At the tests, which were carried out with the greatest care, the quantity of water was measured by means of a floating screen in the inlet canal, and the effective height of fall was ascertained by the difference in level between the upper and the lower water surfaces. The generator was loaded with a water-resistance, and the effect was measured by means of two precision watt-meters. In the results are included the loss of efficiency arising in the inlet-tube, and the influence of this is shown in curve B, which shows the efficiency that would be registered if the head were measured through a manometer placed in the turbine-case or in the way such tests are generally carried out.

The generators produce three-phase current, 25 periods, and 10,000 volts. They are entirely encased so as to obtain efficient cooling. The generator rotors draw by suction the cold air through spacious conduits, which pass within the walls of the power-station and underneath its floors. The air, heated in the generators, is also led away through conduits; during the winter it is used for warming both the generator-station, the tube-inlet building, and the switchboard building; in the summer it is led away, so that the attendants shall not be inconvenienced by it.

For exciting the generators, for lighting purposes, and for power to the auxiliary machines, there is a continuous-current installation for a voltage of 220 volts. This is worked by the three 500-horse-power turbines already referred to, which are placed in the centre of the power-station. Each turbine is direct coupled to a continuous-current generator of 350 kilowatts for 220 to 300 volts. Parallel with these generators is an accumulator battery of a capacity of 4,800 ampere-hours, which serves as a reserve and for counteracting the voltage variations. The switchboard for this installation is placed on a balcony in the centre of the power-station, close to the generators in question.

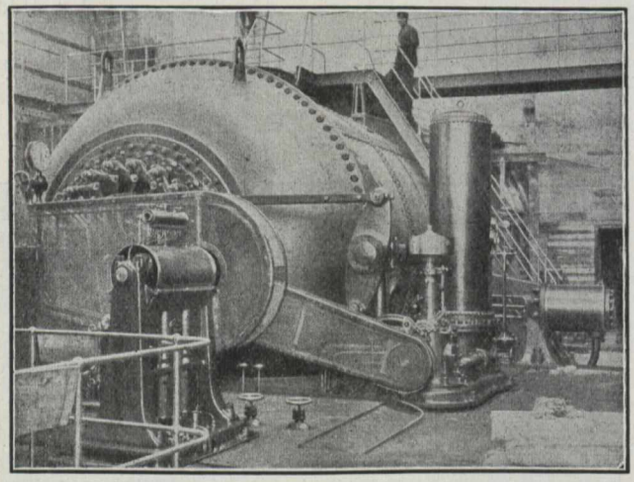

Fig. 5—Completed Turbine.

The regulation of the generator excitation does not take place in the ordinary manner, by means of main-current regulators, but by direct-coupled additional machines or boosters; and the voltage, with separate excitation, can vary from —220 to + 110 volts. By this arrangement the exciting voltage of the generators can be varied from 0 to 330 volts. The alternate current is conducted from the power-station through a tunnel to the instrument house. The tunnel is divided into four separate passages, in each of which there is room for the cables from two generators. It was originally planned to place the instrument-house in the immediate vicinity of the power-station, but various considerations have led to the adoption of the present location, which is some 200 metres (653 ft.) distant from the power-station. The instrument-house contains transformers, which transform the alternate current from 10,000 volts to 50,000 volts. The building further contains main switches, laboratory, lightning-dischargers, and all other appliances for the handling and distribution of the energy. In the centre of the house is the room from which the controlling and working of the station is carried on. In this room, on marble switchboards and desks, are placed all the instruments necessary for ascertaining the load distribution within the alternate-current system, as well as all the requisite signal and warning appliances. The voltage of the current is regulated from the controlling-room. From here, too, the oil-switch of the alternate-current installation is worked electro-magnetically by means of auxiliary switches. The auxiliary switches on the switch-desks are included in a miniature scheme of the alternate-current installation, with movable marks for all the apparatus and fixed marks for the lines, the generators, and the transformers. The movable marks, or miniature apparatus, are partly worked automatically and partly by hand, so that it is at any time possible to ascertain the position of the main switches.

In the switch-room is a telephone station, connected with the power-station and the transformer-stations. The requisite orders for the ordinary working of the power-station are transmitted by means of an electric machine telegraph, as the telephonic connection suffers from the noise of the machinery. The upper story of the instrument-house is used for a repair-shop for the transformers, for laboratory, store-rooms, &c. This portion is entirely separated from the high voltage installations.

The transformers are placed in a series of rooms on the north-western side of the instrument house, four cells on each side of the central part. Each cell is calculated for one transformer group, and each transformer group consists of three one-phase transformers, each 3,670 kva. maximum capacity, thus corresponding with a three-phase generator. The transformers are all insulated and water-cooled. In order to minimize the risk of fire, which can never be fully removed from the use of oil-insulated transformers, the rooms are entirely closed in, and arrangements are made for the free escape of oil. In order to maintain the water-cooling there are signal contacts in the cooling-water pipes to each transformer. These signal contacts give an alarm as soon as the cooling water ceases to circulate. As soon as the temperature in any of the transformers exceeds the permissible limit the thermometer placed in the transformer gives an alarm. The water for cooling the transformers is circulated by pumps in the cellar of the instrument-house. This installation consists of four pumps worked by electric motors. They lift 1,500 litres (333 gallons) per minute to a height of 15 m. (49 ft.) respectively; and 500 litres (111 gallons) per minute to a height of 25 m. (82 ft.). These pumps are also used for the extra voltage precaution appliances, of which more will be said later. Only two pumps are required for the maintenance of the working. The other two are reserve. Two water-tanks of an aggregate capacity of 50 cub. m. (11,250 gallons) serve as an additional reserve for the cooling of the transformers, and one tank of 10 cub. m. (2,250 gallons) capacity as a reserve for the extra-voltage protective appliances. There is a special pipe system for conducting the oil into the transformers, and for emptying them; there are also tanks for the reception of the used oil from the three one-phase transformers, and also for supplying clean oil, as well as appliances for cleaning and drying the transformer oil.

The energy is distributed from the instrument-house partly at 10,000 volts and partly at 50,000 volts. The long-distance lines are generally calculated either for the output of a complete generator or half generator; in the latter case