gears) a 10-in. single-stage double-suction De Laval centrifugal pump. It was also proposed that a new turbine be supplied which would drive a duplicate of the centrifugal pump referred to above, likewise through a set of double helical gears.

Each pump was to have a capacity of three and a half million gallons a day against a total head of 180 ft. when operating at a speed of 1,670 r.p.m. When placed in series, which means running both sets of turbines, gears and centrifugal pumps with one pump discharging into the suction of the other, the output was to be four and a half million gallons a day against 308 ft. total head. This latter condition is required in case of fire.

The pump efficiency guaranteed by the successful bidder was 72%, including the loss in the gears, which was guaranteed not to exceed 1½%.

Direct Drive Not Practicable

As stated above, the turbines run at 200 r.p.m. which is far too low a speed for a centrifugal pump, and in order to obtain a head of 180 ft., it would have been necessary to have used fourteen stages, with 36-in. diameter impellers, and the number and size of the impellers would have produced excessive skin friction, resulting in very poor efficiency.

Double helical gears have been extensively used by the De Laval Steam Turbine Co., of Trenton, N.J., who built the pumps and gears, for years as *reduction* gears in their steam-turbine-driven centrifugal pump and electric-generator installations, but it is obvious that they can be used just as successfully as *increasing* gears, although of course there will not be nearly so much call for them in that capacity.

The use of these gears in this manner enabled a standard speed to be chosen for the pumps, namely, about 1,670 r.p.m., and made possible the installation of single-stage pumps with impeller diameters under 16 ins. The builder's shop test showed an efficiency of 73%, including the gear loss, at normal capacity. The accompanying characteristic curve indicates the capacity, head and efficiency over the entire range of output.

Owing to the war greatly interfering with the builder's domestic work, delivery on the machines was very late, and the installation of the first unit was not completed until July, 1918. Since that time they have been in constant operation.

The new turbine is of the horizontal single enclosed type. The wheel is 36 ins. diameter and the steel case is 10 ft. diameter. It is not equipped with a governor as the load is constant. It was designed to develop 200 h.p. at 200 r.p.m. under an 18-ft. head, which is 30 h.p. more than is developed by the rebuilt wheel.

In summer the difference in elevation of the canal which supplies the turbines, and of the St. Lawrence River, into which the draft tubes discharge, is 30 ft. In winter, however, ice dams raise the level of the water in the river, which is sometimes only 10 ft. below the canal.

The steel penstock is 54 ins. diameter where it passes through the canal wall, and from there to the wheel case it is rectangular, 5 ft. by 7 ft.

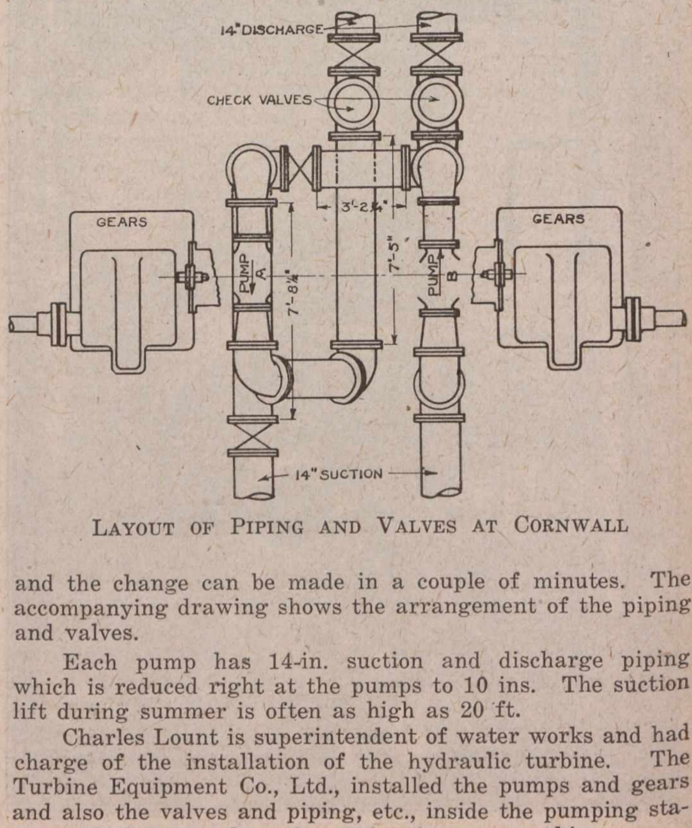
The draft tube is 54 ins. diameter where it connects to the discharge elbow; it then changes to rectangular, 5 ft. by 6 ft. and enlarges to 5 ft. by 7 ft. The total length of the draft tube is 42 ft. and it is all built of reinforced concrete.

Gears are Rigidly Supported

The double helical gears are rigidly supported and enclosed in a cast-iron case. The gears and pinions are made of special heat-treated steel and are lubricated by a spray of oil projected against the line of contact of the gear teeth on the entering side. The pinion bearings are oiled from a gravity system. This oil, after passing through the pinion bearings, flows into the reservoirs of the gear bearings, which are ring-oiled. The overflow from gears and bearings is drained to a reservoir in the bedplate and strained, and then pumped by a rotary pump, driven from the slow speed gear shaft, to a cooling tank located about 18 ft. above the centre line of the bearings. The gear teeth are cut at an angle of 45 degs., which results in low tooth pressures. In this installation they are quite noiseless.

The pumps have 10-in. suction and discharge and are equipped with bronze impellers, wearing rings and shaft sleeves, and have cases split on the horizontal centre line.

The arrangement of valves and piping to enable individual or series operation to be obtained is very simple,



Layout of Piping and Valves at Cornwall

and the change can be made in a couple of minutes. The accompanying drawing shows the arrangement of the piping and valves.

Each pump has 14-in. suction and discharge piping which is reduced right at the pumps to 10 ins. The suction lift during summer is often as high as 20 ft.

Charles Lount is superintendent of water works and had charge of the installation of the hydraulic turbine. The Turbine Equipment Co., Ltd., installed the pumps and gears and also the valves and piping, etc., inside the pumping station, which was enlarged to take the new machinery.