sulators fixed in position. These costs are the averages of many actual figures, and give an approximate idea of the total expenditure per mile of line for various voltages; they do not include any clearing that may be necessary in wooded country, or payments for right-of-way. It is assumed that the conductors are of average size (No. 000 B and S gauge), but the actual cost of the conductors, whatever the size, must be added to the costs indicated by the dotted curves B and D in order to arrive at the total cost of the finished line. These dotted curves, however, do include an amount to cover the labor of stringing the wires. The curves A and B refer to wood poles or rigid steel towers (for the higher voltages) carrying three conductors; while curves C and D refer to a single set of poles or towers carrying six conductors. The cost of a line with flexible steel structures for voltages above 44,000 might be about 75 per cent. of the costs given by curves A and C. It is understood that the curves of Fig. 2 give only an approximate indication of the probable capital expenditure on the line. The actual cost will depend upon the character of the country, the nature of the ground, and other local conditions such as cost of labor and facilities for transportation. These, together with the weather conditions, force of wind and possible loading of wires with sleet or ice, will determine the most economical span and the average height of pole or tower. The cost, as previously mentioned, will also depend upon the material of the conductors, as a larger or smaller sag will influence spans and height of poles. The weight and diameter of conductors, by affecting the required strength of the supports, will be factors in determining the cost of the complete line, apart from any difference in the value of the conductors themselves. The actual cost of stringing very light or very heavy conductors will also differ from the average amount allowed for the purpose of plotting the curves. The number and style of lightning conductors, if any, and whether or not one or more grounded guard wires are strung above the conductors will obviously modify the average figures. Although steel or concrete poles, or steel towers, will generally be found more economical than a wood pole

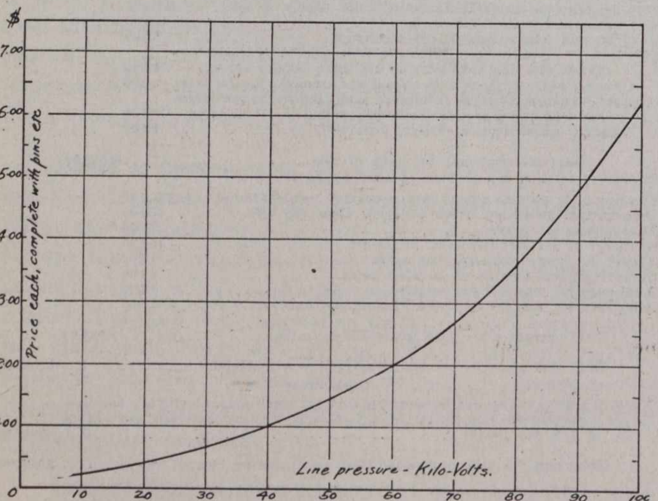

Fig. 1.—Cost of Insulators for Various Voltages.

line for voltages above 44,000 on account of the heavier insulators, wider spacing between conductors, and generally greater height of support, it does not follow that wood poles or wood-pole structures may not prove economical, even for comparatively high voltages, in countries where suitable timber is plentiful and the ready means of transportation and erection of steel towers are wanting.

Steel structures may be either galvanized or painted; the extra cost of galvanizing should be compared with the cost of painting periodically, say every third or fourth year. The cost of concrete poles will usually be between 50 and 80c. per 100 lb. weight. A pole 35 ft. high of square section 6 by 6 in. at top and 12 by 12 in. at bottom would weigh about 2,000 pounds.

The cost of foundations for towers varies greatly. In the case of fairly high steel towers with wide square bases in soil not requiring the use of concrete, the cost of excavating, setting legs, and back filling, not including erection of towers, will generally be between $10 and $20 per tower.

Cost of Conductors.—The capital expenditure on conductors will depend upon the material and the total weight. It is not proposed to discuss, in this article, the relative merits of copper and aluminum as conductor materials, but it may be well to point out that although, at the present market values of these metals, the use of aluminum may lead to some saving on first cost, there are many engineering points to be most carefully considered before definitely adopting either metal. The weight of the conductors necessary to transmit a certain amount of power over a definite distance will obviously depend upon the voltage, but apart from the engineering difficulties encountered at the higher

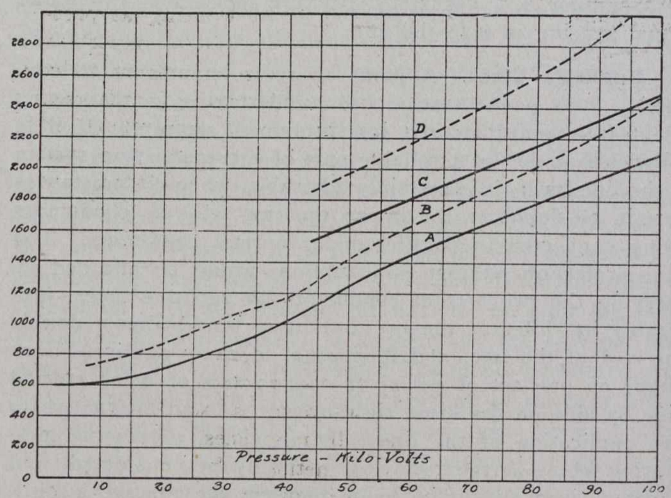

Fig. 2.—Cost in Dollars Per Mile of Transmission Line Complete, Not Including Cost of Conductors, Right-of-Way, and Clearing Ground in Wooded Country.

A—Single 3-phase line without insulators or wires.
B—Ditto, including insulators and stringing but not cost of wires.
C—Same as A, but for double 3-phase line on single set of poles or towers.
D—Ditto, but including insulators and labor stringing wires but not cost of wires.

voltages, there are economic considerations which determine the maximum voltage suitable for any given conditions. Among these may be mentioned a possible increase in the cost of generating plant for the higher pressures, the greater cost of step-up and step-down transformers and of the control apparatus, together with the line insulators, entering bushings, etc. The transmission line poles or towers will also, as previously mentioned, cost more for the higher pressures, because of the wider spacing between conductors. Then again, with the extra high pressures, the increased losses through leakage over insulators and possible corona losses may be quite appreciable.

Given a definite amount of power to be transmitted, and a definite line pressure, the current can be calculated; and the economic conductor cross-section, and therefore the weight and cost of the conductors, will be directly proportional to this current. It is only of recent years that this fact appears to have been generally recognized, and yet, so long ago as 1885, in his Cantor lectures delivered in London, George Forbes said: "The most economical section of