altogether although the valve was still apparently partly open. This may have been due to the type of valve employed which was simply a standard 4-inch gate valve with a certain amount of play in the disk which would render the necessary fine adjustments impossible. It may also have been due to the fact that the head in the upright discharge pipe to the elbow was greater than the head corresponding to this small discharge and the pump discharge thus simply fell off, no water passing along the horizontal portion of the discharge pipe. The conditions changed so rapidly at the small discharges that no results could be obtained.

The curve of efficiency is of good form, giving, as was to be expected, maximum efficiency at normal discharge and being comparatively flat at this point so that for slight increase or decrease of discharge the change in efficiency is slight.

The efficiencies obtained are quite high for a pump of this size acting under so low a head, being slightly over 65 per cent. Although customary in large multi-stage pumps to obtain efficiencies in the neighborhood of 80 per cent., efficiencies of 60 per cent. or over may be considered very good in pumps of this size. In small single-stage pumps the bearing and gland friction is relatively much larger than in larger multi-stage pumps, and uses a much larger part, comparatively, of the input power, reducing the mechanical, and, therefore, the net efficiency. Thus, if the shaft of a large pump is twice the diameter of that of a small pump, while the power is eight times as great, the friction loss is only increased to double that of the small pump. The power consumed in overcoming friction (running pump light) is in the pump, as in other machines, a certain fraction of the total input, and this fraction decreases as the pump increases in size, so that evidently higher mechanical efficiencies should be expected in pumps of large size than in small size ones. Such efficiencies as have been obtained from this pump are the result of very careful design and accurate workmanship, which in turbine pump work are absolute necessities when high efficiencies are sought. In addition, as previously mentioned, the impeller and guide-ring, guides, passages and surfaces were all finely finished and polished in this pump, the construction being so modified as to permit of this being done.

Test of 4-in. Single Stage Turbine Pump
—Test Data Corrected to Constant Speeds—

Table No. 3.

No	Test Speed	Speed N	Head H	Disch. Q	Power P	Effy E
1	2	3	4	5	6	7
1	995	1000	15.40	0.722	1435	48.1
2	995		21.10	0.613	1388	58.1
3	995		24.30	0.517	1330	58.8
4	1000		27.09	0.411	1248	55.6
5	1000		28.50	0.326	1057	54.8
6	1004		28.00	0.252	958	45.9
7	1004		27.00	0.195	890	36.9
8	1005		25.05	0.124	780	25.0
9						
10						
1100 R.P.M.						
11	1093	1100	18.45	0.785	1775	50.9
12	1105		25.50	0.676	1682	63.8
13	1090		28.45	0.596	1700	62.2
14	1090		31.40	0.503	1617	61.5
15	1100		33.33	0.410	1458	58.4
16	1100		34.40	0.333	1330	53.7
17	1100		33.98	0.265	1175	47.8
18	1105		32.60	0.189	1034	37.7
19	1109		30.80	0.128	903	27.2
20	1110		17.70	0.106	899	13.0
1200 R.P.M.						
21	1190	1200	21.50	0.835	2168	51.4
22	1200		29.51	0.735	2082	64.9
23	1186		33.20	0.625	2053	63.0
24	1187		37.10	0.517	1938	61.7
25	1190		39.10	0.419	1772	57.6
26	1195		40.30	0.339	1622	52.6
27	1195		39.50	0.263	1449	44.8
28	1200		37.03	0.190	1282	34.2
29	1195		35.65	0.120	1120	23.9
30	1195		18.65	0.072	1085	7.5
31	1295	1300	25.30	0.862	2585	52.0
32	1300		34.84	0.756	2532	64.8
33	1300		38.93	0.651	2483	63.6
34	1300		43.09	0.544	2360	61.9
35	1300		46.63	0.436	2178	58.2
36	1300		47.04	0.355	2075	50.2
37	1300		45.34	0.276	1802	43.2
38	1300		43.30	0.193	1553	33.5
39	1300		41.20	0.120	1363	22.6
40	1295		24.15	0.097	1353	10.8
1400 R.P.M.						
41	1400	1400	29.46	0.892	3065	53.5
42	1410		38.80	0.799	3005	64.3
43	1410		44.50	0.696	2965	65.3
44	1410		49.80	0.588	2820	64.7
45	1410		53.10	0.494	2675	61.0
46	1410		55.00	0.411	2545	55.8
47	1410		53.70	0.334	2245	496
48	1400		51.76	0.260	1970	42.6
49	1400		50.31	0.196	1797	35.2
50	1400		46.97	0.136	1583	25.1
1500 R.P.M.						
51	1500	1500	33.59	0.923	3720	51.9
52	1500		46.10	0.805	3735	62.0
53	1500		56.07	0.696	3550	68.6
54	1500		58.24	0.593	3315	65.0
55	1500		61.25	0.497	3185	59.6
56	1500		64.06	0.419	2835	59.0
57	1490		62.10	0.333	2605	49.5
58	1490		59.00	0.262	2335	41.3
59	1500		56.14	0.191	2140	31.3
60	1500		50.77	0.136	1955	22.0

Table No. 3.

HYDRO-ELECTRIC PLANT OF UNUSUAL DESIGN.

THERE is nearing completion at Wissota, Wisconsin, a new plant, two features of construction of which are unique and therefore of particular interest to engineers, especially those interested in hydraulics. These two features are the ten sluice tubes which discharge into the draft tubes and the design of the spillway gates.

The ten sluice tubes are carried directly through the dam, sloping slightly downward and discharging horizontally into the draft tubes. The four middle draft tubes consist of two sluice tubes each, whereas the two end draft tubes have only one tube each. The flow of water through the sluice tubes is controlled by means of gate valves, eight being motor-operated and the other two being hand-operated. These sluice tubes are five feet in diameter with a total capacity of 10,000 second-feet, increasing the capacity of the spillway, obviously, by that amount. This gain in spillway capacity, however, is chiefly an incidental result, the primary object of the tubes being to produce an "injector effect" in the draft tube and thereby to tend to increase the partial vacuum on the discharge side of the turbine. From tests which have been made on a smaller scale it is estimated that the efficiency of the turbine will be increased approximately four per cent. by this arrangement. At present, efforts are being made to secure a patent on this particular type of tube. It is understood, of course, that the sluice tube will be used only when the river is supplying water in excess of that being used by the plant.

The spillway gates, thirteen in number, each sixty-four feet wide, are of the type known as the Stauwerke automatic gate. As mentioned, this design of gate has never before been used in America, but is said to be giving remarkably good service in Switzerland under conditions very similar to those prevailing at Wissota. The gate is mounted on a horizontal axis at right angles to the stream, and is so adjusted that a counterweight just balances the pressure of the water at normal level. Any slight rise of level thereby increases this pressure and tilts the gate, thus permitting a much greater quantity of water to pass through the spillway. These gates are expected to regulate the water level of the pond to within four inches of normal under all ordinary conditions, and never to allow it to rise more than six inches above normal even under the most extreme conditions. In addition to being automatic and providing close regulation, the Stauwerke gate possesses a third advantage in that it is curved downstream and hence presents a concave surface to the stream. This design prevents all clogging by drift or ice.

With these two distinctive ideas in dam construction being thus tried on a large scale, the results which the Wisconsin-Minnesota Company obtains at Wissota will no doubt be well worth the attention of all engineers interested in hydraulic power development.