DISCUSSION ON HIGH-TENSION TRANSMISSION PAPERS AT NIAGARA FALLS, N. Y., JUNE 26, 1907

P. M. Lincoln: An inspection of some of the illustrations shows that there is a very apparent angle in the cables at the point where they are attached to the tower structures at the bottom of the gorge. This angle would indicate that the strain at that point is downward. I would like to know why this method of construction was used. It surely cannot be on account of relieving the supports at the top of the bank of strains due to a long span, because the strains in the cables must necessarily be increased by the amount of the downward strain at the point where they are attached to these structures.

F. B. H. Paine: The cables drop from the cantilever loosely to the river-edge tower on which they are dead-ended. The cantilevers support the weight, and the water-edge towers simply hold them out of the vertical sufficiently to prevent their hanging too close to the steep hillside.

P. M. Lincoln: It seems to me that exactly the opposite effect would be obtained by this construction, since the curve which would naturally fall would be made more abrupt by pulling down at this point.

F. B. H. Paine: The span across the river is quite independent of the slope-spans, and is dead-ended on each water-edge tower. The crossing is not a catenary into which the water-edge towers are inserted and steady the cables. It is three independent dead-ended spans; two almost vertical and one almost horizontal.

P. M. Lincoln: I do not see why it is necessary to attach to the towers at that point.

F. B. H. Paine: Mr. Mershon divided the crossing into the three spans to avoid the effects of tremendous winds in the Niagara Gorge—blowing both ways at once—and which unusual condition he feared would result in swinging the cables together. He wanted as short a span as possible and as close to the bottom as possible, to avoid the effects of the cross-winds on one span. I believe our experience shows that the effect of these winds was exaggerated by the "oldest inhabitant."

D. B. Rushmore: Some of Mr. Mershon's power consumers get their power from a single line, and I think it is open to discussion whether such a practice is justified. In the line construction shown, some pertinent questions arise; for instance, from the experience given in the paper by Mr. Rowe, it has been found necessary to put the top conductor below the others, and to run the ground wire in its place. I think that a similar change would be desirable here.

The questions at once arise, why are the wires on separate towers? Why is a single tower not used to carry both sets of wires? Under what conditions can one high-tension line near another be repaired while the other is in operation?

Mr. Buck shows a line construction for very high voltage

and he puts both lines on the same tower. Can he repair one line if the other is in operation?

The wooden A-poles which Mr. Mershon shows have got to be replaced every eight years, we will say, but not all poles will last eight years. Every time a pole is replaced, the transmission of power is interrupted, and while at first the interruptions from this cause are not many, they finally become so frequent that customers grow impatient and new customers cannot be got. Under these conditions it seems to me that a single line transmission with a wooden pole construction is not economically justified.

H. W. Buck: Regarding the possibility of working on one line with the other line alive: in Fig. 2, with the tower grounded and with the circuit out of service grounded, I see no reason why a man should not safely work on that dead circuit. He would have the whole tower structure between him and the live circuit, and the circuits are quite a distance apart, about 20 feet.

J. B. Taylor: Mr. Nicholson's method of locating breaks, or more properly grounds, on high-tension lines is extremely valuable, the broken insulator being the trouble which is most often experienced. I think that the transmission system on which he has made his tests was fortunate in having a man who could take up work of this sort, possess the proper ingenuity to make the proper application for the particular trouble, and be on the ground when the trouble came; but I doubt if the average transmission plant will install the necessary switches and resistances and have the experts to locate troubles in this manner.

A plant that was started up about five years ago had a fourth wire installed on a three-phase system. The idea was that when one of the three wires got into trouble, a simple system of knife-switches could cut in the fourth wire, and everything would go along as usual. The line has had occasional trouble, but for one reason or another—either because the operating force did not feel sufficiently sure of the conditions to cut in the spare wire, or because they felt that the trouble was of such a nature that it was unsafe to attempt to resume service before knowing what the trouble was—the fourth line has not been used.

I have not checked the mathematical equations in the paper, but offhand it is not obvious why the reactances of the long and short sides of the loop should come out in the same ratio as the resistances. The inductive effect of the return current in the earth does not appear in the analysis, and under some conditions this appears to be an essential factor. However, the accuracy of the test locations shows the method to be right for the average transmission line when the two sides of the circuit are separated by a few feet.

Without doubt Mr. Nicholson has considered other schemes for locating these troubles. I wonder if he has tried to locate

a broken insulator by merely passing the current over the faulty wire to ground and measuring the induced voltage in a neighboring wire—one of the transmission wires, neighboring telephone lines, or anything that happened to be handy. Assuming the wires at uniform separation, the induced voltage should be proportional to the length.

William McClellan: It appears as if every essential point had been considered in the design of Mr. Hewlett's insulator. In the long run it should be cheaper, though the first cost would remain the same as for present types. Those of us who have had experience with large 60,000-volt insulators made of cemented shells know what it means to discard an insulator because of a simple broken shell. Another point is the benefit of the full dielectric strength of the material used. We all know that the breakdown potential of a cemented insulator is considerably less than the sum of the breakdown potentials of the separate shells.

Regarding Mr. Hayes' paper, I think emphasis should be laid on the desirability of the open type of wiring for potentials over, say, 25,000 volts. For higher potentials there is a strong tendency among engineers toward outdoor stations, though it must be acknowledged that the last word on this subject will not be said for some time to come. I think that we should cease putting up ordinary knife-switches to be opened with a pole in the hands of a man on a shaky platform 25 feet from the ground. Very simple switches to be opened from the ground have been designed by certain operators in the West and marked attention should be given to this simple but, at times, very important part of the high-tension apparatus.

W. N. Smith: Has the matter of icicles forming between the successive petticoats of insulators of the type proposed by Mr. Hewlett been given due consideration? It would seem as though a chain of insulators, one above the other, might perhaps enable icicles to be formed that would connect from one disk to another. Unless there has been experience to the contrary, I should hesitate to condemn the ordinary petticoat type on account of icicle formation between petticoats, which I think would be fully as difficult to consummate with the petticoat type as with the new insulator proposed by Mr. Hewlett.

L. C. Nicholson: In regard to Mr. Taylor's suggestion as to measuring voltage generated in a parallel wire, I will say that some such methods have been undertaken, but the results obtained were not encouraging, particularly on account of parallel circuits which were in operation at the time, interfering with any measurements of induced voltage in the parallel wire. In case of only one line, I presume some such test could be made, but having more than one line one interferes with the test on the other by electrostatic and electromagnetic induction. In any case, I think it would be necessary to have two instruments; an ammeter to measure the current flowing, and a voltmeter to measure the induction.

S. Q. Hayes: The 200,000 kw. given as the capacity of the oil circuit-breaker is correct; that is, the manufacturers guarantee that that switch will be able to open any overload or short-circuit that will occur on the station having that capacity on the bus-bars. Up to the present time there is no station with that capacity on the bus-bars.

In connection with the troubles in pulling disconnected-switches, it has been proposed in several cases where the disconnecting switches are in rather inaccessible positions to operate, them by means of a soleloid or motor-driven mechanism.

J. H. Finney (by letter): It seems to me that Mr. Mershon's method of tying-in is not so simple as might be employed, although the tie is very ingenious; the chief objection to it is the large amount of tie-wire required, and the fact that the cable is not firmly fastened to the insulator, but simply lies in the top groove.

FIG. 1.

FIG. 2.

FIG. 3.

I would like to call attention to a tie which not only embodies simplicity and a small amount of tie-wire, but has the advantage of holding the conductor firmly on every side, as will be seen by the accompanying illustrations. The tie is made by straddling the line wire and top of the insulators as shown in Fig. 1. Both ends are then carried around the neck of the insulator in the same direction as shown in Fig. 2. Having made a half circle of the insulator, the ends are made off by taking a number of turns around the line conductor shown in Fig. 3. This makes a symmetrical tie, the conductor being held without danger of kinks, and is not subjected to any strains which would tend to cause abrasion and breakage of either tie-wire or conductor. The strain is uniformly distributed around the head of the insulator, the conductor being held firmly in the groove. This tie is decidedly cheaper than clamps, is more easily installed, and, in my opinion is not only

more desirable than clamps, but is one of the best designed ties, from all standpoints, of which I have knowledge.

F. G. Baum (by letter): When trouble occurs on a line similar to that considered by Mr. Nicholson, the station operator will try to find the section of line on which the trouble is located. The trouble may be a broken insulator, or it may be more serious, and repeatedly to throw power on a disabled line to test it may at some time cause very serious consequences. Furthermore, having located the section of the line in trouble, the operator will at once start patrolmen from each end of the section. After the point at fault is located it will require one man, and very often two men, to repair the break. Until the men arrive at the break it is not certain what must be done and what materials will be required. Hence, while the test method may be of some advantage in some cases, generally one would have to use the sure way in addition to it. Power should not be thrown on a disabled line more than necessary, as life and property may thereby be endangered.

Ralph D. Mershon (by letter): Replying to the points raised by Mr. Rushmore. Whether or not service from a single line is justified, depends upon the value and importance of the customer. One would be justified in going to the expense of two lines for a large and important customer, but such expense would render the business of a small customer unprofitable. Mr. Rushmore raises the question of the grounded wire. I have never been fully convinced that the grounded wire actually affords an appreciable amount of protection against lightning, or, at any rate, an amount of protection which would justify the expense of installing it. I had hoped that Mr. Rowe would, in his paper, bring more convincing proof of the value of the grounded wire than has been submitted in the past by those defending it, but I must say I cannot see that he has done this. The question of two-circuit towers vs. single-circuit towers is one on which many arguments can be advanced on both sides. In the end, the choice must be largely decided by the conditions to be met. In our case it seemed best, for a variety of reasons, to make use of the single-circuit towers. What Mr. Rushmore says in regard to wooden pole-line construction is true in many cases; it is not true in this case however. Where the A-frames were installed, the amount of space available was not sufficient to allow of tower construction, and steel-pole construction would not only have been more expensive than wooden poles, from every standpoint, but the necessary deliveries of steel poles could not have been obtained.

As regards Mr. Finney's tie, I would say that the tie we used was adopted for the reasons set forth in the paper, and only after an exhaustive series of tests on all the ties we knew of or could devise. If Mr. Finney will make actual pulling tests on his tie with aluminum cable and aluminum tie wire, he will find, I think, that it will not fulfil the conditions which, as explained in the paper, it was desired to meet, and which the tie adopted does meet.