On the high tension transmission lines of the Central Colorado Power Company, there is a single span 2,500 feet long. The St. Joquin River is crossed by a 3,000-foot span. The 100,000-volt lines of the Great Falls Power Company between Rainbow Falls and Butte, cross the Missouri River in a single span 3,034 feet long.

The longest span in the world is 4,200 feet across the Coquiney Straits.

The tower illustrated in Fig. 4 is 70 feet in height; it is used for supporting one end of a span about 1,000 feet long, where the transmission line crosses a river.

Having determined the maximum load to which the towers of a transmission line are likely to be subjected, it is usual to leave the strength calculations and details of design to the manufacturer; but the calculation of the stresses in the various members of a simple steel structure such as a transmission line tower, is comparatively easy, by making use either of graphical methods **(parallelograms of forces),** or the method of moments. A structure of this sort, when fixed to solid foundations and submitted to abnormal loads, is very liable to yield through the buckling of the members in compression, and the chief task of the designer is so to arrange and proportion the bracing and tying in of the compression members that the unbraced sections of these members shall not be unduly long.

Fig. 4.—Steel Tower at River Crossing.

Rankine's formula for compression members is:

$$\frac{\text{Load}}{\text{Area of Section}} = \text{lbs. per sq. Inch of Section} = \frac{T}{1 + C\frac{l^2}{R^2}}$$

Where T = maximum stress in metal in lbs. per sq. inch.

l = length of unsupported compression member.

R = least radius of gyration.

$= \frac{\text{moment of inertia}}{\text{area of section}}$, expressed in the same units as l.

C = a constant, which is about 1/25,000 for mild steel struts fixed at both ends.

By using the "straight line" formula, very similar results are obtained. For wrought iron angles and tees, with ends fixed, Burr gives:

Ultimate lbs. per sq. inch of cross section = 44,000 — 140 l/R, this value being multiplied by 1.25 for mild steel. To obtain working load, divide by factor of safety.

The "straight line" formula should only be applied when ratio l/R lies between 40 and 200, which corresponds to a length of compression member not exceeding about 20 times the width of flange.

When leaving the design to manufacturers, the specification for steel towers might with advantage contain a clause to the effect that the length of the compression members shall not exceed 200 times the least radius of gyration of the section. Also in the case of painted structures, it is best to allow no metal less than ¼ in. thick. If the metal is galvanized, it may be 3/16 in. and even as thin as ⅛ in. in the case of the secondary members. It is not usual to paint galvanized iron work, partly because the extra protection hardly justifies the expense, but also because ordinary paint does not adhere properly to a galvanized surface. Special paints can be obtained, but, generally speaking, the choice lies between a galvanized structure without paint, and a non-galvanized structure which must obviously be well protected with paint. The first cost of the latter is usually lower, but the coating of paint is not so durable as the galvanizing. Sometimes the parts in the ground only are galvanized, the rest being painted.

When a tower takes a "permanent set" under excessive load, this is often due to slight yielding of the joints before any buckling of compression members takes place.

In regard to the factor of safety to be allowed in the design of steel towers, a factor of three is sometimes called for, and this is a safe figure; but it is usually sufficient to allow a factor of two under the severest expected conditions of loading; which means that, under such conditions, the structure would be stressed to the elastic limit. This factor of safety probably corresponds to a factor of about five under normal conditions of wind and ice loading; moreover, it is unnecessary to allow a very large factor of safety in such structures because abnormal stresses are nearly always moderated by the slipping of the wires in the ties, the slight yielding of the foundations or joints, or similar movements which tend to relieve such abnormal stresses as might otherwise wreck the supporting structures.

The deflection, or movement of the top of a steel tower under load is usually small, and unless the towers are specially designed of the "flexible" type, the strain is rarely sufficient to modify the tension in the wires to any appreciable extent. The design of steel tower line with the object of providing considerable elastic yielding of the supports in the direction of the line, is a special and rather difficult problem which has been dealt with by other writers, and also elsewhere by the present writer.*

The deflection of the top of a transmission tower of the ordinary light "windmill" type with wide square base, when bolted to rigid foundations and subjected to a horizontal load such as to stress the material up to nearly the elastic limit, might be from two to five inches, while the more slender latticed masts of the type shown in Fig. 1 would have a greater deflection.

The following table, which gives the deflections of built-

* "Electrical World," Vol. 60, No. 2, page 97, July 13th, 1912.