volts, and one is a continuous current machine of Thury 12 pole type, supplying current to an electrochemical works nearby at 208 volts, owing to the small space originally allowed in the station for switchboards, etc., the switching devices are very crowded, so much so that several years ago a serious burn-out occurred; this has recently been remedied by additions to the building.

Perhaps the most interesting features of this plant are in connection with the distribution and use of the current. In no city in Europe does the number of consumers of

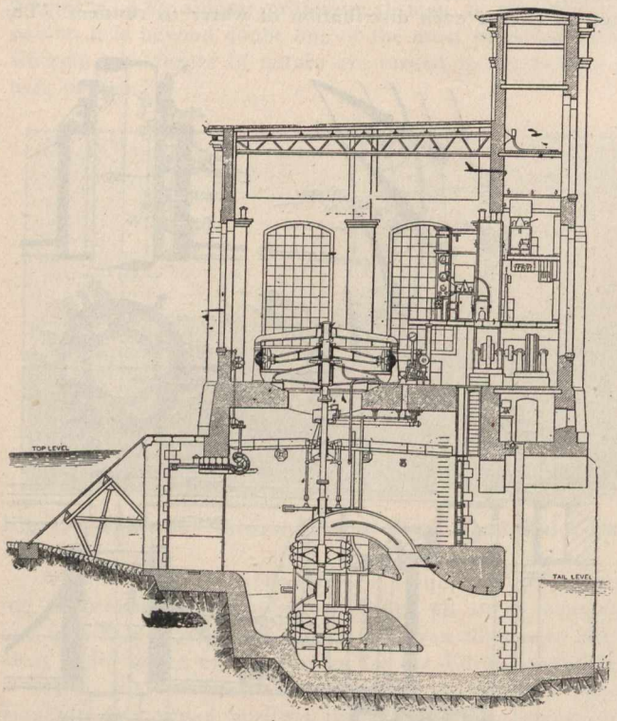

Fig. 8.—Rhinefelden: Section Through Unit.

power bear such a large ratio to the population. This means a very general use of small units, and a very extensive network of distribution lines. About half of the main lines, 90 miles, are still on towers, but they are gradually being put underground in tile ducts, and the engineers hope that within two years nearly all the main lines will be so carried. At numerous places, especially in the suburbs of the city, switching and transforming stations are situated. These are structures of steel and concrete, and are very compact and convenient.

The very general use of current in Geneva was evident in a short trip made by the writer, in company with the engineer, when a planing mill, a bakery, a jeweller's, a printing office and a chocolate factory were visited in which from 2 to 15 H.P. were used. The large number of takers under 2 H. P. was astonishing, and it may be noted that 113 of these small takers at 110 volts were using only 50.6 H. P. altogether, while 189 at 500 volts were using 1,261 H. P. at the end of 1905. The average power of all motors was 1.2 Kw. The total number of incandescent lamps in service at that time was 85,000. For the distribution of this power to 27 city and suburban localities 698 transformers in 83 sub-stations are required, being the largest number of any plant in Switzerland.

Prices charged by the city of Geneva are as follows: For lighting: 16 C.P. lamps (70 watts) one cent per hour, or 16 cents per Kw. hour, with large discount for a considerable number of lamps. For power: On flat rate, 1 H.P. at $64 per H.P. year; 10 H.P. at $43 per H.P. year; 20 H.P. at $32 per H.P. year; 50 H.P. at $28, and 100 H.P. at $22.40. These figures are based upon a ten-hour day with full advantage of the discount. A 24-hour day would increase the amounts by 50%. Coal for steam power is about $7.00 per ton.

The Beznau Plant, River Aare.

One of the most interesting low-head plants in Switzerland to-day is that situated on the Aare River, near Baden, known as the Beznau Station. In it are constituted all the most recent improvements in the application of the water to the wheels, and in the wheels themselves are embodied the results of the experience of the past ten years, with plants operating low-heads with large variations. This plant was completed and put into operation in 1904, and was quickly loaded up with consumers in the surrounding country.

The water is obtained by cutting across a bend in the river with a canal about three-quarters of a mile long and the generating station is placed across the lower end. A removable series of screens is provided, and also commodious spillways, although all ice and debris is deflected at the headworks. The generating station below the floor line is built of concrete, the superstructure being of stone.

The available fall varies between 10 and 15 feet, and, owing to this variation, the vertical turbine units consist of three runners 7'-6" diameter. One pair of runners is at the bottom, right and left, and the third above, discharging downwards into the draft chamber of the upper runner of the pair, see Fig. 6. At a medium head of 13'-0" 1,000 H. P. is obtained on each unit at 67 R.P.M., using 890 sec. ft. of water. The whole unit is supported by hydraulic pressure beneath a disc, so as to reduce the weight on the step bearing, and the small inequalities of this are further balanced by oil pressure from special pumps.

Regulation is secured by an oil pressure governor geared to the main shaft, standing on the station floor, to which is attached to the gate shaft. Links from the latter are connected up to the gate rings surrounding the distributor of each runner: to the gate rings are linked the swivel gates, which, by rotating the ring, open and close on the fixed vanes of the distributor, thus admitting water as required to the runners. These details are shown in Fig. No. 7. The turbines are built by Theodor Bell & Co., of Kriens, near Lucerne.

The power secured in these units varies between 7,000 and 11,000 H.P. for the whole installation of nine units.

The generators are of the umbrella revolving field type, 800 Kw. each, three-phase, wound to 8,000 volts at 50 cycles, and were built by Brown, Boveri & Co., of Baden. Local distribution is at the generating voltage, while long distance is at 25,000 volts up to 20 miles. The latter voltage was the highest in transmission operation in Switzerland at the end of 1905. The total length of transmission lines of this plant in 1905 was 70 miles, the number of localities served was 61, the population, 250,000, the number of transformers 60, and stations 31, while the average power of motors served was 100 Kw., in which respect this plant stands third in the country.

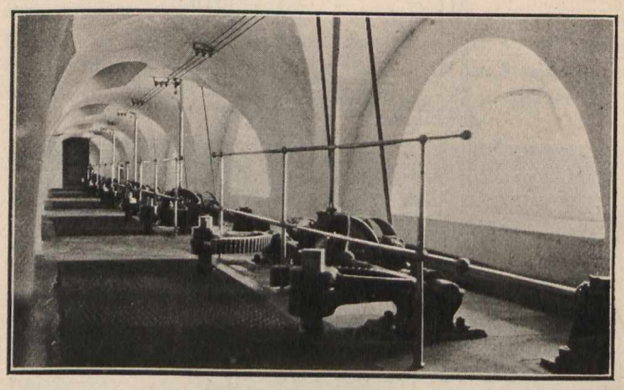

Fig. 9.—Rathausen: Gate Operating Mechanism.

Prices of power are generally as follows: For lighting 16 C.P. lamps, $4 each per year, continuous service. For motors on 10-hour basis flat rate, 1 H.P. at $43; 10 H. P. at $39; 50 H.P. at $34, and 100 H. at $32. For 24-hour basis, 1 H.P. at $56; 10 H.P. at $49; 50 H.P. at $44, and 100 H.P. at $41.

Rhinefelden and Rathausen Plants.

A description of any low-head plants in Switzerland, however brief, would not be fair without some mention of the historical Rhinefelden and Rathausen plants, the former on the Rhine about 60 miles from Zurich, and the latter on the Reuss, near Lucerne.