likelihood, will be selected, although Fort William and Niagara Falls are also mentioned in this connection.

On the evening of the second day of the convention, a banquet was held which was largely attended by the members and their friends. The usual toasts were honored and in a stirring and patriotic speech Mr. Nicholls responded to the toast "Canada, Our Country." Although English-born, he said, this country appealed to him above all others. It was destined to become one of the greatest nations of the earth. "We have every right to look forward to a wonderful prosperity," said the speaker. "Even to-day we have in all walks of life comforts and luxuries unexcelled by any nation. Our railroads are as thoroughly equipped, our school system inimitable, and our electric light and telegraphs most modern. All this has been done by taxing ourselves, but to-day English capital is rapidly pouring into this country and finding profitable investment."

Mr. C. A. Littlefield, of New York, replying to the toast to the "Central Station," reviewed the wonderful progress since electrical energy was first generated.

Other speakers during the evening were Messrs. L. J. Belnap, Montreal; W. W. Freeman, President, and T. C. Martin, Secretary, of the National Electric Light Association; Chas. F. Scott, ex-President of the American Institute of Electrical Engineers; Major Hugh C. MacLean, and W. Bache, Toronto, and A. A. Dion, Ottawa.

NOTES ON TRANSMISSION LINE REGULATION.

By P. M. Lincoln.

The voltage drop between generating and receiving apparatus is usually of first importance to the operating engineer. In other words, the first thing the operating engineer wishes to know about his transmission line is its regulation. Usually he wishes to maintain constant voltage at his receiving station and what he wishes to know is the increase in voltage that must be supplied at his generating station as the load increases in order that the proper voltage may be delivered at his receiving station. It is one of the objects of this paper to describe a short-cut method of approximating transmission line regulation which has been of considerable benefit and use to the writer. The line regulation method offered herein is not claimed to be exact and must be used with an appreciation of its limitations.

In a direct current problem this matter of voltage drop between generator and receiver is extremely simple. It is merely a matter of multiplying the current by the resistance of the line and the voltage drop at once is obtained. In direct current problems, therefore, one only has to know two quantities to obtain this drop, namely: resistance and current. In an alternating current proposition, the equivalent problem requires for its complete solution four additional quantities, namely: leakage, capacity and reactance of the circuit, and the power factor of the load.

The first simplification which we may apply to the problem is to eliminate the question of leakage. In actual transmissions the leakage of current from the conductors is so slight that the most refined analysis does not require its treatment. If the case were one of telephone wires, where the amount of current transmitted is very small and leakage might amount to a measurable proportion of the total, the treatment of leakage might be necessary; but for transmission lines it is not.

The next simplification of the problem will be to eliminate questions of capacity, so far as line regulation or drop are concerned. In determining regulation, capacity has very little effect provided we define regulation to be the change in voltage at the generator in order to maintain constant voltage at the receiver with varying receiver loads and power factors, then a consideration of capacity effects would be current and generator power factor with the various receiver loads and power factors then a consideration of capacity effects would be very important, but if we consider only questions of line regulation, capacity effects may be neglected without serious error. This is not true if the lines are very long, for instance, 300 or 400 miles, and the frequency high, but for the ordinary problem which confronts the engineer this question of capa-

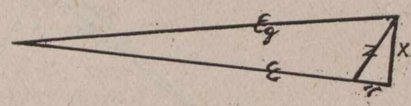

Fig. 1

city may be neglected so far as line regulation is concerned. Later in this paper I am citing some examples which show the amount of error for certain specific cases when neglecting capacity effect.

The elimination of leakage and capacity leaves us four quantities that affect line regulation or drop, namely—current, resistance, reactance and load power factor. The effect of these various factors on the problem of line drop may be shown graphically and the fundamental ideas underlying the short-cut method may be explained by diagrams. In fig. I., let E represent the voltage at the load and let r be the ohmic drop which is caused by the receiver current flowing through the resistance of the transmission line, and let x be the reactive drop caused by the load current flowing through the line reactance inductance. The value of r in this diagram is assumed to be 10 per cent. of E, and that

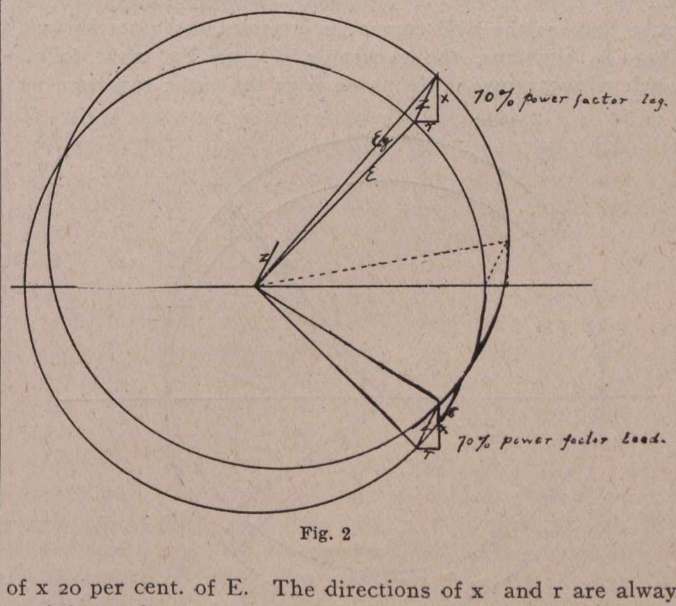

Fig. 2

of x 20 per cent. of E. The directions of x and r are always at right angles to each other. Also r is always in phase with the current flowing and x is at right angles thereto. Fig. 1 shows graphically the generator voltage Eg when the load power factor is unity. When the power factor is unity it means simply that the voltage E at the terminals of the load is in phase with the current which flows through the load. As a consequence the voltage drop caused by the current flowing through the line resistance is directly in phase with both receiver voltage and current, and the voltage drop caused by the current flowing through the inductance x is at right angles thereto. The voltage of the generator Eg