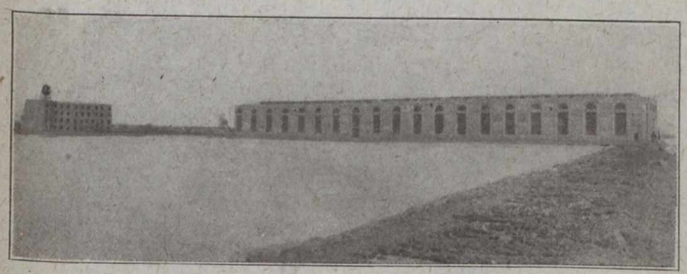
hung dam can find another outlet, the reduction in capacity of the plant may be serious.

If the storage above the power house and dam is reduced 3 or 4 ft. or even less in order to carry the plant's peak load for 1½ or 2 hours daily, and if the storage builds up quickly after the peak is off, it is found that the water rises so rapidly as to over-run the surface ice along the shore and near the dam and power house, resulting in flat ice becoming very thick. By the end of winter, it may be found



HEADRACE, POWER HOUSE AND TRANSFORMER HOUSE—CEDARS PLANT OF THE MONTREAL LIGHT, HEAT & POWER CO.

to be from 2 to 3½ times as thick as the surface ice in the centre of the river or canal.

Damage is likely to be suffered from erosion and scouring of the river banks when the spring break-up occurs unless means are provided to care for same, such as facing the river banks with concrete, timber or stone riprap.

If the break-up is accompanied by heavy freshets, the ice may be shoved into the head race and carried over the dam in layers as thick as 90 ins. Considerable damage may be done, said Mr. Wilson, if the overflow dam is not properly protected, and also the front portion of the power house raised sufficiently above extremely high water to prevent the ice being carried against it. To provide against damage to the apron side of dams and by scouring at the rear of the apron, tumble ponds would be found useful if the design does not allow the ice to discharge in its normal plane and not on end.

The ice troubles affecting the operation of hydraulic equipment have been difficult to overcome with plants of multi-runner type. High specific speed runners have been so successful with modern designs of thrust bearings, that the multi-runner type turbine has passed away in favor of the vertical single runner. The majority of developments, up to 1912, of low and medium heads, consisted of horizontal installations of the multi-runner type, having two, four, six or more runners on the shaft.

The first Canadian plant of the vertical single runner type was the Cedars plant. The result of four years' operation has proven that it is possible to eliminate the ice trouble experienced in the multi-runner plant. When this plant was designed, special attention was given to ice problems, as it was known that severe ice conditions would be encountered, on account of the St. Lawrence River above and below the plant remaining open all winter.

Enclosed Gate House

Experience in the operation of other plants was of great benefit in the design in effectively overcoming the operating difficulties due to ice; for example, enclosing the gate house so that the hot air from the generator room enters the gate house, placing the screens or racks so as to keep the outside air from them, dividing the racks into six sections for each unit, installing an electric crane for handling them, installing motor-driven head gates for each unit, and installing emergency gates to cut off the water completely for examination of racks and head gates. These have all worked very efficiently. Minor changes have been made, however, in the top rack section. The original spacing between the rack bars was 2½ ins., but this was found to be too close and alternate bars were removed so that the spacing was 5 ins.

Each main unit is supplied through three openings, each 12 ft. 8 ins. by 28 ft. The water enters at about 3 ft. per second, passes through spiral concrete casing, entering the wheels at 7¼ ft. per second.

When frazil and anchor ice are running, a certain amount of fine sheet ice and debris of all kinds is mixed along with them, and when this gets onto the racks it coats them so as to block off the water from the wheels.

The ice can be put through by working ordinary rakes up and down the rack bars. The procedure, however, is to raise the top section of the racks and to hit them a slight blow with a wooden maul. The whole coating, maybe 2 or 3 ft. thick, falls away and goes through the wheels. If the ice apparently does not want to enter the spiral casing, the trouble is overcome by manipulating the head gates and changing the velocity of entrance, although this method of operating is only adopted when anchor ice is running heavily. Ordinarily the top section of the racks is allowed to remain up.

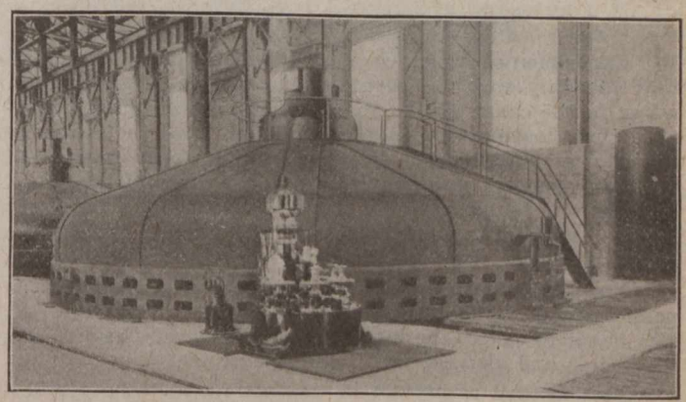
No Choke in Gates or Wheels

Four years of operation under severe winter conditions demonstrate that no matter how much anchor ice or frazil enter a plant, whether before or after the canal is coated with surface ice, no choke takes place in the guide vanes, gates or wheels. The explanation offered for this condition is that the metal parts of the wheel installation are maintained at a temperature just above freezing, causing the ice crystals to slip. The difference measured on the thermometric scale is infinitesimal, although the physical results are enormous.

Operation with the top sections of the racks up, when anchor ice is running heavily, has caused a little difficulty, as a considerable amount of debris has been carried into the runners. Timber, railroad ties, stumps of trees, stones, etc., have been removed from the runners, one stone weighing over 600 lbs.

It has been estimated that the volume of anchor ice to support this stone required between 80 and 90 cu. ft., yet with this large volume of ice no blocking occurred, the only indication that something was in the runner being a broken gate arm. The unit continued to develop its power with this large stone in one of the buckets.

Operation has demonstrated that no trouble from ice shut downs is experienced in plants having single runner



INTERIOR OF CEDARS PLANT, SHOWING ONE OF THE 10,000 H. P. GENERATORS AND GOVERNOR

units with openings in the guides, gates and wheels as large as at Cedars.

After it had been fully demonstrated that however large might be the volume of floating spongy ice entering the power house, it could be put through the wheels, attention was turned to the head-race.

The head-race is slightly over two miles long and 800 ft. wide on the surface of the water. We found, said Mr. Wilson, a considerable decrease of flow in the canal, due to the ice covering and the reduction of free water area on account of the underhung dam formed by frazil, anchor and sheet ice under the surface ice, particularly at the entrance of the canal. This is a serious condition for a plant when