line; it is generally similar to the standard towers with wide base, as used on straight rims for moderately long spans, except for the special arrangement carrying the larger number of insulators.

The term "tower" is also frequently applied to the "flexible" type of structure which has two main vertical members only, and is specially designed to have ample strength and stiffness in a direction at right angles to the transmission line, while it is free to bend, within certain limits, in a direction parallel to the line, without being permanently deformed. Great strength and stiffness in the direction of the line is not always necessary or desirable in a transmission line support; but it is obvious that the strength and stiffness must be sufficient to withstand the forces imposed on the structure during erection, and at the time of stringing the wires. A simple braced "A" frame steel tower of the "flexible" type is illustrated in Fig. 3. This photograph shows the steel and wood pole lines running side by side between Taylors Falls and Minneapolis, Minn. These towers are 42 feet high from ground level to bottom insulator, and have a standard spacing of 440 feet.

The maximum load which a tower must be designed to withstand will depend upon the number and size of wires to be carried and the estimated ice coating and wind velocity. Apart from the wind pressure on the structure itself, the loading in a direction transverse to the line will be equal to the resultant wind pressure on all the wires (which may or may not be ice coated, depending on the climate); the effective length of each wire being the distance between supports.

In the direction of the line the forces are normally very nearly balanced, but in the event of one or more wires breaking, the unbalanced load may be considerable, and it is well to design the towers, if possible, so as to withstand the stresses imposed upon them if two-thirds of all the conductors in one span are severed. On the other hand, it is not unusual to tie the conductors to the insulators in such a manner that the wire will slip, or the tie break before the conductor itself is stressed beyond the elastic limit of the material (about half the breaking load). It must not be overlooked that if the wires break in one span only, the cross-arm, if pin type insulators are used, will be subjected to a twisting moment; and if the break in the wires is at one end only of the cross-arm, the whole tower is subjected to tortional strain.

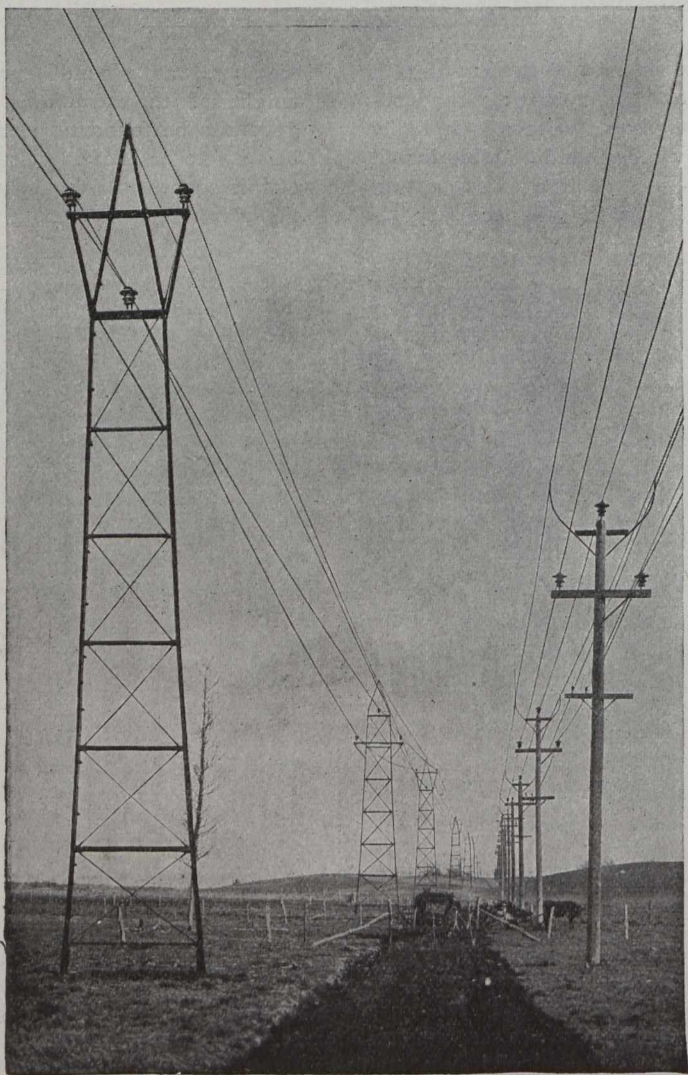

Fig. 3.—Simple Braced "A" Frame Steel Tower.

In Vol. XXV. (January to June, 1911) of the transactions of the Canadian Society of Civil Engineers, Mr. W. G. Chase gives some interesting particulars of the steel tower line from the municipal hydro-electric works of the city of Winnipeg at Point du Bois Falls. The supporting structures are of the "flexible" type, two designs being used, one for firm soil and one for swamp construction; the height being 42 feet. Braced towers are placed at intervals of about 1,200 feet and these were tested up to 6,200 lbs. applied at one end of the cross-arm 43 feet above ground in a direction perpendicular to the line. The test pull in the direction of the line was 7,200 lbs., corresponding to 1,200 lbs. per pin. The "flexible" towers are designed to have the same strength as the braced towers to resist wind pressures across the line, but they are intended to withstand only 480 lbs. in the direction of the line. The weakest point in the line is the wrought iron insulator pin which is intentionally designed to yield before the structure is damaged; these pins withstood on test a load of 1,500 lbs just before breaking. The towers carry six aluminum wires each of 278,600 circ. mils section. These conductors are tied securely to the braced towers, but on the flexible towers, the tie is designed to break with a pull of 80 to 100 lbs.; number 14 soft aluminum wire being used for the ties. This line is 77 miles long, and it transmits power at 66,000 volts.

The normal length of span on steel tower lines usually lies between 400 and 600 feet, but very much longer spans can be used where the character of the country would render their use economical, or where rivers have to be crossed. On the transmission system supplying Dunedin City, New Zealand, with electric energy at 35,000 volts, there is a span 1,700 feet long where the line crosses the ravine near the power station. The peculiarity of this span is the great difference in level between the two supports, the upper tower, which is a special steel structure, being 650 feet above the lower tower.

The 22,000-volt transmission lines of the Canadian Niagara Power Company cross the Niagara River near Buffalo in two spans, the longest being 2,200 feet long. The minimum clearance above water level is 131 feet, necessitating very tall supporting towers. These are of steel, arranged to carry nine 500,000 c.m. aluminum cables with a 15-foot spacing. An attachment consisting of a steel cable passing over a sheave and provided with counterweight, maintains a constant tension on the conductors and takes up variations in length due to changes of temperature.