supported by the grooves in the wall, and by two intermediate supports in addition; it is operated by means of an electric winch or by hand-power. The lowering of the door can be promptly effected by means of an electric arrangement in the switchboard-house. The speed of the water through the free opening of the ice-guard is about 1 m. (3 ft. 3 in.) per second; and in order to incur the smallest possible risk from ice-coating, special types of ice-guards have been designed. Fish which reach the ice-guard through the inlet canal can, by means of a passage in the bottom, immediately in front of the ice-guard, go through the tubes to a collecting-groove running along the distribution reservoir, and from there again to the river. From the intake building the water is led to the power-station through eight large and three smaller

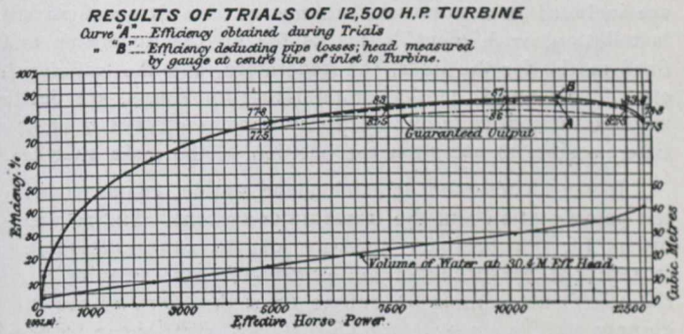

Fig. 3.—Results of Test of Turbine.

tube-conduits. The former, which have a diameter of 4.25 m. (14 ft.), lead to the eight large turbines, and the latter, which have a diameter of 1.2 m. (4 ft.), to the three exciting turbines. The tube-conduits are placed in tunnels in the rock, lined with sheet-iron, and encased in concrete. Each tube-conduit has a length of about 60 m. (197 ft.).

The power-station (Figs. 6 and 7) contains the turbines and the generators, which are direct coupled. The arrangement of the power-station will be understood from Fig. 1, which is a vertical longitudinal section through tube-intake, tube-conduit, machine-house, and outlet tunnel. Fully equipped it can yield 100,000 horse-power under the existing condition of water, and when Lake Vänern has been regulated, as already mentioned, a considerably larger power. The turbines are the so-called twin turbines with horizontal axles direct coupled to the generators. They have rotors of the ordinary Francis type and are fitted with adjustable bearings. Each turbine with a head of water of 30.4 m. (100 ft.), and with a speed of 187.5 revolutions per minute, has a capacity of nominally 10,000 horse-power and a maximum capacity of 12,500 horse-power, measured at the coupling to the electric generator. A vertical longitudinal section through the turbine is shown in Fig. 2. The turbines are enclosed in cylindrical cases of steel, and are directly connected with the tube-conduits, so that the water, without any alteration in its direction, is led from the tube-conduits on to the turbine-wheels. The smallest interior diameter of the surrounding cases is 5 m. (16 ft. 6 in.), and the largest diameter is 5.5 m. (18 ft.). The thickness of the plates varies from 22 mm. to 23 mm. (about 15/16 in.). The turbines may be seen in perspective in course of erection in Fig. 4 and Fig. 5.

In the construction of the turbines the greatest care, in the first place, has been bestowed upon making the casing of the turbine as smooth as possible inside. Most parts, especially those exposed to the severest strains, are made of steel, as are also all the cast parts, which by riveting are connected with the casing. Each turbine has been tested at 75 metres (246 ft.) water pressure. The turbine shaft is of nickel-steel, made in three parts, which are connected by means of couplings, forged on the shaft. It is supported by three bearings, with ring lubrication; two of them are placed against the turbine-case and are accessible for inspection by means of vertical pits. All the bearings are water-cooled, and fitted with thermometers, which indicate the temperature at a convenient place outside the turbine-case. The rotors, which have a diameter of 1,800 mm. (6 ft.) on the inlet side, are made of cast steel and are very securely attached to the shaft.

In order to obtain a construction with combines the greatest possible reliability in working with easy management and durability, all the parts belonging to the governing mechanism have been located outside the turbine-case, so that all the journals can be lubricated and inspected during working. Special interest attaches to the construction adopted in these turbines, which makes it possible to take out each guide-blade separately without causing any serious disturbance beyond the removal of the box belonging to the blade in question, and the uncoupling of the small chain between the crank and the regulator. The guide-blades are of steel, and cast in one piece with their respective shafts.

The governor, which is worked by belting from the turbine shaft, together with the pressure bell, is placed in a cast-iron box, fixed in concrete, which also serves as an oil receptacle; pipes, 100 mm. (4 in.) in diameter, connect the governor with the servo-motor, which acts upon the middle of the governor shaft. The oil-pump is worked by belting from the turbine axle. The brake intended to bring the turbine to a standstill is hydraulic, and is worked from the starting platform.

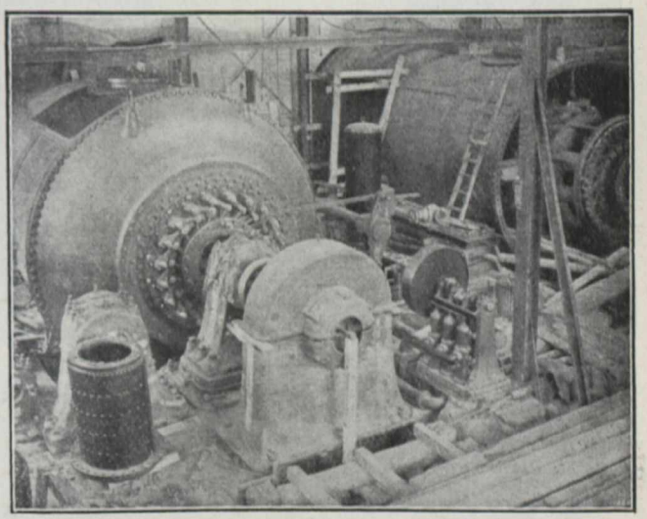

Fig. 4.—View of Turbine During Erection.

In order to give some idea of the large dimensions of the turbines, we append the following particulars of weight:

	Kg.	Tons.
The front ring, of steel.....about	12,000	(12)
The suction-case parts .....about	14,000	(14)
The turbine-wheels, of steel, each weigh .....about	5,000	(5)
The turbine-axle, of nickel-steel about	14,000	(14)
The cast-iron upper parts of the suction-case .....about	32,000	(32)
The front portion of the suction-case, with part of suction-case....about	28,700	(28¾)
Conical portion of case.....about	10,200	(10¼)

The diagram, Fig. 3, shows the satisfactory results of the tests undertaken at the instance of the buyer.