Another writer (Joseph Mayer, Engineering News, Jan. 4, 1906), says:

Such lines should, therefore, be built strong enough to resist not only the commonly occurring, but also the exceptionally violent local storms.

From a mass of data, the writer recommends the use of the following wind loads: (a) On the structure itself, 30 lb. per sq. ft. of exposed surface; (b) on bare wires, 15 lb. per sq. ft. of projected area (length multiplied by diameter); (c) on wires covered with ½-in. coat of ice, 10 lb. per sq. ft. of projected area. In a sleet region (c) should be followed as it is the more severe.

It is noted at once that the requirements given for (1) and (2) do not in themselves determine the loads on the towers or poles unless their distance apart is known. In laying out a transmission line the first thing to find is the most economical span. This is both an electrical and a structural problem. The voltage, size and kind of wires, are to be decided. With these given, the spacing of towers can be determined. The foundations also enter in the calculations. Empirical formulas have been given for the most economical span, but so many variables enter into the question, that they can only be regarded as approximate. Each line is a problem by itself and must be solved independent of all other lines.

(3) The assumptions regarding unbalanced loading in the direction of the line will often determine the design of the tower. Practice as well as theory varies widely in this respect. The following is recommended: A tower having three line conductors or three conductors and one ground wire should be designed to withstand the unbalanced load due to any single wire breaking; a tower, having six line conductors or six conductors and a ground wire should be designed to withstand the unbalanced load due to any two wires breaking. The breaking of a wire throws upon the wire in the adjacent span and thence to the tower a load equal to that which caused the wire to break. For the smaller sizes of wire, No. 4 and under, this load should be taken as the ultimate strength of the wire itself. For No. 3, 90%; No. 2, 80%; No. 1, 70%; No. 0, 60%; and for No. 00 and larger wires it is recommended that 50% of the ultimate strength of the wire be used. The reason for the larger wires being given an advantage is that a break is not liable to occur in them until there has been a reduction of cross-section from burning due to a short-circuit from any cause. The smaller sizes will not permit any reduction of section without breaking.

For line conductors hard-drawn copper wire is generally used. The American Steel & Wire Co. find, from tests, the elastic limit of their copper wire to be 34,500 lb. per sq. in. and more and the tensile limit from 50,000 to 65,000 lb. per sq. in. For No. 00 copper wire, a size often used, the longitudinal pull due to one wire breaking will be 2,500 lb.; for No. 0000 copper wire 4,000 lb. will answer. Care must be taken to provide for torsional stresses caused by unbalanced loading.

In designing the standard towers of the line, the material is to be proportioned for maximum stresses due to any combination of loads (1), (2) and (3).

Unit Stresses.—Equally important with assumed loadings are assumed unit stresses. It might be well to divide proposed towers into three classes—(A), (B) and (C), and assume unit stresses in accordance with the classification of the tower. Two prominent features to be considered regarding any line are the importance of uninterrupted service and the probability of loss of life, due to accident of wires or towers giving way. If the purchaser of power insists upon service at all times under heavy penalty, the tower would come under (A) If interruptions under certain limitations are allowed, (B) may answer. From the standpoint of loss of life due to accident, a line over a thinly settled mountain country would come in (B), while the thickly settled zone about a town or city would require (A). Using open-hearth steel with an ultimate tensile strength of 55,000 to 65,000 lb. per sq. in. and an elastic limit of 55% of the ultimate strength, the working unit stress of steel in tension may be taken at 22,500 lb. per sq. in. for (A) and 27,000 lb. per sq. in. for (B). For steel in compression the recommended formula is:

$$\frac{22{,}500 \text{ or } 27{,}000}{1 + \dfrac{l^2}{18{,}000\, r^2}}$$

To (C) is consigned poles and towers where the primary feature to be considered is the cost. The question then too often becomes, not what the structure should be, but what are the least requirements that can be exacted and the line probably do its work. A common method of reducing material is to consider loadings (2) and (3) not acting at the same time, and increasing the unit stress to 30,000 lb. per sq. in. Some engineers think a high wind will not occur when the wires are covered with sleet.

Even admitting this to be true, arcing sometimes happens between wires when there is a high wind on the bare wires. Owing to lightning discharges, accompanied with wind, it may happen over insulators. This is certainly a combination of (2) modified, and (3) which should not be neglected. For wires covered with ½ in. coat of ice, 8 lb per sq. ft. of projected area for wind load is considered allowable by some good authorities. To this there is not the objection as to the use of 30,000 lb. per sq. in. for unit stresses. The latter comes too near the elastic limit of the steel likely to be used.

It may be said here that comparatively few existing towers are of classes (A) or (B). The engineer often finds it a commercial impossibility to have the towers built as he would like to design them. The situation is similar to that of the highway bridges 30 or 40 years ago. The bridges of that day would not be tolerated now. The towers of to-day will not be tolerated a generation or two hence.

Tests.—Specifications often require that towers withstand certain artificial tests. This means the minimum amount of material that will meet these tests will be used regardless of other considerations. The conclusions from artificial tests are often misleading. The material is new and in good order, and there is the friction of pieces bolted or riveted close together. The workmanship for the test pieces has at least not been slighted. The structure is assembled at the shop under more favorable conditions than will exist in the field. The loads are applied gradually and in one direction, quite different from those that will come after erection. The test generally takes but an hour or two, while the structure is built to last for years, during which it is subject to a continued test.

What is wanted in steel work is durability. This cannot be assured by a structure simply meeting an artificial test. It may be noted that almost every bridge that has failed or had to be replaced was "tested" before acceptance. This does not mean that a mechanical test has no value. The contention is that an artificial test alone does not give the true value.

For poles which are composed of few pieces and are of simple construction, a greater value may be placed upon the test than for towers which are made up of a multitude of pieces and are complicated in their structure, but for both