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CANADIAN ELECTRICAL NEWS AND STEAM ENGINEERING JOURNAL

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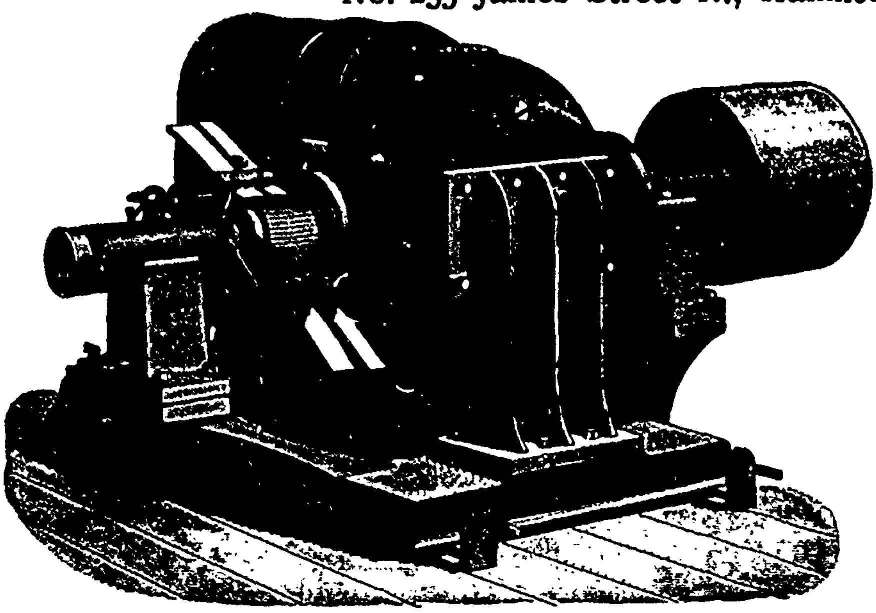

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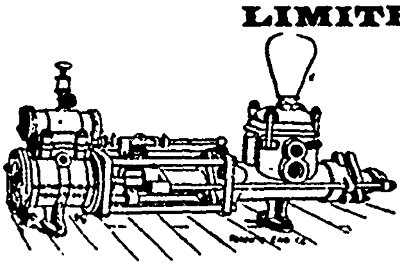

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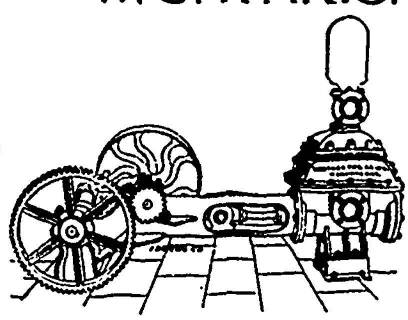

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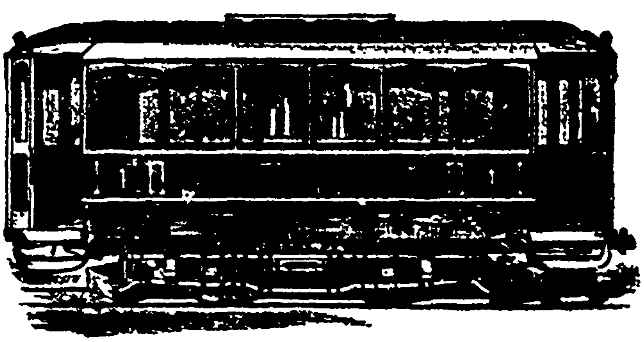

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CANADIAN

ELECTRICAL NEWS

AND

STEAM ENGINEERING JOURNAL.

VOL. IV. OCTOBER, 1894 NO. 10.

CANADIAN ELECTRICAL ASSOCIATION

PROCEEDINGS OF THE FOURTH CONVENTION.

THE fourth convention of the Canadian Electrical Association opened in Room 310, Board of Trade Building, Montreal, at 11 o'clock a.m. on Wednesday, Sept. 19th, 1894. Mr. J. J. Wright, the President of the Association, occupied the chair. Among those present were the following :—

L. B. McFarlane, W. B. Shaw, Jo'n Carroll, D. A. Starr, Fred. Thomson, G. W. Sadler, Geo. M. Wight, Hal Brown, Chas. C. Paige, W. G. Slack, Robt. F. Jones, W. B. Powell, F. W. Atkinson, E. B. Biggar, Geo. H. Hill, Jas. Hunter, Jas. Geen, Montreal; K. J. Dunstan, A. B. Smith, C. H. Mortimer, W. A. Tower, T. R. Rosebrugh, John Langton, Wm. Bourne, J. A. Baylis, A. M. Wickens, J. C. Gardner, Geo. White Fraser, Toronto; J. E. Brown, D. H. Keeley, O. Higman, C. F. Medbury, D. C. Dewar, Ottawa; W. R. McLaughlin, New York; Geo. Black, W. F. McLaren, Robert Dickinson, Hamilton; J. W. Taylor, W. P. Roper, Peterborough; A. A. Wright, C. H. Wright, W. A. McKay, Renfrew; R. G. Moles, Arnprior; Chas. A. Bissett, St. Johns, Que.; E. Carl Breithaupt, Berlin; Chas. F. Ernst, New Hamburg, Ont.; John Yule, Guelph; J. M. Campbell, Kingston; Andrew E. Sangster, Sherbrooke.

Mr. Thomas D. Lockwood, Advisory Electrician of the American Bell Telephone Co., Boston, and Mr. F. S. Francisco, President National Electric Light Association, of Rutland, Vermont, were among the visitors.

The chairman in opening the meeting said: I may express the pleasure it gives me to meet the large attendance present at this the opening session of the Convention. I am glad to see we have some of the electrical fraternity with us from the United States, and am happy to give them a most hearty welcome, and at the same time I might mention our meetings are open, and we will be glad to have our visitors take part in the discussions that are expected to take place on the reading of the various papers. I have to congratulate the Association on the papers we have had prepared by a number of our members.

The Secretary then read his annual report as follows:

SECRETARY-TREASURER'S REPORT.

In view of the exceedingly full programme which awaits your attention, I am reminded that I should make this report as brief as possible.

The Association year, which closed on the 31st of May last, was a comparatively uneventful one, apart from the Convention held in Toronto a year ago, which was admittedly the most interesting and enjoyable of any that had been held up to that date, but which I trust will be eclipsed by this in which we are now assembled.

Three meetings of the Executive Committee have been held since the last convention. At the first of these, which took place on the 24th of November last year, payment was ordered of the accounts in connection with the Convention, the details of which are given in the Treasurer's report; several new members were elected; on motion of Messrs. Black and Smith it was resolved that new members joining the Association in the interim between two annual meetings will be entitled to membership until the close of the ensuing annual meeting, at which time their membership fees shall again become due.

At an Executive meeting held in Toronto on the 15th of May, Mr. W. B. Shaw was elected a member of the Executive Committee in the stead of Mr. D. Thomson, whose removal to the United States rendered necessary his withdrawal from the Committee. The preliminaries in connection with the arrangements for the present Convention were considered and the Secretary instructed to invite papers from the following gentlemen:—Messrs. Rosebrugh, Breithaupt, Parker, Shaw, Galt, Medbury, Langton, Schwartz, Baylis, Pinolet, Fred. Thomson, Keeley.

At the final meeting of the Executive held on June 25th, the consent of all but three of the gentlemen invited to prepare papers was received. Messrs. Parker, Thomson and Medbury felt compelled to decline. It was decided that the Convention should be held in the building in which we are now assembled, and that the Montreal members of the Executive, the President and Mr. Kammerer be a Committee to complete arrangements. On motion of Mr. Dunstan a sum not exceeding $100 was placed at the disposal of the Committee for expenses.

Subsequent to this meeting the offer of a paper was received and accepted from Mr. Elmer A. Sperry, of Cleveland.

You will I am sure be quick to recognize the value of the papers which are to be submitted at this meeting, and the obligation under which the Association is placed to the authors, who, I am personally aware, have sacrificed time and comfort in their desire to advance the interests of the Association.

The number of active members at present on the roll of the Association is 99, and of associate members 38.

The suggestion has come from a number of our members that a reduction should be made in the active membership fee. It is thought that the effect would be to increase the number of members. The suggestion will no doubt meet with proper consideration at this meeting. It is hoped that as a consequence of this Convention being held in Montreal, which is recognized as the electrical center of Canada, the Association will receive many additions to its membership, especially from the ranks of the local Electric Clubs, and the Societies of Civil and Stationary Engineers.

The following is a statement of the receipts and disbursements for the Association year ending 31st May, 1894:—

Receipts.

Cash on hand, June 1st, 1893		$ 6 30	
Cash in bank, " " "		97 18	
63 active members' fees		315 00	
26 associate members' fees		52 00	
J. M. Campbell, to cover exchange on cheque		15	
Ladies' tickets to Niagara Falls		8 00	
			$478 63

Disbursements.

Expenses of Convention at Toronto,			
Lunches at Cliff House	$17 50,		
Dinner on Chicora	37 00,		
J. A. Kammerer expenses incurred for Association	4 35,	58 85	
Reporting proceedings of Convention		26 80	
Grant to Secretary		25 00	
Postage		27 00	
Printing and stationery		65 00	
Receipt book		25	
Exchange on cheques		75	
Refund to W. A. Green for dinners at Cliff House		1 50	$205 15
			$273 48
June 1st, 1894.			
Cash on hand		$ 23 30	
Cash in Merchants' Bank		250 18	$273 48
Total cash on hand, June 1st, 1894			$273 48
Receipts sin[ce] June 1st, 1894.			
7 active members' fees		$ 35 00	
3 associate members' fees		6 00	
Capt. Carter		2 50	
D. Robertson		1 00	
		$44 50	
Expenditure since June 1st, 894		17 04	27 46
Total cash on hand, September 18th, 1894			$300 94

C. H. MORTIMER,
Secretary-Treasurer.

Audited and found correct—Sept. 19, 1894.
D. A. STARR
L. B. McFARLANE } Auditors.

Moved by Mr. McFarlane, seconded by Mr. A. B. Smith, that the report be received and adopted. Carried.

There were elected ten active and five associate members.

Mr. J. J. York, President of the Canadian Association of Stationary Engineers, read an address of welcome from his Association to the members of the Canadian Electrical Association.

The President for the Association thanked Mr. York for the kind welcome from the C. A. S. E., and extended to that Association an invitation to take part in the deliberations of the Convention.

Mr. York thanked the President for his kind invitation to the Stationary Engineers.

Mr. Dunstan: Before calling on the committees to report, Mr. President, I want to call attention to the fact that we have with us Mr. Thomas D. Lockwood, of Boston, Mass., the Advisory Electrician of the American Bell Telephone Company, whose name is well known to almost every member present. He is one of the eminent electricians of America, a walking library of electrical knowledge. I find in Article 3 of our Constitution we have the power to elect by a two-thirds vote honorary members. So far we have never exercised that power. I have much pleasure in proposing that Mr. Thos. D. Lockwood be the first honorary member.

Mr. John Carroll seconded the motion, which was carried unanimously.

Mr. Lockwood: Mr. President and members of the Association—For the first time in my life my breath has been taken away by the action of my brothers. It is a great pleasure to me, indeed, that in my travels in search of recreation I happened to reach Montreal on the occasion of your meeting here, and I feel it a great privilege and honor, not simply to be made an honorary member of your Association, which in itself is a great honor, but to be actually the first one. When my friend Mr. Dunstan nominated me just now, mentioning that I was a walking library, the word library was indeed a great relief to me, for when he spoke I thought he was going to say I was a walking delegate, which I assure you I am not. (Laughter and applause.) I must congratulate you on the eclecticism of your programme. Until a few years ago the knowledge possessed by physicians and medical men as to the application and use of electricity was largely of the negative kind. That is so no longer, and it is a matter, I think, that the entire fraternity may rejoice in, that medical electricity is made equally important with every other branch of the applied science, and looking over your programme it seems to me that the papers which we are about to hear read will be of great use to every one of us, and I trust on behalf of myself, as well as on behalf of the members about me, that the discussions will be considerable and that each paper will be thoroughly and practically discussed. I once more thank you for the honor you have conferred upon me. (Applause).

GENERAL BUSINESS.

It was moved by Mr. K. J. Dunstan, seconded by Mr. A. B. Smith, that the word "five" in the second line of Article 5 of the Constitution be struck out and the word "three" substituted, and that this reduction in active membership fee date from the 1st of June, 1894, the Secretary being instructed to refund two dollars to all members having paid $5 for yearly subscription from that date.

Mr. Dunstan read from Article 9 of the Constitution referring to this point.

Mr E. Carl Breithaupt moved, seconded by Mr. Kammerer, that Messrs. Smith, McFarlane and Dunstan be appointed a Committee to take the matter in hand. Carried.

Moved by Mr. A. B. Smith, seconded by Mr. Kammerer, that all previous committees be dispensed with, and that committees be nominated by the President on Legislation, Statistics, and Constitution and By-laws. Carried.

The President read a communication from Mr. Cunningham, Chief Engineer of the Montreal Street Railway Co., extending an invitation to the members to visit the power house of the company.

It was arranged that a visit should be made there at 2 p.m. on the following Friday.

The President read a communication from Mr. Paige, manager of the Packard Lamp Co., inviting the Association to visit the Queen's Theatre this evening.

At twelve o'clock noon the President declared the meeting adjourned to 2 p.m.

AFTERNOON SESSION.

At 2 p.m the President took the chair and called the meeting to order. He then appointed the following committees:

On Statistics Messrs. E. Carl Breithaupt, Berlin; John Langton, Toronto; John Galt, Toronto.

On By-laws and Constitution—Messrs. J. J. Wright, J. A. Kammerer, A. M. Wickens, A. B. Smith and K. J. Dunstan, all of Toronto.

On Legislation - Messrs. J. Berkeley Powell, Ottawa; L. B. McFarlane, Montreal; John Yule, Guelph.

These nominations being put to the meeting, were adopted.

The President called upon Mr. W. B. Shaw, of Montreal, to read a paper on "The Application of Electricity for Medical and Kindred Purposes from Light and Power Circuits." Mr. Shaw illustrated his paper with a transformer. (See page 125.)

Mr. Black. I have listened to the paper read with great interest. There is one point which the reader of the paper did not make clear which I would like to have cleared up, because it would not do to go to the public as the opinion of this convention that this current used by doctors is perfectly harmless or is without danger. About fifteen months ago I read a discussion in the Electrical World on this subject, and I agree with Dr. Waite, who took the ground that it would not be right for a doctor to employ a current coming from outside, because a wire might come into contact with a current of fifty or one hundred volts, or possibly come in contact with a thousand or two thousand volt wire. The person who took the other side of the discussion suggested that a fuse would remedy that, but we must bear in mind that a fuse takes time to act and the mischief would be done before the circuit would be opened, and on the other hand a sudden opening of the circuit is sometimes dangerous to the patient. The view of the writer of that article was that it was both dangerous to the doctor and dangerous to the patient, and that no doctor should take such a risk upon his hands. When we consider also that others besides educated medical men are dabbling in these things, if it became known that everybody who liked could dabble with the current that comes into his house, it would be rather dangerous. I would like if Mr. Shaw could tell us what precautions should be taken in such cases as that. He simply gives a few words: "A broken wire would cause the patient to receive a violent shock, which in internal examinations might prove fatal. A worse objection is, however, open to the straight current brought in from outdoors, viz., contact with a higher tension wire."

Mr. Shaw. In regard to that question I do not see any means or method by which the current can be made absolutely safe. The danger from a falling wire always exists. I do not know of any way by which that could be got over.

Mr. Black: The proper way would be to use a generator.

Mr. Keeley: Did you say your method was to put in a transformer, Mr. Shaw?

Mr. Shaw: Yes.

Mr. Keeley: In that case you would have a low tension. It would be altogether independent of the outside current.

Mr. Shaw: Yes, I would in that case.

Mr. Lockwood: It seems to me that the Association owes a great debt to Mr. Shaw for giving such a practical paper on a rather unusual subject, and a subject with which perhaps most of us who are engaged in the other practical applications of electricity are less familiar than any other, and I for one will gladly own my debt to Mr. Shaw. I have been instructed by this paper, and I desire to express my pleasure as to the information I have received from it. I have a particular sympathy with the remarks of the paper concerning the dentist's chair, because I have been there myself, both as a practitioner and as a patient. In my early years I could not find anything else to do at one time, and therefore undertook the post of a journeyman in a dentist's office in Port Hope, Ontario. I remember when the dentist had poor patients come in who he did not think were worth fifty cents, he would turn them over to me at twenty-five cents to practise on. (Laughter.) And we had no electrical appliances at that time worth being called such; in fact, the only practical utilization of electricity then was telegraphy, unless I except, of course, the making of electrotypes and electro-plating with which we were very unfamiliar indeed. But at the present time the dentist's work has been made comparatively easy to the practitioner, and comparatively painless to the patient. I say comparatively, because I think even now with all the improvements which art and science have been able to give to the dentist, it is still a matter of dread to the ordinary man or woman to sit in the dentist's chair even to have teeth filled, much less extracted. With regard to the hair brushes which Mr. Shaw has honored with a mere mention, I would like to say that I have found that with you as well as with us the charlatan is still abroad in the land. Almost the last thing before I left Boston I had occasion to buy a hair brush and one of the principal druggists in the city earnestly entreated me to take what he called an electric brush, and showed me it was surely electrified because when he waved it over a small pocket compass the needle deflected. (Laughter.) Bei[illegible] an ignorant man I had not sufficient faith in that form of elect[illegible]y and declined to buy the brush on the endorsement of its being an electrical one, and was foolish enough to buy one with ordinary bristles. I lost that brush, and while I was at Ottawa this week on going into a drug store to buy another I was very much surprised to have the same experience, almost entirely the same. This brush I was entreated to buy was electrical and for the same reason, that by waving it over a compass it made the needle deflect. I have had some small experience in different branches of electricity. One of the most ordinary afflictions with which mankind is cursed is to have little fatty tumors, some people call them wens. Electrolysis applied to this is one of the best and most perfect means of bringing them down, so that they will not have sufficient strength to rise again; I have known many persons benefitted by it. I am specially pleased at seeing this paper advocated, although perhaps not as strongly as it might, the taking of an electric current from mains which are ordinarily intended and used for other purposes. This is especially advantageous where it can be done, for the reason that if you have a voltaic battery, I do not know whether it is not called a Faradic battery here, all the voltage you can get at any time is that found between the terminals of the poles, but if you take current from the main by interposing resistance you can get easily whatever difference of potential you may want, and I do believe, and I hope my belief will be correct, that the time will come, and at no very distant date, when the electric mains will be introduced into many more places than they are now, for industrial purposes, not only those which are the most preferable to use and the most ordinarily used, but also for the many uses of domestic and scientific work, and for this reason that you can regulate your voltage by interposing resistance to any degree you please, and I think we may all bear in mind profitably that that indeed is one of the principal distinctions between the two ordinary terms, "electromotive force" and "potential difference."

It was pointed out by some of the members that all risk of outside contact with dangerous wires could be overcome by using a motor on the street mains connected by a belt with a small generator giving the required voltage for the practitioners' use.

Mr. J. A. Baylis, of Toronto, then read his paper on "Electrolysis," and produced some photos of water and gas pipes, and telephone cables injured by electrolysis in Boston, Hamilton and other cities. (See page 143.)

Mr. Keeley: In one portion of your paper you say "putting the negative to line." And you say later on "the negative pole of the dynamo should be grounded." You also say, "absolute protection as far as is known, it is impossible to have, but to ensure the greatest freedom from destructive action, the track circuit must be of the lowest possible resistance." I presume that you mean that the positive pole should be to line.

Mr. Dunstan: We would like to hear from Mr. Black as to the trouble that has arisen in Hamilton, and whether it has been yet overcome.

Mr. Black: In reference to Hamilton, I know every few days I used to see something in the papers about the water pipes being examined in the City Engineer's office; he has a pile in the corner of his office, but those were the days when they used the old strap rail and the bonds were broken. Those familiar with the position of Hamilton will remember that the main return circuit ran down James street. The single track ran to the power house and York street, King street, Barton street branched off. The whole current had to be returned to this one set of strap rails, and when the strap rails were worn the bonds broke, and the current would get off some other way. Since they have laid the new rails and made their bonding I believe there has been no complaint. All the pipes taken out were in the neighborhood of, and not very far from the power house. I believe they were not found injured in any other place than in the neighborhood of the power house. The City Engineer has gathered quite a mass of information, and I intended calling on him to see if he could give us anything on the subject for this meeting but I heard he was not present at his office. But I think everything is changed there now, for I understand the railway company have now connected the main water pipe with their ground wire at the power house and that reduces the chances of further trouble. I move a vote of thanks to Mr. Shaw and Mr. Baylis for their very instructive papers.

Mr. Shaw: In regard to the remarks as to the electrolysis being occasioned by the polarization of gases, that would cause an even wearing away of the pipes right along, but there is not an even wear.

Mr. Keeley: I think it would be found that wherever there was a marked effect on the cable, the ground would be very moist at that point. I think it would be found surrounded by water. Here is a piece taken from the vicinity of the power house in Hamilton and it looks as if it had the small-pox, and it has evidently been in water. Possibly the water may have passed through a limestone formation. I think it would be well for the members to keep in mind to note particularly the condition of the spot from which the specimens are taken.

Mr. Lockwood: The subject of this paper is one of great importance to many classes of people. It is of great importance to City Engineers because they have control of gas and water pipes, at least they ought to have if they have not. It is important to the telephone man, and it is important to the railroad man, because he naturally does not want to interfere with other people's belongings any more than he can or must. Then it is of importance generally because we ought to know and we want to know all about the working phenomena of electricity that we can know, in order that we may perform our own work properly. There seems to be one thing further that paper might have mentioned and did not, and that is, that a great deal of this electrolytic corrosion of underground cables is dependent on the amount of electricity that is pumped into the earth within a given area of space. Now, I suppose the most noticeable instance of this kind of thing is that which has occurred in Boston. Many of you, certainly all of you who are concerned in street railroading, know that there is the largest installation of electric street railway in the world, and it is needless to say that there the largest currents are brought back to the dynamos through the earth: larger than anywhere else. I was a little surprised in learning that the paper says that one of the remedies, the first remedy that has been suggested and tried, is grounding the positive pole at the dynamo and putting the negative pole to line. I wish to do them justice by saying that they have showed themselves always ready to try any experiment which persons conceiving themselves electricians have suggested, to prevent the electrolytic corrosion of underground cables. It is my memory that the dynamos of that company ordinarily have their negative pole to line, and that it was not until their attention was called to the fact that they changed it and put the positive pole to line. With the negative pole to line (and this again is entirely a question of memory), with the negative pole to line, so large is that system and so enormous are the amounts of electricity delivered to the earth after passing through the trolleys and the motors, that the electrolytic corrosion of pipes and cable tubes was in all quarters. In fact, it spread nearly all over the city, and it seems to me that it was as a suggested remedy that the present method has been adopted, in which the positive pole of the dynamo is to line, and while it is not a remedy, still it is a change which is mentioned in the paper, in a kind of negative way. It does restrict the trouble to a small area immediately around the power station, and when it is restricted to such a small area it is much more easily handled than a corrosion distributed around a large city. In addition extremely large copper cables are used. In Boston, copper cables of more than one inch in diameter have been employed, to aid the rails in returning the trolley current, and the trouble is very largely minimized. I personally do not think that in small installations of electric railroad serious trouble need be expected, but I think in large cities it is to be expected, and every remedy that can be thought of, provided it is proved to be at all efficacious, should be effected. The bonding of the rails, as suggested, is no doubt one of the principal things that is required. I do not think that the electric welded rails have, to any great extent, gone into use yet, and I think the unwieldiness of handling them will be an insuperable objection. But, with the best conductors that are made, we have still to remember that the old doctrine that used to be promulgated, that electricity would choose only the best path, must be discarded, not only from our lips but also from our thoughts, and remember that electricity avails itself of all paths in proportion to their respective resistances; and when we think of that, we cannot help but see, no matter how perfectly our roads are constructed, we should make the return conductor as perfect as it can be, and it is still the best thing to have the positive pole of the dynamo to line, and to aid the rail in the vicinity of the dynamo and of the power house by very large copper conductors.

Mr. Baylis: That remedy was suggested in an article issued in one of our papers in July of this last summer, as having been tried in Marseilles, in France, and it was strongly recommended there. They grounded the positive pole and had the dangerous area distributed over a large portion of the town, and they were experiencing no trouble, and this was commented on in an editorial in the London Electrician. It was stated, however, that it was not a true remedy.

Mr. Medbury: In Ottawa I had some experience with the Engineer of the Bell Telephone Co. in taking some readings of the different potentials between our rails and the ground, and after looking up the matter carefully we believed that by taking readings at different points, different manholes, we could simply connect the cables to the rails where there was the greatest difference potentially, or make the connection between the rail and that portion of the telephone cable which came nearest the power house, and in that way, of course, assuming always that the cable is positive regarding the rail, do away with pretty nearly all the effects of any electrolytic action. In a small city that would entirely remedy the matter, I think. In that case I would have the positive pole of the machine to the trolley wire. Of course our station there is located some way from the centre of the telephone cables, and unfortunately we could not measure the amount of current flowing on the cables. We did not much more than find out where the greatest action was going on, but of course, with a careful test, we could find out how much current was flowing, and whether it was bunched, or where the greatest tendency was to leave the cable.

Mr. Baylis: In Toronto, in the westerly portion of the city, the potential difference is three volts. Taking the opposite side of the city, it varies from two and a half to four volts. And there is a gradual decrease from the three volts in the west to about zero in the centre, and gradually increasing to about four in the east.

Mr. Shaw: Which pole does the trolley wire connect with?

Mr. Baylis: To the positive. And the current we get off the cables, measuring from the cables in our easterly manhole, the manhole nearest the power house, to the water main which is in the manhole, is eleven amperes.

Mr. Medbury: The potential difference between those cables and the rail does not mean anything unless you take the amperes along to make a reading of.

Mr. Baylis: I think the potential is the most important thing because, in the case I have been speaking of, I can measure the number of amperes flowing from the cable to a given point, at the junction of a water main in a manhole, we can get a large amperage. The measurements that may be taken on any pipes, either cables or water or gas pipes, with an ammeter and volt meter, are generally valuable in showing the direction in which the current is flowing. It is impossible to measure the number of amperes running from one point to another unless you can insulate the pipe entirely from the ground through its entire length. You are simply taking the alternative path of the current, as it were.

Mr. Medbury: Potential difference is not what is doing the damage. We get a very low potential difference, but get a considerable current on the pipe. You can find out a cable is carrying a certain amount of current by fastening on to that cable and conducting it back to the rail or any other circuit.

Mr. Baylis: Well, if you take the readings of the ammeter, taking a gas or water pipe, for instance, which is buried in the earth, and expose the pipe for seven or eight feet and put an ammeter between the pipe and the ground, you probably will get a very small current flowing. At the same time a great deal of current may be flowing from the pipe to the ground. The The current is leaving the pipe all right enough, but it is not going through your ammeter.

Mr. Medbury: I can see your point. My point, as I have understood it, and my experience in the matter is this, that taking two streets, (this is how the case stands) two parallel streets, and this cable runs down one street and the electric railway is on the other street, but as there is a current going up to the farther street it takes just a short cut over that cable, and the whole of that current is going down that cable. It branches off the street and makes a conductor for it. If the cable happens to turn three or four streets down there, the current is leaving the cable again. Of course, if you take it at that point and put a tap on, you are not getting any electrolytic action at all. The cable simply acts as a conductor for the twenty or thirty amperes that happen to be flowing over it. Of course, after you have got away 100 feet from that corner, perhaps there would be no current to speak of flowing around the outside of the cable; it would all be going over that cable, perhaps twenty amperes. Of course readings taken anywhere inside of that zone of electric current would give various readings according to the position at which you are taking the readings, but twenty feet from the corner you have quite an number of amperes running over the cable.

The President called on Mr. L. M. Pinolet, of Montreal, to read a paper on "Alternating Current Motors." (See page 126).

Mr. Medbury, in discussing the paper, said: This is a very interesting paper and contains a great deal of information in a small space. I was much interested recently in watching the operation of starting synchronous motors by the currents induced in special closed circuit windings on the fields. When synchronizing speed was attained, the field circuits were connected with the proper current and the motors then ran synchronously. The fact that the speed of a synchronous motor depends upon the rate of alternation of the exciting current, does not appear to be universally comprehended, for I recently received a communication from a person to whom I had supplied one of these motors, asking how to reduce his speed and saying that he has considerable resistance in circuit with the motor to lessen its speed, but without affecting the speed at all.

Mr. Brown: I would like to hear something further on this subject as I understand considerable trouble has been occasioned by the false currents due to the self induction of the motors flowing back through the transformers, the line and the generators. I understand this has caused considerable trouble and condensers have been used with the motors to overcome it, but have been found to be objectionable.

Mr. Pinolet: Many of the early polyphase motors were not well designed and were inefficient, but with a well designed motor the loss due to self-induction is trifling. Dr. Louis Bell in his recent paper to which I have already referred, published a comparative test of the current of a polyphase motor and that of a continuous current motor of the same capacity at different loads. His tests showed that false currents were only noticeable in the polyphase motor at very low loads and at overloads. Between these limits, the currents taken by the motors were substantially the same.

Mr. Medbury. If there is no further discussion on this paper, I would like to present something which may be of some interest to those who are in the same line of business as I am. We are often asked regarding the relative cost of transmission for any long distance transmission plant at say 2,000 volts without step-up and step-down transformers and say 5,000 volts with step-up and step-down transformers. I made up a little equation which I will hand in because I think it may be useful, as I only recently ran across a case where there was a transmission of two and a half or three miles and the parties were strongly urged to use 5,000 volts with step-up and step-down transformers. It is hard work, and takes considerable time to figure the thing out without an equation in black and white. Of course there will be a certain distance at which the cost of the wire for the 2,000 volts will equal the cost of the wire for the 5,000 volts plus the cost of the step-up and step-down transformers. For a distance beyond this point, transmission at 5,000 volts with step-up and step-down transformers will be cheaper, and for a shorter distance which does not reach this point, transmission at 5,000 volts will cost more money than at 2,000 volts.

An equation to determine the distance at which the cost of transmitting any given power electrically is equal, whether a lower voltage is used without raising or lowering converters, or a higher voltage is employed, using raising and lowering converters, may be of interest to those who are frequently asked to decide between the two methods of transmitting power any given distance. The following equation, which seems to be useful for this purpose, is offered:—

$$d = \left\{ \frac{1}{ck} \quad \frac{bB(T+G-)}{aB-Ab} \right\}^{1/2} \qquad \text{where}$$

d = Distance in miles at which costs are equal.
a = Amperes on lower voltage line.
A = " " higher " "
b = Volts lost on lower voltage line.
B = " " " higher " "
c = Cost of copper wire per pound.
k = a constant 3950.5.
T = Cost of transformers for higher voltage line.
G = Extra cost (if any) of higher voltage generator over lower voltage generator.

A study of the equation shows that for any assumed values per unit of size of transformers, d is independent of changes in A or a, that is, the distance does not vary with the power to be transmitted, but varies inversely as the square root of the cost of copper, and directly as the square root of the cost of transformers, and as the drop in volts where the per cent. of loss taken is the same for both systems, or in other words, d varies very slowly for changes in B, b or T. As an illustration of the use of the equation, let us determine the point at which, for transmitting the same amount of power, the cost of a 2000 volt installation, without raising or lowering converters, equals the cost of a 5000 volt installation using first a 5000 volt machine and lowering converters and then a lower voltage machine and both raising and lowering converters. Let A = 1. Then for the same power transmitted a = 2.5. Let the loss be 16⅔%, then B = 1000 and b = 400. Let the cost of bare copper wire be 14c. and raising or lowering converters cost $20 per K. W. Then in the first case T = 100 and in the second 200, say G = 0. Substituting these values in the equation we have

$$d^2 = \frac{1}{.14 \times 3950.5} \quad \frac{1000 \times 400 \times 100}{2.5 \times 1000 - 1 \times 400} = 35.7312 \text{ or}$$

71.4624 when raising and lowering converters are used with a lower potential machine. Now $\sqrt{35.7312} = 5.98$ and $\sqrt{71.4624} = 8.45$, which shows that under the conditions assumed for transmitting any given power up to 5.98 miles, a 2000 volt installation costs less than a 5000 volt installation with a 5000 volt generator and step down transformers; beyond that distance the 2000 installation costs more, and when both raising and lowering converters are used this distance is increased to 8.45 miles. It should be noted, however, that this distance as already shown depends upon three factors, the assumed cost of copper, the loss on the line and the cost of raising and lowering converters.

An equation which enters into the above equation may also be of interest, as it determines quickly without the need of a circular mils table the total weight of wire required for any power transmission. It is

$$\text{weight of copper} = 3950.5 \frac{a \quad d}{\text{volts lost}}$$ where a and d are as above.

These equations are based upon 10.7 ohms as the resistance of a mil foot, and five per cent. has been figured for sag allowance.

The chairman asked Mr. Medbury if he remembered having at the last convention made some reference to distribution by polyphase currents for light and power that was to take place at Rochester and asked if he had any particulars as to how it was operating.

Mr. Medbury said there were three machines in operation there at the present time. They were combined continuous and alternating current generators, each giving at one side two-phase alternating currents and at the other side continuous current, so that at the same time both continuous and alternating currents could be obtained from the same machine. It is a commercial system with alternating current motors operating successfully by two-phase currents. At Concord there is a three-phase plant and three-phase motors in successful operation.

Mr. Brown: Are these motors synchronous or non-synchronous motors, and are condensers used?

Mr. Medbury: They are non-synchronous motors in both cases, and are operated without condensers.

Mr. Medbury requested, as Mr. Higman, of the Government Inspection Department, was present, that he should speak to the meeting on the position the bill in relation to electricity was in.

The chairman said it was very short notice for Mr. Higman, and requested that gentleman to present the situation at the following session of the Convention.

It was moved by Mr. A. B. Smith, seconded by Mr. H. A. Brown, that the thanks of this meeting be tendered to Mr. W. B. Shaw, of Montreal; Mr. J. A. Baylis, of Toronto, and Mr. L. M. Pinolet, of Montreal, for the instructive papers they have given this afternoon. Carried.

Mr. A. B. Smith reported that the Committee on Membership Fees recommended that the fee for active membership be reduced to $3.

Mr. K. J. Dunstan, in speaking of the report, said: It is a reduction in the membership fee from $5 to $3. The reason I make the motion is simply this: By the Treasurer's report we have on hand about $300; the cost of the last convention was in the neighborhood of $200; that means we have a surplus of about $100, after paying the expenses of this convention, assuming they are approximately the same as last year. We have also all the fees which will become due for the current year. The Canadian Electrical Association is not a money-making institution; we simply desire to pay our way. We fixed the fee at $5 with the view of being sure we could pay expenses. Having found that we can now reduce it to $3, I think it is in the interest of the Association that the reduction be made. We want members more than than money. We have no debt to pay off; we simply want to make ends meet. I think probably if there is only a difference of a dollar between the associate membership fee and the active membership fee, nearly all of the associate members who can qualify will become active members, and take part in all the proceedings of the Association.

The President: I think those remarks are all right, provided the members all pay up. Quite a number of the members are in arrears for their last year's subscription, but I presume if the amount is made less there will probably be less difficulty in collecting it.

The motion being put to the meeting by the chairman, was carried.

A letter from R. J. Corriveau, of the Montreal Park & Island Railway Co., extending an invitation to the Association for a trip over the suburban line to Sault au Recollet, was read.

The President announced that owing to the unfavorable weather the trip down the Lachine Rapids was postponed to Friday morning at 8 o'clock.

At 4.45 p.m. the meeting adjourned.

SECOND DAY.

On the 20th of September at 9 o'clock a.m. the members assembled at the Queen's Hotel and thence visited McGill University, where an investigation was made of the electrical appliances in the Macdonald Building, on the invitation of the Faculty of Applied Science and Prof. Chas. A. Carus-Wilson of the Electrical Department. An inspection of the electrical laboratories was made and a practical test on a transformer of apparatus for the measurement of alternating current power given by Professor Wilson.

At 11 a.m. the President called the meeting to order in the Board of Trade Building and stated that Mr. Higman of Ottawa would in the afternoon give an explanation of the working of the Inland Revenue Department as to testing electric meters.

Mr. A. B. Smith moved, seconded by Mr. McFarlane, Resolved that the hearty thanks of this Association be tendered to Prof. Chas. A. Carus-Wilson of McGill University for the elaborate and extremely interesting exposition of the electrical testing apparatus in use in the University and that the Secretary be instructed to forward a copy of this resolution to Prof. Wilson.

The President put this motion to the meeting and it was carried unanimously.

Mr. E. Carl Breithaupt, of Berlin, read his paper on "Municipal Electric Lighting." (See page 139).

The President then called upon Mr. J. Francisco, of Rutland, Vt., President of the National Electric Light Association of America, to address the meeting, extending to him also an invitation to take part in the discussions.

Mr. Francisco replied:—Mr. President and gentlemen—When I left the United States I supposed I was going to leave the question of "Municipal Ownership" behind me. I did not know I was going to come into it here, and hear the discussion following the reading of a paper on this subject.

I have devoted a great deal of time to the subject of Municipal Ownership, and have received a great deal of cudgeling in my experience on account of the position I have taken. I find almost all over the cry has been raised, not only through the States, but through the Canadian provinces, of the wonderful cheapness with which municipalities can furnish light, but it is pure humbug. It cannot be sustained, and never will be. There is a principle involved that makes it practically impossible for any city to carry it out. When a man who has every ability in the business invests his money in it, can he be compared with a political man, who has no interest whatever except to draw his pay and to help along some political scheme? When it is said a politician can do better than a man who has every ability in the business and his dollars invested, it is nonsense to make such a statement, he cannot do it. (Hear, hear.)

Now, references are made in this paper in regard to some places in the United States that are producing their own lights. At our Convention at Cape May I read a paper on Municipal Ownership which was the first paper read on this subject, and it was the first time we had attacked Municipal Ownership. The head electrician of the electric plant of the City of Chicago was there and he got up and stated emphatically that I was a very broad liar. (Laughter). He said the statements I had made in regard to Chicago were false, that the cost of electric lighting in Chicago did not exceed nineteen cents per light per night. Now, about three or four months ago that same electrician issued a report in Chicago on the cost of electric lights of the system there, and he gave the total expense at $96.64 per lamp per year. That is simply for the lighting expenses, not counting depreciation, interest, taxes, water rent, or anything except the cost of producing light.

In Dunkirk, New York, it was thrown in my face that the total cost of running 107 arc lights was $2200 per year. What were the facts on investigation? No engineer was employed or fireman, and not a ton of coal used at the station. They have an engine there that starts without a man going near it to look after it. The lights start themselves and they trim themselves and everything goes on automatically. That is why it only costs $2,200. (Laughter.)

When you get behind the curtain what do you see? All charged to the Water Department. Every cost of running the lights except the Superintendent's salary was charged to the Water Department. Of course it would only be $2,200. (Laughter.)

The Mayor of Topeka, Kansas, told me personally that when they took the lighting plant from the Company there they guaranteed it should not cost over $64 a year per lamp for the 2,000 candle power lamps. It has cost them $132 per year by actual experience by keeping a record of the running expenses of their plant, and he told me also there was no question but what the city of Topeka could have saved money by hiring lighting from a local company instead of running the plant themselves. They are building it all over and putting in a new thing, the old plant being used up. But they did not charge this; this is an improvement that does not cost anything, that is simply charged up as improvements, and the taxpayers pay it. (Laughter.)

And in Hannibal, Missouri, they had a little bit of a cyclone there which took the top off their power house and everything down to the dynamo, and then they went to repair it. It cost them $1000 odd, and they charged it up to "Construction." It appears now on the city's books as Construction.

In the course of my investigations in this matter I have visited nearly all the stations of municipal plant in the United States, and for the last six months I have had a very extended correspondence with cities and municipalities throughout the Provinces here, and with Toronto. I have been asked questions by officials in Toronto from the Mayor down. It is amusing to read some of the statements made by parties who advocate this municipal idea. You would think it was a perfect Eden in every place where the city owns the plant it is no expense whatever, the lights are perfect and everything running in magnificent shape. The mayor of Toronto asked me in regard to this same question. In regard to Philadelphia where they had an exhaustive investigation made as to the cost of the plant, three different estimates were made, one by the City Electrician, one by the manager of the city plant, and one by the local companies, all employing outside experts who were supposed to understand their business. And there was a difference between the two estimates of over $150,000 in installing plant. When it came to the running of the plant there was the most peculiar diversity you ever heard of. Of course the electrician was in favor of Municipal Ownership and wanted to show the whole thing in as bright a light as possible. They were going to run 507 arc lights. He did not think it was necessary to have more than one engineer to do the whole business. They were going to start about half past three in the afternoon and run on till the next morning. When he was asked when the engineer was going to clean his engine and look after everything and get some sleep, he said, "Oh, he would do that between those hours." (Laughter.)

The question was asked him how much he expected to pay the engineer to do that kind of work and run it that way. He said he was going to pay him two dollars a day. That is the basis on which he founded his calculation. Where will that go? What is the use of talking in this way to an intelligent electric light man who is experienced and expect he is going to take any stock in that theory.

I have probably travelled over 7,000 miles through the States visiting the plants, and not a single one of them will you find where they can show in one instance that they can produce the light for less than the private or local company can do it under the same conditions and have the same light and get as good results. If you charge all these things to other departments it is very easy to make a small amount, but if you want to produce the light on the same basis, and showing as low expenses, they cannot do it as cheap as the private company can. That has been demonstrated time and again and can be at any time of the year.

Here is another feature. In Canada of course it is not expected that you have anything like what we have in the States. They are all honest here. (Laughter.) The fact is that nine out of ten of the public men who have charge of this business are men you can buy hand and foot. I have had experience of that kind in my own city. Rutland has always been a village until last February. Then they put it in as a city and elected a Council. I do not believe that there has been a single transaction of any kind made in the City of Rutland since that date but what has been boodled. What was the result? They called for bids on city lighting. There was one company there. Another concern from the west came in and made a proposition. The Council gave the contract for lighting to the outside company at five cents per lamp higher than the local company offered. The question is, how much did they spend for boodle? We know they did it as well as if we saw them do it with our own eyes. That is the way that village is run, and that is the way it is run all through the States. You can talk about honesty and integrity in office—you may have it here, but on the other side they do not deal on that basis. But we have some very fine men over there, as fine as you can find anywhere, but the men of character and standing are not in office.

I thank you heartily for your courtesy in extending this privilege to me and trust I shall have an opportunity of meeting you personally. (Applause.)

Mr. A. A. Wright, Renfrew: This speech presents facts and information that every central station man ought to take to heart. If any municipality wants you to undertake to light their streets, the best thing you can do is to say, "No, thank you, I do not want to do it," for it is only a curse to any man as long as he lives. At our town I told the Council a while ago that I would rather deal with five hundred men than with one set of Councilmen. They want you to do the whole thing free gratis for nothing, without being paid a cent for a lot of work they want done, and then have it changed to something else. A central station man cannot do that kind of thing. I say to those who are out of the municipal lighting business, to stay out and not have anything more to do with it.

The Chairman: That is very entertaining for those who are out of it, but it is not much information for those who are in it as to how to get out. (Laughter.)

Mr. Wright: I am in it and I want to get out. I am thinking very seriously of using my dynamos for motors and giving up the electric lighting on the streets altogether; I think it will pay me better than having anything to do with the municipality.

Mr. D. H. Keeley: Would it be out of the way to suggest that we might set about collecting statistics as opportunity offers, of all the information coming under the notice of members of the Association. It should include facts in regard to the cost of lighting and the difficulties that are actually encountered in regard to dealing with municipal bodies and municipal lighting, and this information should be put on record so it could be sifted out afterwards by the members. The gentleman who has just spoken from the United States tells us there is quite a comparison to be drawn between the municipal bodies of the United States and those of Canada. We can hardly be guided in Canada by the statistics that are furnished from the other side when qualified in that way. If we were able to gather such information in our own communities it would be of great importance. A little while ago in the city of Ottawa the same question came up and there was a great agitation over it, and after a lot of talk it was decided that the companies could do the work just as efficiently as the city could, and the question was left open. The result has been that the companies there have amalgamated and are in a position to give a very excellent service; but that does not dispose of the question at all, and I think if we can, as an Association, put ourselves in the position to get together the information at a future date, it would be of great importance to us.

Mr. E. Carl Breithaupt: This is a good idea. It is a very difficult matter to gather statistics in that way. For the purpose of this paper I have endeavored to get statistics from all the municipal plants in Ontario, and some in Quebec, and have found it very difficult, as half of them would not answer my correspondence at all. I may say the statistics I gathered do not show any better figures than those of the United States published by Mr. Francisco. I have a lot of statistics in my pocket about Canadian municipal plants, but they are somewhat incomplete, and for that reason I did not want to quote them particularly.

Mr. A. A. Wright: I suppose the reason they are not complete is that the people giving them did not know how to do it. These people that are running municipal plants do not know how to do it.

Mr. E. C. Breithaupt: For the benefit of the Committee on Statistics, I would like to say a word on how this committee is to go to work, whether they will be allowed to go to any expense for the Association in the matter, which would almost be a necessity to make the statistics of any value, because just gathering statistics by correspondence like this you cannot get accurate figures.

Mr. Higman: There is another matter, and that is as to standard of power. The Department has received several letters bearing on that subject, asking us to embody in the Bill a standard similar to what was adopted in the United States as to energy.

Mr J. Langton: In this subject of municipal lighting the point seems to be the business efficiency of municipal government, and it is of interest to know what room for improvement there is. An article was published in the Forum a couple of years ago on municipal institutions in America and England, written by the Right Hon. Joseph Chamberlain, who made his first mark as a public man when Mayor of Birmingham. That city has now the reputation of being the best governed in the world. In the article I speak of he makes a comparison between the municipal expenses of Birmingham and Boston. The populations are almost exactly the same, Boston being 448,000 and Birmingham 430,000. In the article he gives detailed expenditures. The result is that the total cost of municipal government in Boston is twelve millions and a half, and in Birmingham it is two millions and a half; relative figures, five to one. There were some expenditures in Birmingham which were not undertaken in Boston, and vice versa. These related principally to schools and relief of the poor. Excluding these he gets the expenditures for strictly municipal government purposes in Boston a little over ten millions and in Birmingham one million six hundred thousand. The proportion in this case is six to one. Of course Birmingham is a high standard. The last census gives the expenditures of one hundred cities in the United States, ranging in population from 15,000 to 1,500,000, and having a total population of twelve millions and a half, or about two-thirds the urban population of the United States. The cost per head of municipal government varies from $3.79 in Oswego to $27.61 in St. Paul, with an average cost of $16.77 per head, against a standard set by Birmingham of about $4.50 per head, so that if there is anything in these figures, in order to put themselves on a par with private corporations in business efficiency, municipal governments in America must improve till they are about four times as good on the average as they are now. Of course there should be an advantage, if it is properly used, where it is possible to run the electric light in conjunction with water works or other public works, and save some of the general expenses. Whether there is any real advantage from this is a a question for each individual case. In favor of municipal ownership instances are cited of what some one town in one part of the world has thought it profitable to do, as an example of what another town in another part of the world should do. If that is an argument, the city of Geneva, in Switzerland, should be an argument against municipal electric plants. In Geneva the city has developed an extensive system of waterworks and derives a good revenue from water sold for power purposes. But in spite of owning and operating profitably this large system of water and water power supply, they do not seem to think it profitable to supply electric light, although the private electric company gets its power from the city, buying it at a very low figure. I do not think it is much of an argument to assert that an isolated instance in one part of the world furnishes a proper example to be followed by some individual town in another part. But when that sort of argument is used in favor of municipal electric plants, the case of Geneva should be equally valid on the other side.

Mr. Francisco: In answer to the arguments put forward I simply state that the National Association at their last Convention in Washington adopted a standard for our 2000 C. P. arc lights as 10 amperes and 45 volts or 450 watts. That has been adopted by the Executive of the National Association and will be adopted in all probability by the Government.

It was moved by Mr. D. H. Keeley, seconded by Mr. O. Higman, that it would be desirable that steps be taken by members of this Association, to gather and communicate to the Committee on Statistics, any reliable data and information relative to the comparative cost and efficiency of electric lighting by municipalities and by private companies.

Mr. Campbell: In the majority of cases in towns through the the country they do not keep any separate details. The accounts are all jumbled together in one item; power and incandescent lights all from one engine, and it is pretty hard to get at these details unless you go to the man who is at the business and see if there are any books kept and get the details. Any information got in that way, unless it is correct, is worse than useless.

Mr. W. B. Shaw: As the statistics will probably be accepted by the Inland Revenue Department later on, it would be well to sift them, not only in the interest of the Association but of private companies.

Mr. Keeley: It was my intention that only reliable information should be sent in to the Committee. Unless a member could come forward and say, "this is a fact," we do not want the information.

Mr. D. Starr: I think, for the reason that Mr. Higman in his department in looking after and inspecting plants, he or his deputies could gather a great deal of information, and it would be a good thing to have him on the Committee on Statistics.

Mr. Higman: I do not know that the department concerns itself much about statistics except in regard to the number of lamps used, but I will be very glad to do anything I can.

Mr. Keeley: It is not necessary that a man should be on the committee to get statistics together. I said in my motion that it was desirable that the members should communicate to the Committee on Statistics. The committee might consist of one person as far as that goes.

Motion carried.

Mr. Dunstan: Mr. Breithaupt has brought up the question of expenditure in gathering these statistics. I do not think that it is the desire of this Association to incur much expense, but still there will be some necessary expenditure for postage and other things, and the members of the committee cannot be expected to meet it personally. I therefore move that the Executive Committee be empowered to grant from the funds of the Association an amount sufficient in their opinion for the requirements of the Statistical Committee's work in securing statistics. As the work proceeds, and the committee find out exactly what statistics they wish to gather and what the cost is likely to be, the Executive Committee can then consider the matter carefully and grant from time to time whatever sum is required for the work. Seconded by Mr. A. B. Smith. Carried.

Mr. A. A. Wright moved a vote of thanks be tendered to Mr. Breithaupt for his ably prepared paper. Seconded by Mr. Shaw and carried.

Mr. McFarlane exhibited for the inspection of members of the Association an interesting collection of original letters and photographs of celebrities such as Morse, Cyrus W. Field, Vail, Elisha Gray, Galvani, Volta and Ohm, which had been kindly loaned for the purpose by the owner, Mr. John Horne, of Montreal. The collection included also some copies of an electrical journal called "The Canadian Electrical News," of which five numbers only were published by Mr. Horne in the "sixties," but which, as he states, proved to be ahead of the times. Mr. Horne is an old and practical telegrapher, and ex-Manager of the Western Union Telegraph Co.'s New York Stock Exchange, which at one time did the largest business of any branch outside of the main office. Mr. Horne many years ago commenced the collection of original matter relating to the history and invention of the electro-magnetic telegraph.

At 12:30 p.m. the meeting adjourned till 2 p.m.

AFTERNOON SESSION.

At 2.30 p.m. the President resumed the chair and called the meeting to order.

The first order of business was the reading of a paper on "A Method of Distribution with Equalization of Potential Difference," by Mr. D. H. Keeley, of Ottawa. (See page 140).

Mr. Campbell, in discussing the paper said: Fig. No. 8 illustrates the same idea as No. 6 as adapted to what is known as the three wire system. Are they both of the same size?

Mr. Keeley: They are all of the same size. The three wire system is the adoption of two dynamos. If you were using the three wire system and you increased the voltage to 200 volts, each machine giving 200 volts—

Mr. Campbell: Do you say 200 volt lamps?

Mr. Keeley. No, 100. It does not make a particle of difference.

Mr. Campbell. Whether this figure 8 is a two wire system or three wire system?

Mr. Keeley. It does not make any difference as far as voltage is concerned.

Mr. Campbell, after some discussion on the two and three wire systems, claimed that figure 8 was an impracticable idea altogether, as it would take four times as much copper. In theory and practice it was all wrong, and not equal to No. 7.

Mr. Keeley claimed figure 8 was what he represented it to be. He had made experiments carefully and if it was followed out carefully it could not fail to act.

Mr. Campbell. Take figure 6, it would take more copper and will not give as good distribution as the ordinary parallel system.

Mr. Keeley: It would necessarily have to be a better system. The idea is this, if we were going to supply a block in our immediate vicinity I should run my leads out of this side of the house and bring them in on the other side.

Mr. Campbell: If you could install the plant and build the town around it that would be all right, I suppose. I am in the dark to see how figure 6 is a better distribution.

Mr. Keeley. Well, for instance, you have your station, and the places you are going to supply the current to are about a quarter of a mile away. Your view seems to be that you would be running out four wires and would be using more copper than the ordinary mains. What I say is that you have exactly the same amount of copper you have with your ordinary two wire system. The highest difference of potential you can get at any point will be that from the first end of the circuit. As I have pointed out there in figure 2 you get the difference of potential, absolutely. In figure 2 you get the same potential difference between points 2 and 4 as you will get in figure 1 between the points 3 and 4. I have stated here that this difference of potential must necessarily involve that the current that is received in any one lamp is equal to that you can get at the furthest end of the circuit. Take figure 6 and supposing this is a direct current circuit we are considering. The sources of current D1 in figure 6 are direct current generators for that matter. We will take one lamp placed across between 3 and 4. It is taking one ampere. Supposing we are going away around to F at the further end of the circuit, and we put on 100 lights, we will then have 101 amperes of current running through the circuit. It stands to reason that the electromotive force between those points is the same there with lamp F1 whether we turn on that gang of 100 or turn it off.

Mr. Campbell: The current to run this 100 lamps has to run a greater distance than with a parallel system.

Mr. Keeley: No.

Mr. Campbell: 100 lamps at F. and one at the other place, they are using 49 amperes at F. How does the current run from the dynamo to there and back again?

Mr. Keeley: 50 amperes will run from B, and 50 from D1.

Mr. Breithaupt: I think we ought to have a blackboard at these meetings; where we could then discuss these matters thoroughly and all could see and understand.

Mr. Langton: If the lamp in figure 1 was a certain distance from the central station, say one mile, figure 5 would be the same lamp fed by two central stations two miles apart.

Mr. Keeley: One mile on each side.

Mr. Langton: Figure 6 would be that system folded together so as to consolidate the central station. It shows four wires to the lamp, distant one mile from the station. If these wires are of the same size as they are in figure 1, the loss would be one half and take twice as much copper. I cannot see any difference between this and a straight two wire system.

Mr. Keeley. If you are sending four amperes along the line with a pressure of 100 volts, you have a certain drop in the mains. Supposing you cannot connect it up in accordance with figure 6 you are sending two along on one side and two on the other, and you have a certain drop along the mains. In each case the drop would be one half. In figure 1, instead of having four per cent. drop you will have an eight per cent. drop, whereas in the other you will have only four per cent., and take the same amount of copper.

Mr. Langton. Figure 5 is simply a double system of figure 1, and figure 6 is figure 5 folded together. They have the same lamps, you have to send out the same current and you use twice the length of wire of the same diameter, with consequently half the loss, or you use twice the length of wire of half the diameter with the same loss.

Mr. Keeley: I claim we have a marked saving in the wire. At the same time I admit that the total amount of copper used in the four wires would be equal to the total amount of copper in the two wires. Now, the question comes in, where is the saving? It is here. The statistics of the different general central stations as I have been given to understand is, that out of a total number of 1,000 lamps for which wires have been put in, there is only a demand at any one time for 450. You can put it at 55 or 60 per cent. It stands to reason, at that rate, that the greatest demand at any time is only 60 per cent. on the station for the total quantity of copper that has been put out; there is forty per cent. lying idle. If you have a system by which you can start and give an equal potential throughout the entire town instead of having to run a multitude of circuits for long distances, you can effect an enormous saving in running the wire from the station over your mains for a maximum of sixty per cent. of the number of lamps put in. You save forty per cent. of the copper.

At Mr. Keeley's request the following note, written subsequent to the Convention, is printed as a part of the discussion on his paper:—

NOTE. I have to thank Mr. Campbell for bringing out a point that should have been duly considered in my paper. The whole of what obtains in the operation of the circuit in Fig. 7 has not been clearly set forth. The three wire system as represented in that figure has been dealt with as if simply constituting two separate circuits, in the light that if one lamp alone is in circuit between A and C, the current operating it is derived from the source A alone, and if another lamp is put between B and C, it in like fashion gets its current from the source V1. But it should be recognized that in doing this we have doubled the E. M. F., and doubled the lamp resistance, while the other part of the circuit resistance remains unaltered. We know that the E. M. F. absorbed in any part of a circuit is equal to the resistance of that part multiplied by the current, and we can therefore double the E. M. F. and supply double the number of lamps without increasing the current in circuit. This is what is done in Fig. 7, when an equal number of lamps is put on each side of the neutral wire. So if, in the plan as laid out in Fig. 8, the sources of current V, V1 correspond with those shown in Fig. 7, say 100 volts each, and if the volume of current to be distributed in each case is the same, it is true, as has been suggested, that for a given drop the leads in Fig. 8 would have to be twice as heavy as those in Fig. 7, because the same amount of E. M. F. as is absorbed in each of the separate circuits of Fig. 8 does duty for both circuits of Fig. 7, when there is an equal number of lamps on either side of the neutral wire, since the figure then represents what is practically a single round circuit including the sources of current with the two groups of lamps in series, and there is no potential difference between the ends of the neutral wire. When this balance is disturbed, however, by an unequal number of lamps being put on the two sides, a potential difference is set up between the ends of the neutral wire, and the volts thus lost or absorbed in it have to be supplied from the source that is on the same side as the greater number of lamps. The drop on that side thus becomes greater than on the other, and the regulation of the supply is interfered with. Here then we find a tendency of the sources of current, V, V1, to operate in separate circuits in the same way as they would actually do if the lamps were placed on one side only of the neutral wire, and it might perhaps be better to permanently arrange them so. The system could be permanently balanced if it were practicable to altogether eliminate the neutral wire, or to go to the other extreme and reduce its resistance to nil. Without the neutral wire, however, we could not use the 100 volt lamps singly as at present, and 200 volt lamps are not yet available, so the next best thing is to reduce the interference of the circuits by making the resistance of the neutral wire as low as possible. It is to this end I fancy that in some instances the neutral is given three or four times the cross section of the outside wires, and a great deal further enlargement in the same direction would be perfectly rational, as can be seen, but when it comes to multiplying the total weight to an extent approximating that of the two wire plan of distribution, the best course would be to lay out the wires in the way shown in Fig. 8, so as to secure not only immunity from interference between the circuits, but at the same time an equalization of potential difference throughout the whole. Now the entire argument I have advanced goes to show, I think, that we can obtain what is claimed at the outset of my paper, viz., an equalization of potential difference, with the same total weight of conductor and same drop as obtains in a single two-wire circuit, and the same result in a three wire system with an increase of conductor that has been expressed as 25 per cent., but will have been understood to represent an increase in the proportion of $\frac{5}{4}$ to 1.—D. H. K.

Moved by Mr. Campbell, seconded by Mr. Breithaupt, that the thanks of the meeting be tendered Mr. Keeley for his very able paper. Carried.

The Chairman called upon Mr. O. Higman to enlighten the members regards the provisions of the Electric Light Act. Referring to the criticism in the last number of the CANADIAN ELECTRICAL NEWS, page 101, he said: One of the objections is to clause 7, and I explained that the original copy of the draft of the Bill included a number of clauses dealing with underwriters' rules, and acting on a request from the Underwriters' Association, those clauses were subsequently stricken out. Later on, however, when the bill was taken up, that is some few years ago, I found numbers 6 and 7 reinstated for the purpose of giving the consumer the opportunity of being able to test his wires for leakage, giving the consumer the power to call in an inspector to test the wires for leakage. The other principal objections in this article are as to the utility of this inspection. This is a matter of opinion. The Canadian Government has thought fit to inaugurate a system of weights and measures inspection, and that system has been in operation for the past twenty years, as to weights and measures for the sale of ordinary commodities that we can feel and handle. If it is necessary we should inaugurate a system of dealing with these weights and measures, I think it will be readily admitted that with an article impalpable in its character, the reasons are emphasized an hundred fold, as in the case of electricity. Parliament in its wisdom has decided that · is advisable. We will take up the bill and see what we fi· in it. Starting out we will ask ourselves the question, what constitutes a measure of electricity? What enters into the measure? To my mind there are four questions to be considered: First of all, the insulation of the consumer's wires, the voltage, the limitation or variation of the voltage, the accuracy of the apparatus itself, and the illumination of the lamps, if that illumination is a part of the contract? We simply have power for the testing of lamps for illuminating power, but it strikes me that companies at the present time are not in a position to say that they will give sixteen candle power illumination in a lamp, at least they cannot maintain it, because we know very well after a very short period the lamp deteriorates. Now, taking the first of these propositions, that is, the insulation of the wires, as I said before, that is not very clearly dealt with in the Bill, but in the regulations that we propose arranging for carrying out this work we will endeavor to construe the clause to mean that and provide for it. I think that is a very reasonable provision. We had prepared a Bill with four per cent. as the limitation of variation allowed, but Parliament again in its wisdom has decided that is too much. A gentleman, a Senator who was interested in electric lighting, and who no doubt had been thoroughly primed by the local company which he represented, when this clause was reached, moved that eight per cent. be made the allowable variation. That is out of the question altogether; that would give you sixteen volts or more on a 120 volt system and 8 volts on a fifty volt system. Another very learned electrician who occupies a prominent place in the Senate, told the other gentlemen that they had failed to grasp the intention of the Bill, and he moved that it be reduced to three per cent., and he carried his point, so that the Department is clearly not chargeable with this reduction in the percentage. I may say that we had a good deal to contend against in getting this Bill through 215 members and between 80 and 90 Senators. We will have electricians in Parliament as well as out in a very short time. (Laughter.) I am afraid in operating the fifty volt system the three per cent. will cramp them. It only allows them one and one-half per cent. as the stated voltage. That possibly will be a rather narrow limit. A drop of one volt does not materially lessen the light of a fifty volt system, but it will go half a volt further if there is a want of prompt regulation in the machine, so while three per cent. may be somewhat cramped you cannot afford to exceed it much, otherwise the consumer will not be guaranteed to be getting good light. We will take up next the meters Clause 13.) It is not compulsory, it is at the option of the consumer.

Mr. Campbell Is it at the option of the consumer whether the meter is on or not? It is at their option to have one on?

Mr. Higman Yes. It is a question whether the meter system after all will not be the more profitable one, and I do not think the companies need concern themselves very much about that. They rent the meters and the consumer will pay the rent of the meter.

Mr. A Wright: Have we to put in a meter if the consumer says so and get no remuneration for it?

Mr. Higman: I am not quite sure but what there is a clause providing for that. I think they can charge the rent for the meter. We have constructed the bill along the line of the Gas Companies' Act, and have complied with that as far as we can without encroaching on the electric light. (Reads clause 15.) That clause I hope meets with the approval of the General Electric Company. It was made expressly for them. (Read clause 22, 23 and sub-sections, and 28.) That will place the going into operation of the Act about the 1st of March. It is not intended to attempt any more than seven or eight places at the start. Those will probably be London, Hamilton, Toronto, Ottawa, Montreal, Quebec, St. John and Halifax. We are in hopes in the interval of six months we can get these into shape and verify meters in these places.

With regard to sub-section A in the last clause. (Reads.) If the companies undertake to provide absolutely a stated candle power, then I presume that is a part of the meter work.

Mr A A Wright · The Government have not yet decided the number of watts for a 2,000 candle power lamp.

Mr. Higman · No The Department has not taken any action and probably will not until this Association comes to us and says, "we want a standard for arc lighting" When that day arrives we shall be very glad to take it up. While I should very much like to see some arrangement whereby contracts with municipalities might be facilitated, I am rather doubtful if this arrangement of energy, the number of watts as a standard, is a proper one. That standard eliminates altogether the lamp and the carbons, two very important factors in arc lighting. That is my view, but it is quite possible that in delivering the 450 watts to the lamp the company's contract would end there. They might get a very cheap lamp with a very poor carbon, and get poor light, but they would perform their part of the contract and there it would end. I do not think, therefore, it is a very good standard. There is perhaps one other subject I can touch upon. (Reads from same clause.) It is the intention for several reasons to employ such machinery as the Department has already in operation. The Gas Inspectors for the most part are very intelligent men, and they are well practiced in those tests. The gas test, as you very well know, is a very delicate thing after all. The test for ammonia and other things requires intelligence and skill on the part of the operator, and I am not without hope that these men will be able to learn how to test the electric meters. It is not necessary they should be learned electricians, but I think they can be got into shape to do the work, and thus lessen the burden on the companies and the consumers, because the consumer is the party who will ultimately pay all the expense.

Mr. A. A. Wright read clause 4.

Mr. Higman . I think you have already done so. I think in most companies they have declared the voltage at which they are working.

Mr. Brown I think this is a very important point for those who are using the alternating current. For instance, we use the fifty volt transformer, and supplying a man from that transformer, the variation in transformer alone is two and a half volts. We have another drop of two per cent. generally on fifty volt circuits leading into the building, which would make a variation of six per cent. If the Government insists on us regulating within three per cent., we cannot do it, and we will simply have to shut our plants down.

Mr. Higman : But you know already that the drop will be so much, so you can make an allowance for it.

Mr. Brown . But you cannot very well state that. Using a large transformer a man might not use very many lights or might use a lot of them. They will vary as high as five and six volts on these large transformers. You cannot give a man within three per cent., no matter how perfect the regulation in the central station may be.

Mr. Thomson: The ordinary transformer to-day will vary from two per cent. to two and a half per cent. between small load and full load. In a transformer alone there is a greater loss than the Government will allow.

Mr. Higman : At the present time you undertake to deliver 50 volts at the consumer's terminal, or 52 volts. I do not care what it is, but you do state it in your contracts

Mr. Thomson . Suppose there were two houses—one man in one street would use five lights, and the next man would use 55 lights off the transformer; between those two there is a drop in the transformer of two and a half to five volts without counting the wiring at all.

Mr. Higman : You cannot afford to have a very wide variation on the 50 volt system or you are not going to have a very satisfactory lamp.

Mr. Thomson · I believe it is impossible to get a transformer that will give you 90 or 95 per cent. of efficiency with less than that drop in the transformer. If you decrease the efficiency of the transformer you might get the result of that drop, but the object now is to keep the transformer with very high efficiency. As to the wiring, you cannot wire an ordinary building at one per cent.

Mr. Higman : Take the voltage at the terminals, there would be a loss at any rate, I suppose.

Mr. Brown : I think they ought to give us an allowance of six per cent. on any voltage.

Mr. Thomson : I do not think there is a central station in the country to-day that does not vary more than six per cent.—ten to fifteen per cent. very often.

Mr. Higman : If it is found to be unworkable we can see about that. I hope next year when the convention meets again some progress will have been made in that direction.

Mr. John Langton, of Toronto, was then called upon to read a paper on "A Note on Possible Reduction of Station Plant on Small Electric Railways by Multiple Series Control of Motors." (See page 144.)

Mr. Campbell : I can thoroughly agree with Mr. Langton in reducing the station capacity of the dynamos. In Kingston there is a plant supposed to run five or six cars. We follow out Mr. Langton's ideas in that respect. We run the motors in series altogether. On the generator we run eight and ten to twelve cars instead of six, and the generator is not overloaded. With those cars hauling trailers they will not go over 90 amperes generally. There is not only a saving in the generator, but there is a saving on the motor, in reducing the voltage around the commutator and making everything run easy. It can be all traced, I think, to the parallel controllers.

The Chairman : There is a paper by Mr. John Galt, of Toronto, but he is unfortunately confined to the house and unable to be present. He requested his paper to be presented, and hoped any discussion that might be had would be referred to him and he would be happy to reply thereto.

At 4.15 P.M. the meeting adjourned to take a trip to Back River over the Montreal Park and Island Ry., on the invitation of the management of the road. On arriving at Back River the members partook of their annual dinner at Peloquin's Hotel.

President J. J. Wright was chairman of the evening, and the first toast he proposed was "The Queen," which was responded to with cheers and the singing of the National Anthem.

The next toast was "Our Sister Societies," the National Electric Light Association of the United States and the American Society of Electrical Engineers.

Mr. Francisco in responding on behalf of the National Electric Light Association, said : This meeting to-night reminds me very forcibly of the royal reception that the citizens of Montreal tendered the National Association at the time they held their convention at Windsor Hall here. Whether it was the peculiar effect of the Governor-General's presence that night, or the peculiar air from the ride on Mount Royal that affected the members at the time I cannot say, but I think if a vote had been taken that night that the great scheme of annexation would have been carried out. That is, instead of annexing Canada to the United States, they would have annexed the United States to Canada. (Hear, hear.) The reception received here by the National Association at that time has been not only electrically but indelibly impressed on the memory of every member of the Association, and I trust and hope the time is not far distant when this Associatian and the National Association will be one society and one brotherhood, extending from the Atlantic to the Pacific, and from the Gulf Stream to Hudson's Bay. Then we will alternate these conventions on the other side of the line and on this side, until finally it shall be so managed that there shall be no line, it shall be all one thing. This, I trust, is a matter that will be entertained by your Association. It has been discussed heretofore a good deal, and at our next convention, which I presume will be in Cleveland, Ohio, we cordially invite all of the members of this Association to meet us at that time. We cannot give you the peculiar influence that Montreal has upon the members of any Association, but we will tender you what cordiality and greeting can be produced on the other side of the line. (Hear, hear.) Trusting that this meeting which I have had with you, and the pleasure I have experienced in connection with this meeting with your Association, may be renewed and continued at that time.

Mr. T. D. Lockwood, of Boston, in responding on behalf of the American Association of Electrical Engineers, said: Mr. President and Gentlemen. I would for your sakes I were like my friend, Mr. Francisco, a silver-tongued orator, for I would know then what to say. But I unfortunately do not come in that category. This is something new to me, at least—it has not been my experience for a great many years to be at a dinner where "God Save the Queen" was sung, and I want to say here that I like it. (Hear, hear.) I am glad you did not proceed to go on and sing the other verses, which, if I remember right, and I sung it myself some forty years ago, goes on to confound other people's politics. (Laughter.) Which of course ought to be confounded from a British point of view. It is one of the privileges of a person responding to a toast to say as little on the subject of the toast as possible, so I am proceeding on that line. I am very glad indeed to once more listen to those familiar words which have just been sung. I think we have great reason to congratulate ourselves that in this last decade of the nineteenth century we have some half dozen electrical societies in the two countries, the United States and Canada. We have had more perhaps, but I do not think that there has ever been a time when the electrical societies of these countries have been on so satisfactory and useful a basis. I can remember when at the annual meeting of the Institute of Electrical Engineers it was very hard to muster a corporal's guard. We had the Secretary to read the papers, which were few, and the four or five persons who heard them would go out occasionally with a friend, which would consequently leave no person on the floor to listen to and discuss them. (Laughter.) No doubt many of us are members of that Institute and we receive the proceedings regularly, and while sometimes there are papers no doubt admitted which should not be, as is the case in all societies, as a rule the papers are good, good to listen to and better to read. And I would like to add this suggestion, which I think is pertinent, not only to them but to all other societies, and that is, that it is a splendid rule not to check discussion unless it goes to personalities, for it is my experience as well as yours, I think, that the real value of a good paper lies in the discussion it elicits. I think the American Institute of Electrical Engineers, the National Electric Light Association and the Society with which I have now the honor to be associated, are perhaps the three leading societies of the kind, leaving out, of course, that one of all of them, the Institute of Electrical Engineers of London, which I think is slightly in the lead of any of us, and it seems to me that it is the duty of members, if possible, to prepare papers when called upon, and be ready to discuss papers, because even the youngest of us and the most inexperienced no doubt has something which can contribute to the well-being and instruction of the others, because the experience of each one of us is certainly different. Not only are men different, but they look upon things from different points of view, and frequently a suggestion from one who knows comparatively little about the art in which he is engaged may be the suggestion that others have been looking for, and perhaps in vain. You younger men have advantages which we older men have not had. Most of you are graduates of technical institutes or of other educational institutions where you are not only taught the work but the doctrines and theories and reasons which underlie the practice, which we had to find out by rule of thumb and hard experience. I heard with great interest the remarks of my friend, Mr. Francisco, but I must confess I am not able to agree with some of them. I like the idea of having two societies at least. I like the idea of each nation having its own society, if only for the reason that we can attend the conventions of the two societies and have a dinner with each of them. (Laughter and applause.) And such a dinner as this is enough reason for the separate existence of not only two, but two hundred and two. Thanking you for your kind attention. (Applause.)

The President called upon Mr. Marples, of the Montreal Park and Island Railway Co., to say a few words. Mr. Marples said this was a very unexpected pleasure for him, and in the name of his Company he wanted to thank heartily the members present for the honor they had conferred on his Company by accepting their invitation to travel out over their road. Mr. Marples went on to describe how the work was begun on the road and the difficulties they had labored under. He thought these railways would be one means of building up Canadian cities. His Company had met with great successes that were not expected, and they intended going on and extending their line until the whole Island was encircled.

The Chairman proposed a toast to the Canadian Association of Stationary Engineers, which was drunk amid applause. The toast was responded to by Mr. A. M. Wickens, of Toronto, who heartily thanked the President for calling on him to answer on their behalf. He was proud to say the Society of Stationary Engineers had for years been working on the same lines as the the electrical men. He believed the stationary engineers had more depending on their skill than men in any other business, and notwithstanding all the difficulties they had to contend with, he was glad to say they were holding their own in the land.

A toast was drunk to Mr. McFarlane, who responded amid cheers, and expressed the hope that all had enjoyed their visit to Montreal thoroughly. The Convention had been a complete success.

THIRD DAY.

At 10:30 A.M. on the 21st of September the President opened the meeting and took the chair. The first business, he said, was any discussion there might be on Mr. Galt's paper. As it was a very able paper he did not think it should pass without some discussion on the part of the members.

Mr. Breithaupt: This paper of Mr. Galt's is a very interesting production, and a scientific production to a large extent. We have all recognized the difficulty we have encountered with fly wheels. While I have not had the time to look over Mr. Galt's paper very much in detail, in conversation with Mr. Galt some time ago, I recognized the principles he means to apply in this construction of the fly wheel. He applies the tension on the rim of the fly wheel in a straight instead of in a bending position as it is at present in the spokes. To go into a detailed discussion of the paper it would have to be read up very carefully. I think it is a very able production and I have very much pleasure in moving a hearty vote of thanks to Mr. Galt for his paper.

Mr. Sperry: Before that motion is seconded and put through, I would like to say one word. I read the paper coming up on the train last night and I want to agree with the previous speaker that it is a very ably prepared paper indeed, and it is a subject that is attracting a great deal of attention at the present time, as we all know. In looking at the cuts, (Fig. 7.) it might be thought that in the spokes put in there are some of them tongued, but I do not understand that is the case. It seems each spoke A and A' as it goes down from the rim presses upon the hub in a spiral way, passes around on the outside and goes back to the rim. It makes it a very ingenious arrangement, because each spoke not only forms a tangential tension there but forms a lateral brace. This is the first time Table 1 has been published, I think, and it is certainly a very valuable addition to the designer's tables. At a glance it will give you what you want. I am glad this paper has been produced, and I have taken much pleasure in reading it myself.

Mr. A. M. Wickens: There are so many flywheel accidents that the paper to my mind on that ground alone, is most valuable. As the use of engines in this line has increased the manufacturers have begun to make a fly-wheel pulley with a very wide face to get the driving surface for belting, &c., they required, possibly sacrificing the strength of the rim a bit. The article very plainly shows what effect that trouble has. Some years ago we hardly ever heard of a flywheel accident; we did not have the rim we have to-day. At the present time the whole tendency is to get plenty of energy stored in the rim of a wheel, but from the fact that we are spreading our wheel rims out so far we have an inherent weakness there that should be overcome some way. The paper is very valuable on the lines suggested. The requirement to-day is a flywheel with a speed that is safe. Recent flywheel accidents have nearly all occurred in conjunction with other accidents. The engines were going above their normal speed, and of course in building a wheel the idea is to make one that is practically safe at a suitable speed and will keep the cost down. I think if the ideas in the paper are followed out it is highly valuable. I take much pleasure in seconding the motion of thanks. Carried.

A paper on "Telephone Cables, their Construction and Maintenance," was read by Mr. F. J. Schwartz, of the Bell Telephone Co., Montreal. (See page 123).

Mr. Keeley in discussing the paper said: As I happened to be associated with the telephone a long time I take a keen interest in anything pertaining to it, and I must say the Association will be very glad years hence to have on record this splendid paper that Mr. Schwartz has given. Mr. Schwartz says, "at one time the telephone man had the earth." We all want the earth sometimes, and now the electric railway men have it they ought to be very happy. I remember away back in 1872 when I was in a telegraph office in Kingston, I heard of the Western Union putting in a pneumatic tube in New York. They had occasion to put a wire through it and were staggered how to do it. After two or three vain attempts it occurred to Mr. Garrett Smith, who was considered a genius at the time there, to procure a weasel and a rat. He tied a string to the rat's tail and put the weasel in after it and it went through. But this is not on record. (Laughter). In regard to group 7. (Reads from paper). Fancy finding a burn under a clip. Those clips are run along and you will notice at the same time what a very small section of the cable has been cut out. Fancy all these clips to be running from pole to pole and an electrician being able to sit down and say that the trouble is under a certain clip and going down to that pole and taking the clip off and finding the trouble under it. It is a most extraordinary thing, and sometimes it would be very important in the interests of students to know what methods were adopted. Mr. Stevens, who was a prominent electrician of the Maintenance and Construction Company, of London, England, told me once that in all his vast experience he had found that personal equation as it is called generally was depended upon by all successful electricians in testing for faults. Something seems to suggest to a man the method that he is adopting is false, he tries another method and if he gets a reading he is satisfied is correct, he will go that way. If we could from time to time put on record what we have done and how we have accomplished certain results it might in the end reduce the thing down to some rule of thumb method and get results very rapidly without having to go into a great deal of experiment. I have again to express my gratification to Mr. Schwartz for putting this paper before us.

Mr. T. R. Rosebrugh, of Toronto, read a paper on "Duplex Telephony". (See page 140).

Mr. Lockwood: I would like to ask Mr Rosebrugh what is the longest length of line that this system has been practically operated on. I understand it is being practically tried between Toronto and Yorkville. Is there a practical line being operated in Canada upon the principles enunciated in the paper.

Mr. Rosebrugh: I understand from Mr. Baylis that it has been successfully applied between Toronto and Hamilton but is not in ordinary use, as they very frequently wish to extend one of the metallic circuits further west and the extension would throw the system out of balance.

Mr. Dunstan: Mr. Baylis will be very happy to state exactly what our experience has been. He can tell you better than I can how it works between Toronto and Yorkville.

Mr. Baylis: We have had three lines in Toronto working on this principle. The first one was set up on a trunk line between our main office and one of the branches. This worked very well. This line has worked ever since we put it in, and we have had little trouble with it. We have had some slight difficulty in ringing over the two original lines. The second line was put in between Toronto and Hamilton. This was not satisfactory because Oakville used one of the lines for their conversations, and when they cut in it rendered the other two circuits useless. Last year we built another line and that gave us two direct wires between Toronto and Hamilton, not used for local conversations. We duplexed these two lines and the derived line is now working very satisfactorily for conversations between subscribers in Toronto and Hamilton. But if for instance, Woodstock and Peterboro' were talking over one of the lines between Toronto and Hamilton it would be impossible to use the duplex, as it would be too noisy. We have a three pair cable to the Island, and three stations working there. We left one pair idle and duplexed the two working lines, putting the third station on the derived line. That worked very satisfactorily. There was not very much business done over the line but what was done went through without any trouble. It seems to be a very practical thing to do with long distance lines that are not used for local work. It seems to be a perfectly practical thing to do within certain limits.

Mr. Keeley: I should fancy if Mr. Rosebrugh would refer to the drawing, that in Fig. 2, if the wire marked $2C^1$ were grounded this system would not work.

Mr. Rosebrugh: It is supposed to be connected either with the corresponding point which connects with Q^1 on the second circuit so as to use each metallic as a single conductor or else to use another separate wire connecting with the other end of the first metallic. It will not work as well unless the transposition were perfectly carried out.

Mr. Keeley: That is to say you contemplate using two pairs, that is as illustrated in Fig. 2 there are two metallic circuits and those two are utilized to form the sides of a third circuit. You would have three working circuits on the four wires. How would you manage if you had two wires? Would you have a metallic circuit into 2 and this extra circuit by wire running back to the other end of the line where the $R_2 C^1$ goes in?

Mr. Rosebrugh: I think it could be done that way, but I am doubtful whether a perfect balance could be obtained.

Mr. Keeley: As I see it there would be a leakage. You can talk with that telephone at T_5; your transmitted current would be divided at the point T_1 in R and travel both sides of the metallic circuit and come out at the telephone corresponding with T_5.

Mr. Rosebrugh: I think that practically none of the current which was produced by either of the transmitters in the original metallic circuit F_1 and F_2 would pass over that branch, because the middle point, P_1, can easily be proved to be of the same potential as the corresponding point at the other end of the metallic. Thus, if you use current produced by either of the transmitters, being of the same potential, there would not be any tendency for any current to go between them.

Mr. Dunstan: In regard to the derived circuit, I would say that if one of the original metallics is thrown out of balance from any cause whatever, not only will the derived circuit be rendered useless, but the original metallic will also be made noisy. You would be obliged to then cut out your duplexing apparatus, and lose the derived circuit until the defective metallic is put in order. If you depend upon the derived circuit for your everyday business, to the same extent as you depend upon actual circuits, you will find it a serious matter to have two lines rendered useless in that way. Suppose you have three circuits, you may find yourself any day with only one circuit actually working. Every trouble is multiplied by two if not three. Of course where the wires are in cables there is not very much danger, but in overhead wires not in cables, and where there is a possibility of lines being thrown out of balance, there is the great objection which I have mentioned to the use of the derived circuits for ordinary everyday business.

Mr. Lockwood: Mr. President, I think I can well conceive a subject like this to be of great interest, but more particularly of interest to some of us, yet to those to whom it is interesting at all it is of vital interest. Of course the one primary thing to be achieved in duplexing telephone lines as well as in duplexing telegraph lines is indicated in the first column of the paper, viz., to place the receiver of one of the sides of the duplexing apparatus in such a position that it will not be operated upon by the transmitter at the same end. The mode of duplexing telephones indicated in this paper is, it seems to me, the most plausible as well as practical way, and probably the way in which success, practical commercial success, will be achieved, if it is at all. I do not think the difficulty in the way of such success is at all over-stated, and for this reason, the changes occurring in the telephonic current must of necessity be equal to the changes in the voice producing the working current, and I think they rise to as high as 28,000 per second sometimes, and of course those difficulties will be accentuated as you increase the length of your line. For that reason I think Mr. Rosebrugh is quite hopeful, and if you will permit me to say so, a little optimistic in duplexing the Chicago and New York line. It is not so that people who are connected with electrical works do not try experiments; although it is often assumed by persons having inventions or writing papers, that those who are practically engaged in any form of electrical application never try experiments with anything. Of course it is not so in this case, as Mr. Rosebrugh knows there are some of us engaged in telephonic work, who occasionally think about such matters as these. And I am very glad indeed that I have the opportunity of rendering a well deserved tribute to Mr. Black, of Hamilton, Canada, who with Mr. Rosebrugh's father, was the projector of the very first mode or method of sending two kinds of communications, one telephonic and the other telegraphic, over the same wires, and that as early as 1878. On the Boston and New York circuits, which are all metallic, we could work each of the two sides as a separate telegraphic circuit, and while we worked the telephonic circuit. Brokers were telegraphing their quotations over the line while we were using the other circuit for subscribers to talk over. The brokers sometimes found out that other people were using the same wire as they and they felt a little aggrieved because they had not a monopoly of the wire, even if it did not make any difference to their work. The man that uses the telephone does not know the two sides are used at all. This was an invention of Prof. Van Risselburg. I may say here that this very arrangement that Mr. Rosebrugh shows in his figure 2, has turned out to be really the best arrangement for telegraphic work on a telephonic circuit. That is, the two metallic circuits may be used for telegraphic work while the telephonic message is interposed between them. Our experiments, however, such as I have had the good fortune to be engaged in, in this line, show that it is very difficult indeed, although we can readily talk over short lines on the methods proposed here, to work successfully a duplex of this nature for an extremely long line, and for the reason that when there are four lines or even three lines engaged in the communication a very small trifle upsets the balance and throws the whole arrangement out. No doubt for lines of small length it will prove quite practically and commercially useful. I will throw out one further remark for which I hope Mr. Rosebrugh will pardon me. Anyone who puts in a paper expects to be criticized. I should not mention this, but he speaks of resistance as being "Ohmic" resistance. I am sure he will agree with me that there is but one kind of resistance, and that, therefore, speaking in cold blood and critically, we should not call it any kind of resistance, but simple "resistance."

Mr. Rosebrugh: I was merely using the ordinary language of the electrical journals of the present day.

Mr. Lockwood: Extra-ordinary language, you mean. (Laughter.)

Mr. Breithaupt. I move a vote of thanks to Mr. Rosebrugh and to Mr. Schwartz for their highly instructive papers. Seconded by Mr. Keeley. Carried.

Mr. Medbury extended to the Association an invitation to hold the next Convention in Ottawa.

Mr. Higman on behalf of the Department of Inland Revenue extended a hearty invitation to the Association to go to Ottawa next year, and guaranteed a first class bill of entertainment would be provided.

Mr. Taylor on behalf of Peterboro', extended an invitation to that town, and pointed out its many advantages; among others members would have the opportunity of inspecting the Canadian General Electric Co.'s works in operation there.

Mr. Medbury stated that if the Convention were held at about the same date next year, cheap rates could be got on all the railways, which would be an inducement.

Mr. Higman said that as an extra inducement, he thought a room could be got in the House of Commons where the Convention could be held.

Mr. Medbury on behalf of Messrs. Ahearn & Soper extended an invitation to all members wishing to go to Ottawa to-morrow.

Mr. Lockwood: Mr. President, I wish to express to you and to your Association my highest sense of appreciation of the kindness and courtesy which this Association collectively and individually has displayed towards me in inviting me to take part in your deliberations and especially in electing me an honorary member. I do not ascribe all of this courtesy to my individual merits but to the fact that I am still a prominent member of the institution on whose behalf I responded last evening. I have been profoundly affected and highly delighted with the many courtesies and kindly words and actions I have received. I desire especially also to extend many thanks, and my sense of gratitude for the many kindnesses I have received in conjunction with the members present, from the gentlemen who represent the Montreal end of this Association, Messrs. McFarlane and Carroll, and to state that my thanks certainly are due to them for the many pointers and kind words and good things I have received at their hands. (Applause.)

Mr. Dunstan. We have all been more than delighted to have Mr. Lockwood with us. We consider ourselves fortunate that he happened to be here at this particular juncture. We are glad he is our first honorary member. He has contributed greatly to the interest and pleasure of the meetings. His remarks on the papers have been interesting to everybody. I think I express the united sentiment of the Association when I say we hope he may be in Canada next year, and that we may have the pleasure of meeting him at Ottawa.

Moved by Mr. A. B. Smith, seconded by Mr Yule, that an allowance of $25 be made from the funds of the Association to meet the expenses incurred by our Secretary-Treasurer while in attendance at this meeting. Carried.

Mr. Medbury read a telegram from Messrs. Ahearn & Soper, of Ottawa, extending a cordial invitation to the Association to hold its next meeting in Ottawa.

A vote on the next place of meeting of the Association resulted in favor of Ottawa.

Moved by Mr. Dunstan, seconded by Mr. A. B. Smith, that the next Convention be held in Ottawa, and it be left to the Executive Committee to decide the exact date, it being understood the meeting shall be, if possible, in the early part of September. Carried.

ELECTION OF OFFICERS.

Mr. Black nominated Mr. K. J. Dunstan, of Toronto, for President.

Mr. L. B. McFarlane was nominated, but declined the honor.

Mr. Taylor nominated Mr. John Yule, of Guelph, for President.

The Chairman appointed Messrs. John Langton and A. M. Wickens as scrutineers.

The vote resulted in the election of Mr. K. J. Dunstan. The Chairman thereupon declared Mr. Dunstan elected President for the ensuing year.

Mr. Dunstan said he recognized it was a position of honor and responsibility to which he had been elected, and he would do all he could to forward the interests of the Association.

For 1st Vice President, Mr. Higman nominated Mr. A. B. Smith, of Toronto.

Mr. Paige nominated Mr. John Carroll, of Montreal.

Prof. Rosebrugh nominated Mr. J. W. Taylor, of Peterboro', but he declined the honor.

Mr. John Yule nominated Mr. C. Berkeley Powell, of Ottawa, for 2nd Vice-President.

The vote resulted in the election of Mr. Smith for 1st Vice-President.

As there was only one nomination for 2nd Vice-President, Mr. C. Berkeley Powell, the Chairman declared him elected by acclamation.

Mr. Breithaupt nominated Mr. C. H. Mortimer for Secretary-Treasurer.

As this was the only nomination the President declared Mr. Mortimer unanimously elected.

The 5 members of the Executive who were re-elected for the ensuing year were:

Messrs. George Black, E. C. Breithaupt, L. B. McFarlane, T. R. Rosebrugh, John Yule.

The nominations for the five new members of the Executive were as follows:

Mr. Medbury nominated Mr. John Carroll, Mr. Paige and Mr. D. Starr.

Mr. John Yule nominated Mr. J. J. Wright, of Toronto.
Mr. McFarlane nominated Mr. O. Higman, of Ottawa.
Mr. D. Starr nominated Mr. J. A. Kammerer, of Toronto.
Mr. Paige nominated Mr. J. W. Taylor, of Peterboro'.
Mr. Dickinson nominated Mr. A. M. Wickens, of Toronto.
Mr. Taylor nominated Mr. F. Thomson.

The result of the balloting was the election of the following members:

Messrs. O. Higman, of Ottawa; J. W. Taylor, of Peterboro'; D. Starr, of Montreal; J. J. Wright, of Toronto. J. A. Kammerer, of Toronto, and John Carroll, Montreal, having each an equal number of votes, Mr. Carroll retired in favor of Mr. Kammerer.

The Chairman then called upon Mr. Elmer A. Sperry to read a paper on "Electric Brakes." (See page 133.) Mr. Sperry produced a large number of photographs, which fully illustrated the working of the brake, and which Mr. Sperry used in illustrating his paper. He also brought into use for purposes of illustration a specimen brake

Mr. John Langton moved, seconded by Mr. Medbury, that a vote of thanks be tendered Mr. Sperry for his able exposition of the Electric Brake. Carried.

Mr. Dunstan moved a vote of thanks to the Press of Montreal, the Montreal Park and Island Ry. Co., the Eugene Phillips Electrical Works, the Montreal Street Railway Co., the Bell Telephone Co., Messrs. Ahearn & Soper, of Ottawa, and all others who had extended courtesies to the Association. Seconded by Mr. Higman and carried.

Mr. McFarlane moved a vote of thanks to Mr. John Horne for the use of the valuable papers that he tendered the Association. Seconded by Mr. W. F. McLaren Carried.

At 2 P.M. the Chairman declared the Convention adjourned to meet in Ottawa next year.

Immediately after adjournment the members of the Association availed themselves of the kind invitation of the Eugene F. Phillips Electrical Works to enjoy a drive to Mount Royal Park, and of the Montreal Street Railway Company, to inspect their new power station. A couple of hours were thus most pleasantly and profitably spent.

THE ST. STEPHEN ELECTRIC RAILWAY.

The St. Stephen Electric Street Railway is completed and is one of the most thoroughly equipped roads in the maritime provinces. It is laid with 56 pound steel rails. The cars are of the very latest and most improved make. The company has four open cars for summer use, and has ordered three "trailers" to be drawn by the regular cars in case of a rush.

The power house is built so as to be easily enlarged as soon as the growth of the road requires it. There are seven miles of track. Starting from the shore line depot the road runs up to Milltown, then in a south-westerly direction to Calais, Me., and back again to the starting point. The company will endeavor to make the round trip in half an hour. The earnings of the road have averaged over $100 a day since it was opened. Every effort will be made to run the cars during the winter. The company has provided itself with improved snow-plows and all the equipment necessary to keep the road open all the year round.

The St Stephen and Calais people have had great difficulty in getting the road. The first charter was granted some eight years ago. But two years have elapsed since the matter was actually agitated on this side, and a charter granted to Frank Todd, Henry Todd, C. W. Young, G. W. Ganong and Irving R. Todd. Then Calais parties with George A. Curran at their head had their charter renewed and steps were taken to interest foreign capitalists and have the road constructed. A. F. Gerald, of Fairfield, Me., I. C. Libby, of the Waterville Loan and Trust Company, and H. B. Goodenough, of Boston, from representations made, concluded that there was a chance to make a dollar in the border towns and they guaranteed the necessary capital. The St. Stephen charter was made over to the Calais company, for purposes of management, and the latter company was organized with the following officers:—H. B. Goodenough, president; I. C. Libby, treasurer; George A. Curran, clerk; C. A. Richardson, C. D. Hill and W. H. Pike, directors; A. F. Gerald, general manager. George A. Curran is counsel for the company and acts as local manager.

After a mutually satisfactory arrangement had been made with the border towns a contract was entered into with the Worcester Construction Company, of Worcester, Mass., and the work of track laying in Calais commenced on June 1st. The cars were running in Calais on July 4th and then a break was made in St. Stephen, where the first car made its trial trip on August 22nd, nearly a week's delay occurring in getting a right of way over the upper bridge. As was natural in connection with an enterprise of such magnitude, there were some conflicts of interest, but the company cheerfully complied with every reasonable demand made upon them. Mayor Clarke in St. Stephen, Mayor Ray in Milltown, and Mayor Murchie in Calais, looked carefully after the interests of their respective towns and gave freely of their time to guard the interests of all. The road is completed as far as it can be until the new bridge is built, and the general opinion is that it is thoroughly constructed and well equipped.

TRADE NOTES.

On another page will be seen an advertisement by Mr. Geo. White-Fraser, who has started a general consulting and constructing electrical engineering practice. The want of independent electrical engineers of experience has hitherto forced intending investors in electrical enterprizes to place themselves more or less in the hands of the manufacturing companies or their agents, who are of course interested in keeping up prices and in pushing the sale of special lines or sizes of machinery, which may or may not be best adapted to their requirements. The special functions of a consulting engineer are watching the interests of his clients, securing for them the best machinery at the best prices, checking the contractors, and generally counteracting the efforts of the agents to secure their own interests at the expense of the purchaser. The specifications whereon electric installations are based should be the work of experienced men, instead of being, as they too often are, made to suit particular "systems" of machinery, to the exclusion of others. Mr. Fraser, by long experience in the lighting and railway field, should be well qualified to ensure the interests of his clients, who, we understand, are already numerous.

The electric fan is being used as the central feature in a game of chance. The modus operandi is to paste a number on each blade of the fan, then cause the fan to revolve slowly, and while it is revolving wage which number will be at the bottom when the fan comes to a stop.

THE INJECTOR.*

BY ALBERT E. EDKINS.

WHEN we take into consideration the vast number of injectors that are in use for feeding steam boilers, it seems somewhat strange that the principles which govern their action are not more generally understood. Probably there has no other appliance been placed in the hands of the engineer for operation, of the principles of which he has known less, and yet has been able to work so successfully.

In speaking of the principles which govern the action of the injector, I wish it to be distinctly understood that I do not allude to the pages of complex formula and matter, to be found in every scientific work on the subject, and which are too far advanced for men of limited education to understand; but what I allude to as the principles of the injector is the common, everyday principle involved, and which can be readily understood by any engineer who can read, and is endowed with ordinary intelligence.

We can well afford to leave the formulas for the proportioning of the jets of the injector to the scientist and the makers of them; but what we want is to know sufficient of the principle of the instrument to enable us to keep it operating successfully, and in case of a failure to be able to detect the cause thereof. It is with these things that this paper is calculated to deal.

The injector, we are told, was invented by Gifford over thirty years ago. I have heard it said, or I have read it somewhere, that the original inventor was experimenting with some apparatus on a steam boiler, when he found to his surprise that it was possible to inject water into a boiler by utilizing the steam pressure of the same boiler. This seemingly paradoxical result was very much wondered at, and we can easily imagine that it would be looked upon by many as an utter impossibility.

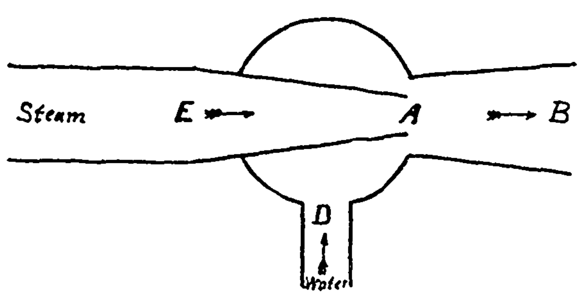

FIG. 1.

Referring to diagram No. 1, to a person having no knowledge of the subject, it does certainly look unlikely that water could be forced into a boiler by the very steam generated within it, and this too (as is often the case) in the bottom of the boiler, where the pressure is greatest, in consequence of the height of water in the boiler.

Diagram 1 represents a section of the injector, and boiler also, from which the injector takes its steam to operate it in feeding water into the bottom of said boiler. A, represents the dome or steam space from which is carried a steam pipe B, which is connected to a cone C, which is connected to a tank full of water D. The cone C is connected to another pipe or cone E, through which the water is driven into the boiler.

All the valves and cocks are left out in the sketch, as they are not necessary for illustration.

To a person unacquainted with steam engineering, the idea of this arrangement of tubes forcing water into the same boiler from which it is supplied by pressure to operate it, might look absurd or impossible, but to us, as operative engineers, it is quite feasible; in fact we see it in successful operation every day.

We will now find out what would be the velocity of steam issuing from an opening of one square inch. If the pressure in the boiler be five atmospheres, or 75 lbs. per square inch, and the temperature of steam at this pressure be 307 F., the weight of 12 cubic inches of steam will be ·001149 pounds.

As the steam has to flow out against the atmosphere, the effective pressure, to which the flow would be due under above conditions, would be 75 lbs. − 15 lbs. = 60 lbs. per sq. inch. If we take a pipe with 1 sq. inch area, and we need to put in that pipe 60 lbs. of steam (i.e., 60 lbs. weight of steam), how long must the pipe be?

To find the necessary length of pipe we have only to divide the total weight, or 60 lbs., by the weight of 12 cub. in. of steam, under a pressure of 60 lbs. per sq. inch, which is ·001149 lbs.

This will give us $\frac{60}{.001149} = 52{,}218$ feet.

If we now take the formula given by D. H. Clarke for determining the velocity of steam flowing from orifices into the atmosphere, viz.:

$V = 3.591\sqrt{h}$.

Where V = velocity in feet per second.

h = The height or length of a column of steam at the given pressure and of uniform density,

Then we have 52.219 (228.4 = feet

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Then   228.4
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819.956 = velocity in feet per second, which steam at 60 lbs. will flow into the atmosphere at constant density.

Dr. Kinnear Clark tells us that the lowest initial pressure for which the preceding formula for determining the velocity, can be safely used is 25·37 lbs. per sq. inch. This formula has been borne out, we are told by the experiments of Mr. Brownlee.

There is a point regarding the flow of steam through orifices, which I have only became acquainted with myself, since studying the matter up for this paper, and I thought it well worthy of mention. It is this: The flow of steam of a higher pressure into a space of a lower pressure, such as the atmosphere, increases as the difference of pressure is increased until the outside pressure is reduced to 58 per cent. of the absolute pressure in the boiler.

The flow of steam is neither increased nor diminished by reducing the outside pressure below 58 per cent. of the inside pressure, even though the outside pressure be reduced to a vacuum.

This fact was a most surprising thing when made known to me a short time ago, and I have no doubt but that it will be the same to some of my hearers in this room.

But to return to my subject. We find that steam at 65 lbs. pressure will flow into the atmosphere with a velocity of 819·9 feet per second, but this is the velocity of efflux at constant density, and D. H. Clarke tells us that the *actual* velocity of efflux expanded at 75 lbs. (absolute) is equal to 1,446 feet per second. Therefore the velocity of steam issuing from an orifice of 1 sq. inch in a boiler carrying a pressure of 75 lbs. per sq. inch will be = 1,446 feet per second.

We will now assume that we have an orifice of 1 sq. inch in the bottom of a steam boiler, the pressure inside the boiler being the same as before, and we require to know the velocity with which water will issue from the orifice, under precisely the same conditions as in the case of steam.

Of course there will be a slight increase of pressure in the bottom of the boiler, due to the height of the water line in boiler, but as it is small, we may leave it out of the question.

Using the same method as we did for the steam (with the exception of the weight of 12 cubic inches of steam), we have now to use the weight of 12 cubic inches of water, or ·44 and the formula will now be

$V = 8\sqrt{h} = 92·8$ feet per second.

Where V = The velocity of water in feet per second.

h = 136 feet, or the height of a column of water equal to a pressure of four atmospheres,

Then we have— feet
136 (11·6 × 8 = 92·8 feet per second

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       ----
        144
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We now have it that steam, under a pressure of four atmospheres, will issue from an orifice of 1 square inch area at the rate of 1,446 feet per second, while the water under the same conditions will only issue at the rate of 92·8 feet per second; this means that steam will issue from an orifice with a velocity sixteen times greater than water. Notwithstanding the greater velocity of steam over water, as shown, the latter could not be forced into a boiler against (its own) pressure; because the momentum of the two streams are equal, because they are both due to the same head or pressure.

The momentum is the product of the mass ×, the velocity with which it moves, and is expressed in formula thus:

$$V\frac{W}{g} = \text{momentum.}$$

* Paper read before the 5th Annual Convention of the C. A. S. E.

Where $\frac{W}{g}$ = the weight W divided by the acceleration of gravity g, which is equal to 32.2 feet per second (= momentum). The acceleration of gravity is the force (expressed in feet per second), which the earth exerts over falling bodies, in excess of the weight of the falling body itself and is = 32·2 feet per second.

A given force imparts velocities to two bodies, inversely proportional to the mass, or their respective heaviness or density.

But by inserting the injector, between the forces, we increase the momentum of the steam, and by condensing it with the water, its velocity is imparted to the water, and the stream of water and steam combined, is as it were, forced into the boiler.

A longitudinal section view of an injector is shown in diagram 4.

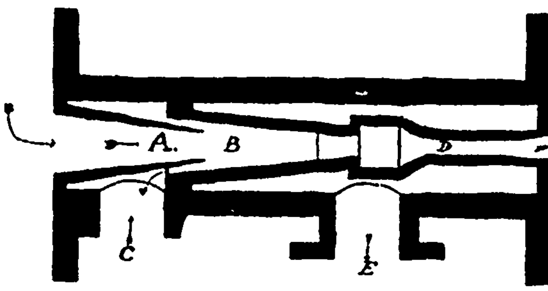

FIG. 4.

A is the steam cone, through which the steam is admitted from the boiler, and let it be distinctly understood that this cone A represents the power of the injector. The steam, in issuing from this cone at a high velocity (as we demonstrated before) is condensed by the water flowing through C, and its velocity is imparted to the water in the cone B. The combined streams of water and steam are then forced into the receiving cone D, where the force of water issuing from the boiler is met and overcome.

The sectional areas of the cones A and D are in proportion to each other as 2·0106 is to 0.7854 (at their respective smallest diameters.)

When the water comes in contact with the steam at the outlet of cone A, it is propelled along by the concentrated steam, and the water (which as you all know is nearly incompressible) is projected into the delivery cone D, and thence into and through the feed check valve and into the boiler, by the impulsive force of the steam, due to its great velocity and elasticity. To sum up the principle of the injector in a short way: It is an instrument which (by the proper proportioning of its jets) takes advantage of the superior velocity with which steam issues from a boiler, as compared with water, and is capable of producing a combined jet of steam and water, flowing through an orifice or jet at a greater velocity that at which an opposing stream of water can flow from the same boiler which supplies the steam to operate it. All injectors (and their names are legion) work on this same principle. The only difference, so far as I know, being that some are water-lifting and some non-lifting, and some are both lifting and forcing combined.

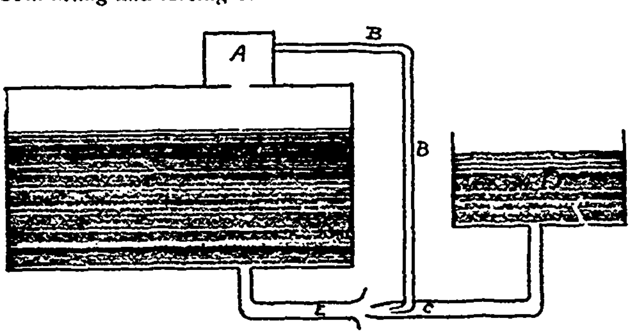

FIG. 3.

In diagram 3 we have a sketch of a lifting jet. Steam enters the pipe at E and issues at the nozzle A, and forces the air out of chamber B to the atmosphere; the air in suction pipe D immediately commences to expand itself into chamber round A, and this action goes on until there is a partial vacuum in D, and the water rises to A by the pressure of the atmosphere acting on its surface, and at A the steam is condensed, and the action takes place which has been before explained. For an injector to lift its feed water, it becomes necessary for the opening B to have considerable more area than A, as, if it were not, it would be impossible to produce a vacuum in D.

Figure 2 represents a non-lifting jet, and it will be observed that the area of the outlet of cone B is somewhat smaller than the steam cone A, and if steam be turned on at C, and issues at A, it will expand and fill the cone B, causing a pressure to back up into suction pipe C. So that with injectors of this type it is necessary for the feed water to be forced into the injector under a head, either by gravitation or from the waterworks mains.

We will now briefly look into a few of the causes of failure of injectors to work.

Injectors often throw off when the temperature of water supplied to them exceeds 130° to 150°; and this is due to the fact, that neath these conditions it requires such a large quantity of water to condense and concentrate the steam issuing from nozzle A, that the velocity imparted to the water is not sufficient to overcome the opposite flow from the boiler, and, consequently, the injector kicks.

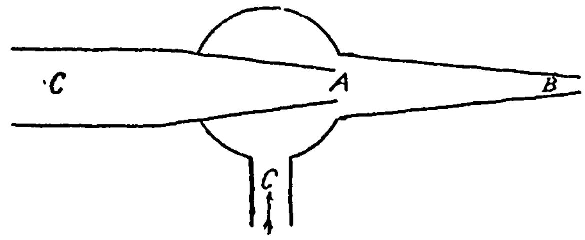

FIG. 2.

Sometimes injectors work along smoothly for hours, days, months, and even years, and then all at once refuse to do their duty.

This may be due to one of several causes.

I have no doubt that some of those present have fed boilers with injectors which took their feed water from a barrel or tank, and when you have started it, and it has worked for a few minutes, and then thrown off, or kicked, as we call it, and you find your water in feed tank is hot; but you say the injector started to work at first, and why not continue to do so? Simply because the injector itself may have been quite cool when it was started and therefore it assisted in condensing the steam from nozzle A, but as it became heated gradually, and the feed water itself was too hot to cool the steam, the injector kicked, and keeps on kicking until you reduce the temperature of feed water. Again, the feed water in the tank may not have been all of the same temperature and as the suction pipe reached down near the bottom, it worked all right until it commenced to take the water of a higher temperature which was in the top of tank when it started, and it kicks again. The injector will always throw off when the volume of steam feeding it is not enough to give it required velocity to overcome the opposing steam or flow from the boiler. Here too, we may be inclined to say, well, but the steam worked the injecter when it was started, and that may have been so; but we must remember that the water that the injector has forced into the boiler has been, comparatively speaking, cold, and this has reduced the velocity of steam from the cone A, and the volume of water entering through feed pipe has remained constant as when the injector was started, and the necessary speed is therefore not imparted to the water with the result that injector throws off.

Then in addition to the above causes of failures there are old-timers, well known to all engineers, viz., leaky suction pipe, no water in tank, end of the supply choked up, foreign matter in the jets of injector, hot section pipe, etc., etc, and I have even known a check valve put on a pipe wrong end to, to prevent an injector from working. I have also known the jets to become coated with a deposit to such an extent as to alter the proportion of area so that they would not work.

There are scores, yes thousands of engineers who use injectors of one of the many kinds; and who, in the event of its failure to work, will take it down, clean it, and remove the cause of trouble, and put it together again and make it work successfully, and yet never once think of trying to enquire into the principles which govern its action, and yet it seems to me that an engineer who is of an enquiring turn of mind (and who refuses to take a thing for granted, simply because there is abundant evidence that it is so, but who enquires into the reason of things, and posts himself as fully as he can on the principles of steam engineering) must eventually find himself in better circumstances than the man to whom it is quite sufficient to know that a thing is so, because he sees it is so, and who is quite satisfied without enquiring the reason why.

It is understood that the Victoria Street Railway Company has made satisfactory financial arrangements and that an issue of first mortgage bonds will be taken by capitalists who have examined into the value of the franchise and assets of the company. The new loan will be used to pay off existing obligations and to place the railway in first-class condition.—Victoria, B. C., Times.

In placing a gauge on boilers, it should be so connected as to take steam from a part which will be as free from vibrations of pressure as possible, that is, away from the outlet of the engine, and a siphon should never be omitted. It is also necessary that the gauge shall not be placed at or near the lower level of a connecting pipe which has a drop of any extent, which will create an excess of pressure on the dial by the weight of water in the column. In a battery of boilers there should be a gauge on each boiler and not one gauge for the whole.

CANADIAN ELECTRICAL NEWS AND STEAM ENGINEERING JOURNAL

PUBLISHED ON THE FIRST OF EVERY MONTH BY

CHAS. H. MORTIMER,

OFFICE, CONFEDERATION LIFE BUILDING,

Corner Yonge and Richmond Streets,

TORONTO, - - CANADA.

Telephone 2362.

NEW YORK LIFE INSURANCE BUILDING, MONTREAL.

Bell Telephone 2299.

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IN order to place before our readers as early as possible a complete report of the proceedings of the fourth Convention of the Canadian Electrical Association, it has been necessary to considerably enlarge the size of the present number of the ELECTRICAL NEWS. While regretting that we are compelled to greatly condense or omit entirely many matters which we should have like to mention in detail, we are of opinion that considering the variety and importance of the subjects discussed at the Montreal Convention, we could not present to our readers matter of more immediate interest than the report which we publish. It need scarcely be said that the Convention was the most successful one that the Association has ever held. A perusal of the report of the proceedings shows this to be the case. There were a larger number of papers read than at any previous Convention. The subjects treated were all of an interesting character, and in every case were most ably handled. What is of quite as much importance is the fact that the papers were more thoroughly discussed than those at any former Convention. There is still room for improvement, however, in this particular. We expect to witness greater freedom of discussion at future meetings, arising partly out of the better acquaintance of the members with each other. The presence at the Convention of the President of the National Electric Light Association of the United States, and of Mr. Lockwood, advisory electrician of the Bell Telephone Co., added greatly to the interest of the proceedings, and it is hoped that these gentlemen will be seen and heard at future meetings. Another interesting feature was the excellent paper by Mr. Sperry, of Cleveland. It unfortunately happened that Mr. Sperry did not reach Montreal until the close of the second day's proceedings, and the apparatus which he needed to illustrate his paper did not arrive until an hour before the time set for the adjournment of the Convention. This delay was a matter of much regret to the officers and members of the Association. The local Committee, the Montreal members of the Association, and several of the local electric companies, whose names appear in the report, exerted themselves to the utmost to make the visit of the outsiders as enjoyable as possible, and they entirely succeeded. The officers elected for the ensuing year are such as we believe will promote in every way possible the growth and influence of the Association, while the selection of Ottawa as the place of the next Convention is certain to contribute to the same end. The Association is indebted to Mr. J. J. Wright, the retiring president, for the valuable service he rendered on its behalf during the three years he held that important position. His successor, Mr. Dunstan, is known to be a gentleman of good executive ability, who as vice-president always manifested the deepest interest in the welfare of the organization, and under whose direction it bids fair to continue to prosper.

CABLE CONSTRUCTION AND CABLE FAULTS.

By F. J. F Schwartz.

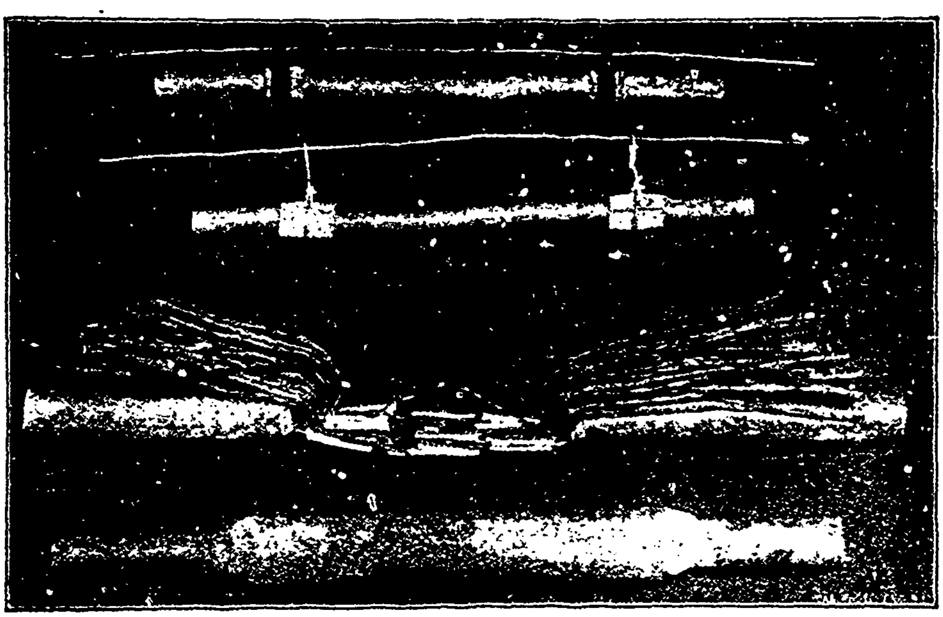
The number of wires in use when the telephone made its appearance was very small as compared with the number of wires or circuits in use to-day, or even as compared with the number in use after the adoption of the telephone commercially. It follows, therefore, that few wires took any one route or converged to one head or central office, and it was an easy matter to run these lines, each supported by its own insulator, and several inches from any other conductor, while at the central station it was only necessary to provide a suitable roof fixture or cupola where the line wires might terminate. The connection between the lines and the apparatus could easily be made by means of insulated wires supported by cleats. The larger number of circuits made necessary by the increasing number of telephones in use quickly rendered such a method inconvenient, and soon impossible. In the days of comparatively short lines, well separated from one another, with no interfering electric light

Fig. 1.

or power currents, with few or no complaints of cross-talk, the life of a central office manager might have been regarded a comparatively peaceful one. The earth was his.

The increase in the number of circuits to be accommodated, and the necessary grouping of all the wires in a route into cables, in order to economize space as the circuits neared the office, brought peculiar classes of troubles, or made old ones more noticeable. Briefly mentioned, these annoyances were due, first, to currents induced from foreign wires into the telephone lines, which being cabled with others, would more or less disturb them; second, to the interference between one telephone circuit and another, giving rise to cross-talk; and third, to a muffling of the conversation due to the retardation of the telephonic current. To these must be added all troubles caused by flaws or faults occurring in the cables or joints.

A large number of cables of different kinds are now in use, some especially intended to overcome or prevent the annoyances mentioned. All consist of a specified number of insulated wires bound together, forming a core, which is inclosed in a wrapping or sheath to protect the core from moisture. One of the early forms of cable, which was very light and flexible, was composed of a core of cotton or rubber insulated wires, inclosed in a rubber covering, which was in turn protected by a painted, braided cotton jacket. By far the larger number of cables were of the lead covered type in which the core was drawn into a leaden pipe, and the space between the core and the pipe was then filled with insulating material. In other cases the lead was formed about the core by pressure; the process making the pipe, and covering the core at the same



Figs. 2, 3, 5, 6.

time. In one style of cable, the core was covered by two thin leaden tubes having a layer of tar between them; the outer lead being protected by a wrapping of painted tape. The presence of tar on the outside would indicate a break in the lead, while there was a chance that the tar would fill the break, and prevent the entrance of moisture.

It has been mentioned that circuits in cables were found to be more subject to inductive disturbances than separated circuits; and several plans were resorted to with a view of overcoming the difficulties. These consisted generally of winding about each insulated conductor a wrapping of tin, lead or copper foil which was to be connected to earth, and which would act as a shield between each wire and its neighbor by providing a circuit for the induced currents other than by the way of the cable wires. Bare copper wires were also placed among the foil covered conductors to facilitate the connection of the foil to earth as well as to connect the foil of one section of cable to that of another where splices were necessary. Some cables were made with each insulated conductor

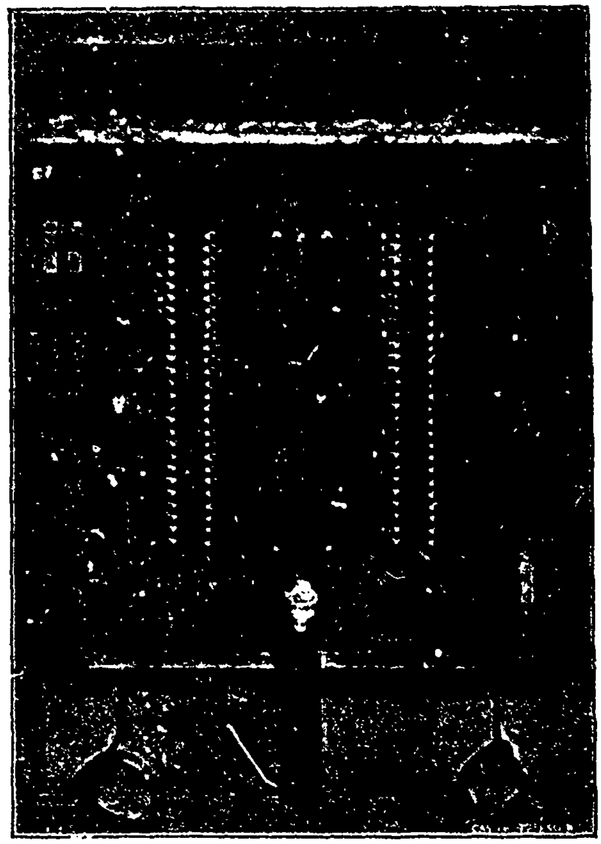


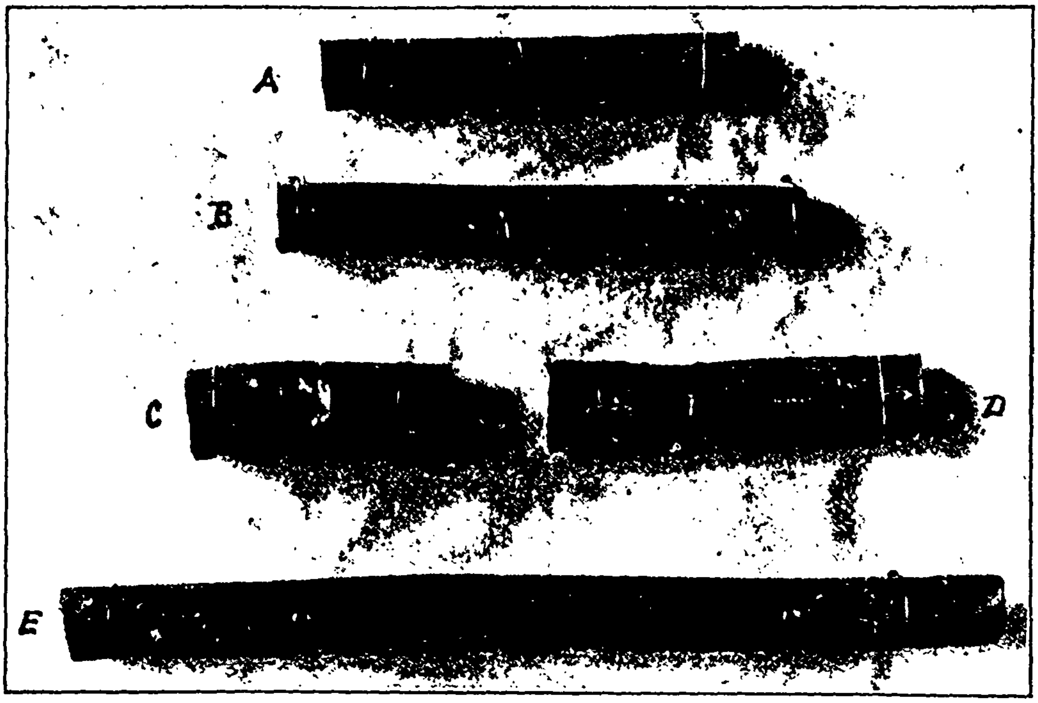
Fig. 4.

inside of a leaden tube of its own, the whole forming a core, which in turn was covered with an outer leaden pipe as usual; and still other cables were provided with a single large copper wire placed in the centre of the core.

With these shields there was less interference between the several wires, but on account of the greater static capacity of cables so constructed, the telephonic currents were impeded and conversations were rendered indistinct. This was most noticeable in the case of long cables. Other cables were made having only a portion of the conductors foil covered; and all of these cables were made for aerial work, as the demand for underground work had not then arisen; in fact, underground work was considered impracticable as much on account of the increased cost as well as on account of the greater amount of retardation that would be experienced; and it was impracticable to operate underground telephone lines of any considerable length when employing the cables of the day, and working with grounded circuits.

The increase of disturbances brought about by the presence of electric light and power circuits seriously affected the telephone service, and it was realized that a return wire would have to be employed for each line in order to quiet them. In the cables hitherto referred to, the conductors were laid up, either straight or in long spirals, while in certain forms the inner conductors were given a twist in one direction, and those in the outer layers were given a twist in the reverse direction. These forms were not adapted for metallic circuit work, as the two sides of a circuit could not occupy the same relation to a disturbing circuit. The cable suitable for metallic circuit work is one in which the two wires used for a pair are twisted together throughout their entire length. The insulation chiefly used for cable wires in the past has been cotton saturated with paraffine or with some other of the many insulating compounds, but for underground work it was found desirable to make cables having as low a capacity as it was possible to obtain. Air having the lowest specific inductive capacity, and dried paper having a very high insulation resistance, cables have been made in which the conductors are loosely wrapped with paper so as to give more or less air space about the conductors. Various methods are employed to still further increase the air space, such as by perforating the paper, or by winding twine in long spirals about the wires, and over which the paper is applied.

One form of novel construction is shown in figure 1, where two bare wires are inclosed within a paper tube but are separated by a spiral partition, also of paper. The wires lie in the grooves of the paper partition. By this method a large air space is insured, which is favorable to a high insulation as well as to a low static capacity. It is claimed that in cables of this description the capacity per mile sometimes falls as low as fifty-three thousandths (.053) of a microfarad, and that they usually average under seven hundredths (.07) of a microfarad per mile.



GROUP 7.

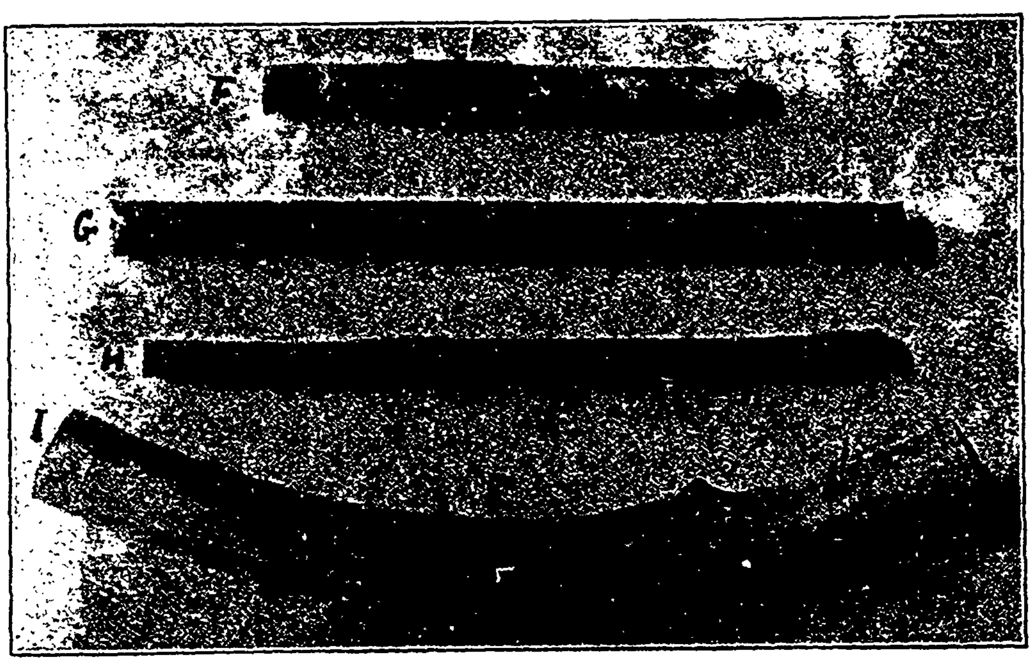
According to the specifications for underground cables, the insulation resistance per mile of cable, when connected up, must not fall below five hundred (500) megohms, and the average capacity per mile must not exceed eight hundredths (.08) of a microfarad. Numbers 18 and 19, B. & S. gauge, are the sizes of the wires generally used. The high insulation mentioned is not absolutely essential for good service, but it is desirable as being one of the best guarantees that a cable has been carefully made, handled and spliced.

Paper insulated cables are now in use both for underground and for aerial work. In putting up aerial cables it is necessary to first run a supporting wire, one end of which is brought diagonally from the terminal pole to the ground. By means of this slanting wire the cable is drawn to its position on the poles, where it is suspended by cable clips to the supporting wire. These clips or hangers are sometimes made of malleable iron, and are pressed about the cable to prevent them from slipping, while a piece of canvas placed between the clip and the cable is intended to keep the lead from being marred. Another form of hanger consists of two grooved pieces of wood bound to the cable by wire, one end of which is bent into a sort of hook. It has occasionally happened that the supporting wire has been crossed by other wires falling upon it, with wires carrying a heavy current, and the current has passed to the cable lead at some one of the clips, and the cable has been burned. With the wooden blocks, a foreign wire must make contact directly with the cable lead in order to burn it. Figures 2 and 3 show methods of supporting the aerial cables. At the terminal pole, the end of the cable is brought through a leaden pipe into an iron box, where the wires are secured by means of insulated screws, nuts and washers. The screws pass through insulating bushings to the outside of the iron box, where, between other nuts and washers, are connected the short wires leading from one end of the fusible wires provided for the protection of the cable. Waterproof insulated wires lead from the other ends of the fusible wires to the line wires on the poles. The entrance tube at the bottom of the iron box is wiped to the body of the cable, and when the cover is screwed on the terminals are moisture-proof.

Figure 4 represents one of the forms of cable terminals now in use. It accommodates twenty six pairs of wires, and, with its fuse wires, is inclosed in a wooden box. The other ends of the cables are similarly sealed, but special forms of arresters are generally secured to the outside of the iron boxes. These arresters connect to ground any circuit carrying a dangerous current, whereupon the fuse in the outside cable-box is melted, and any current is prevented thereafter from entering the cable. Spark-gap arresters are also employed in combination with the above.

When it becomes necessary to run a cable underground, jointed poles are pushed through one of the ducts from one manhole to another. To the last rod a rope is fastened which, when pulled through the duct, is used in drawing the cable. The lengths of cable handled at a time in underground work are much shorter than those that can be easily handled in overhead work, and consequently there are splices in nearly every manhole. Splices, as made in paper insulated, underground cables, are shown in figures 5 and 6. Figure 5 shows the splice partially made, and figure 6 the completed splice. The wires are bared for a short distance, and a paper tube is passed over one of the wires. The wires are then spliced so as to form a long twist, after which the paper tube is drawn over the joint. The joints are not soldered. After all of the wires are connected, they are bound together with paper and twine to prevent the paper tubes from slipping, and then boiling paraffine is poured over the splice until all moisture is expelled. This is indicated by the absence of bubbles. A leaden sleeve, previously passed over one of the cable ends, is next drawn over the splice, and the ends of the sleeve are wiped to the cable lead.

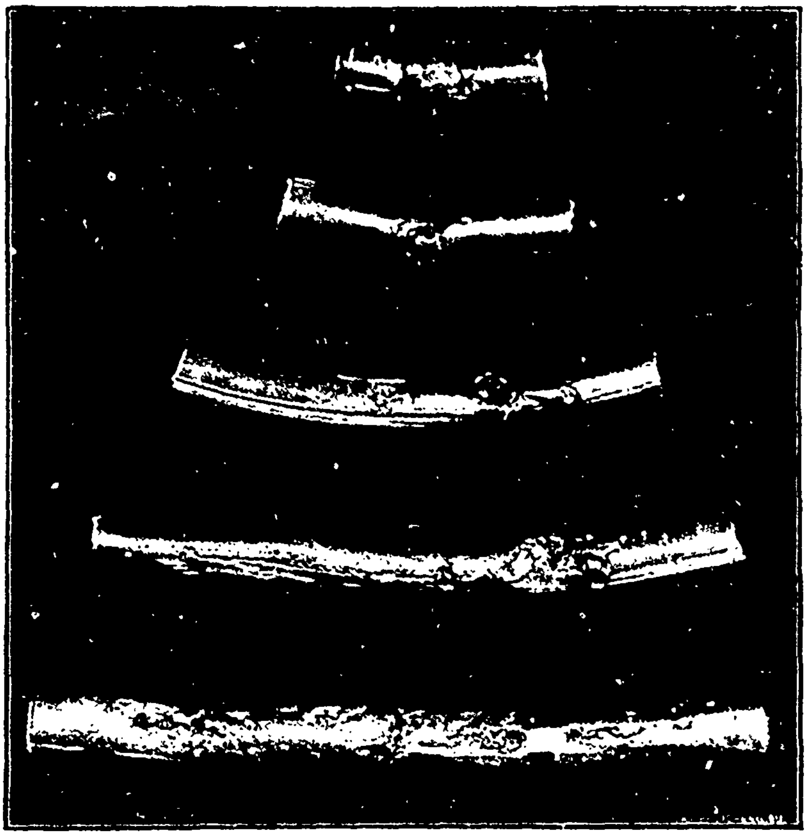
We will next consider the faults which cause the most annoyance, and it may be generally stated that some form of injury to the cable lead gives rise to nearly all of them. In the older work the wiped joints were made by plumbers, and as this work was done on the poles or in the middle of a stretch, it sometimes happened that the work in time proved to be faulty. Referring to group 7, fault A was originally started by a slight cut, and it afterward opened out in handling the cable. Fault B was caused by a wire resting against, and sawing into the cable. Faults C and D are samples of small trolley burns, C occurring under one of the iron cable clips. In sample E the holes shown were caused by linemen's spurs. Such faults rarely occur, and this is but the second of the kind that I have seen.



GROUP 8.

The faults of group 8 differ from those previously shown in that they are due chiefly to flaws and faults in the manufacture of the leaden covering. The cracks shown in F and G are evidences of poor or damaged material, possibly the lead may have been burnt. In the cables from which samples H and I were taken, a seam extends along the entire length. Ordinarily it cannot be detected, but sometimes it will open out as shown, and it is quite likely to do so if the cable becomes twisted while being pulled.

When the trolley system was introduced, it was found that some of the lower hanging cables were dangerously near to the trolley guard and supporting wires where the latter were fastened to their poles, and just beneath the cables. Group 9 represents a number of burns which occurred in a single stretch of cable. Another burn occurred quite recently in an underground cable which has, however, aerial branches used in connection with it. A broken wire crossed one of the aerial branches of the cable with the trolley wire, and a hole was burnt in the lead at the point of contact. The cable wires were not injured at this point, but the current passed into the lead of the underground cable and finally to earth in one of the manholes, where it fused the lead and burned into several pairs of wires. This will have to be guarded against by providing two terminal boxes at each junction with the underground cable. The lead of the two cables will not then be continuous, but the conductors will be connected through by short wires from box to box.



Group 9

The amount of underground work in Montreal is at present small, and there has been no destruction caused by electrolysis. There is, however, considerable difference of potential between the cables and the earth at different points, and it is probable that trouble will be experienced. Enough has been shewn to prove that cables are sufficiently liable to faults and injuries without those due solely to carelessness. With overhead construction more or less of the mentioned faults will still continue to occur, and with underground cables the troubles, though fewer in kind, are no less destructive. To meet these, special means will have to be adopted as occasion requires.

THE APPLICATION OF ELECTRICITY FOR MEDICAL AND KINDRED PURPOSES FROM LIGHT AND POWER CIRCUITS.

By W. B. Shaw.

Mr President and Fellow Members of the Canadian Electrical Association.

When the thunderbolt in the shape of a letter from our worthy Secretary fell upon me demanding a paper, I was at a loss as to what to launch out upon. I have heard so many able papers on various subjects already read before the Association, that in searching around for "pastures green," I thought that the above subject might be of interest to some—if not for its "electrical instruction, then for its "novelty." I have headed these remarks, "From Light and Power Circuits," but there are no doubt many here who are interested in battery work, so there will be no harm, I presume, in my detailing the battery methods a little before showing how they can be more readily and less expensively worked from the circuits before mentioned.

Let us take first the dentist, who probably uses electricity least of all. Yet let us see what this "least" means. No enterprising dentist nowadays thinks of standing on one leg (while the temperature is about 100 deg in the shade) working his foot-drill with the other. They run by motor. Some have 2 or 3 cells of accumulators and run a small 4 or 6 volt "Crocker Wheeler," or "C & C" motor. The cartage around, however, of the accumulators to have them re-charged, makes this an expensive method, and of course the 110 volt direct current is much preferable. Unfortunately, in Montreal, there is very little of this to be had, and quite a few dentists decline to handle a 250 volt motor, even though it is of small power and properly insulated. There is another reason also, and that is that they generally use a pedal switch for starting and instantly reversing. The accumulator outfit is easily regulated by switching in one or more cells as required. With the 110 volt outfits a rheostat is put in the field circuit. In both cases the wires from the circuit are first led to the pedal which sets as a pole-changer before the current is let into the armature. Some members may think that this instant reverse would be apt to put a finish on the armature. All I can say to this, gentlemen, is that I know of a 1/6 H P, Crocker Wheeler, 110 volt motor which has been treated in this way for the last 3 or 4 years and is still going. I fancy, myself, it is because there is no weight to the armature. With 250 volts, however, it is a different matter. The flame which would flash around from the brushes on attempting this would certainly frighten any patient out of a dentist's chair, so in this case we have to use a motor transformer, taking 250 volts on one side and delivering current at 8 volts (used in conjunction with the storage battery motor) or at 110 volts, where the motor is wound for same, the motor transformer to be put on a bracket near where power wires enter. Most of us who have sat in a dentist's chair can tell exactly the moment when the dentist is awaiting the momentum of the fly wheel to carry him over the dead centre point. The drill slows up a little and suddenly makes a rush, but I need not detail this, for it is no doubt a case of "You've all been there before," or at least a good many of you at any rate. But the electric motor keeps the drill running at a constant and steady speed. It is instantly reversed if necessary and under perfect control. It is also a known fact that the faster the drill goes the less pain will be caused. The power required for the S. S. White Standard Upright Pedal Drill is from 1-12 to 1/8 H. P. For the small lathes which dentists use in their workshops for buffing plates, artificial teeth, etc., a 1/6 H. P. motor would be required.

All the above figures refer to an ordinary practising dentist. Where a man has a rush of trade it may pay him to run a small dynamo (say ½ H P) with a motor and connect on his small motors from a pair of bus wires run around the room.

Probably some of you have heard of the "pull teeth without pain" idea. Personally I do not take much stock in it, but I must admit that I have seen a patient operated on who affirmed he felt no pain. The idea is this. A German savant declares that if the vibrator of an induction coil is caused to vibrate with such rapidity that the buzzing tone will be the same as the note "A," that the electrical vibrations will be quicker than the impulses of pain vibrations from the nerve centres to the brain. The mode of application is as follows. The patient is given 2 handles from an induction coil driven by a battery, the plunger is then pulled out until he says "Enough," the battery is then shut off for an instant by means of a floor push, the 2 handles which the patient is still holding being connected together now on to one pole of the battery, the dentist, taking a flexible wire from the other pole to his forceps, immediately on pulling the tooth (or rather just as he begins to pull), sets the coil in action again by means of pressing on the floor push.

Of course the above can easily be worked by means of a straight current with a proper rheostat. Our dentist will also use a small electric light for examining cavities in the mouth. This not only shows up the decayed parts in the teeth, but renders the teeth translucent. Once in a while a dentist can use hot cautery wire for what they call "dentine" work.

It appears from the above that the straight current station has the best of it. This is so as regards the motive power for the alternating motor is not very successful for such work. The writer has had one of the Meston types specially wound, and it is now running for such work, but certainly it has not given as good results as the straight current motors do, and I have been unable to find any small alternating motor suiting our rapid alternations. Instant reverse of course is lost, but when we come down to illuminating the small lamp and working the cautery I think that any of you will agree that the small transformers now on the market for such work are most convenient, ahead of a rheostat where straight current is used and altogether over and above the storage battery. One thing I have noticed, and it seems grossly absurd, for dentists and medical men generally who use cauterizing tools to have a storage battery giving a rated output of 7 amperes when of the many cauteries I have tested the current taken by the smallest was 12 amperes and by the largest 48. Many and many a storage battery has been ruined by this work. It is simply nonsense for medical men generally to try and save $5 00 at the start only to lose $20 00 later on. The item of power supply may appear small to a power station, but remember, gentlemen, these professional men are about the only ones who can help you out with a day load on your lighting circuit, and when I tell you of one dentist with simply one assistant using over $140.00 worth of current in one year, you can readily see that a few such would be no little help.

So much for our friend the dentist.

Let us now turn our attention to the oculist. He is a difficult man to please in regard to light, as when he examines the eye with the small species of pocket telescope which he has for the purpose, he gets a double reflection, showing the filament on the eye and spoiling his examination. To overcome this, use a frosted lamp. Have the filament "edge on" to the eye of the patient and use a Ries reducing socket, so that the oculist can tone the light down to suit himself. The opthalmascope, or instrument for testing the sight, is easily illuminated by means of 4 8 C. P. lamps clamped all around the wooden board where the face of the patient is set. These lamps are all shaded from the patient's face by means of aluminum shades shaped the same as the half of an incandescent lamp, the light being projected on the black bridge by means of the telescope through which the oculist looks.

The nose and throat specialists simply use cauterizing apparatus, which is easily accomplished on alternating current by the small transformer before referred to, but as the cauteries used, especially in those cases, are excessively large, it is impossible to economically use straight current for the purpose unless in conjunction with a couple of large cells of accumulators. I have seen one cautery which consumed about 68 amperes at about 4 volts to get it to the proper white heat.

I do not intend in the slightest to speak of electric belt and other appliance men, lightning hair brushes, &c. One quaint little note of Sylvanus P. Thomson in his book entitled "Electricity and Magnetism" covers their case very nicely, and with your permission I will repeat it. He writes as follows —

"It is not out of place to enter an earnest caution against numerous quack doctors, who deceive the unwary with magnetic and galvanic appliances. In many cases these much advertised shams have done incalculable harm. In the very few cases where some fancied good has accrued, the curative agent is probably not "magnetism" but "flannel."

It may not be out of place either to call the attention of our worthy organ, the Canadian Electrical News, to the manner in which the Electrical Review, of London, England, is exposing all such nonsense. It is not long since that the writer of this paper was offered on sale near the post office in Montreal, "bottled electricity for curing headache."

A few words may not be amiss in regard to "Electrolysis," as the removal of superfluous hairs is termed. It is a simple operation and consists of destroying the hair by decomposing the watery tissue at the root of the hair. A simple equipment for this is to use say 10 cells of the large size Samson battery with a 3 pt. switch giving 5 cells, then adding 3 more and 2 more, the strength being regulated according to the resistance encountered at the positive electrode. The usual mode of operation is as follows —

The patient takes a sponge electrode in one hand, this being connected with the positive pole, the operator inserts a fine needle, which is in connection with the negative pole, at the root of the hair. The reason the negative pole is used is that if the needle were attached to positive a black spot would be left owing to the metal becoming oxydized. It may seem strange to you, but it is a fact, that there are specialists in this city for this work alone. I believe they also remove wine marks and other facial blemishes by this means, in such cases using a number of needles in one handle. This work of course cannot be done with the alternating current but can be done with the straight current through a suitable resistance or in conjunction with a few small cells of accumulators.

I have said enough about specialists and will only mention one other specialty although it really has nothing to do with the medical line, before getting down to our doctor or regular practitioner proper, i. e., the photographer. Give him two drop lights in his dark room, one equipped with a spring cord adjuster, an ordinary socket and a 32 C. P. lamp with very light frosting, the other light to be left conveniently within reach and equipped with an 8 C. P. ruby glass lamp and Ries regulating socket. The red light hanging low is of course most handy and he will turn it on slowly, getting the desired amount of light according to the sensitiveness of the plate he is operating on. When red light is no longer absolutely necessary he can reach up and pull down his white light, by this means having every facility without the danger of lighting a match where collodion and other inflammable chemicals are lying around. If alternating current is not there, a Ries socket of course cannot be used, but a carbon rheostat switch as manufactured by the McCreary Electrical Specialty Co., of New York, can replace it.

Now let us take our regular practitioner and see what he wants.

1st. Current for small examining lamps and for cauteries.
2nd. Current for galvanic work, for removing fibroid tumors, &c.
3rd. Faradic current for rheumatic and paralytic patients.
4th. Mild continuous current for nervous diseases.

For item No. 1 the usual way at present is to have a couple of cells of accumulators or a bichromate plunge battery.

For the 2nd 48 or 50 cells of Leclanche battery, a milliampere meter and a double collector switch as made by Gaiffe of Paris.

The 3rd current is supplied from many of the Faradic portable batteries with induction coil for physicians, or sometimes they use the coil alone connecting it to 2 or 3 cells of Leclanche battery from their Gaiffe outfit, i. e., when they have such an outfit on the premises. I may say that physicians have dropped the old magneto electric crank machines almost altogether.

The 4th current uses an outfit similar to that described for No. 2, except that they have an adjustable rheostat as well as the Gaiffe double collector switch, also a button for interrupting the current and a double arm switch to act as a pole-changer.

You can see how readily all this business can be done with straight current at say 110 volts, a proper rheostat and one or two cells of accumulator. The accumulators would attend to the small examining lamps and the cautery. The straight current and rheostat would do away with the cumbrous cabinet containing 50 Leclanche cells also with the nuisance of continually replenishing the cells with water, testing them for breaks in the wire, putting in new zincs, recharging, &c. This matter of broken wires is an important one, as the Gaiffe collecting switch has a wire running from every couple of batteries, so that the current is increased by 2 cells at a time, there being 2 switchboards with the contacts cross-connected. It is evident that the difference of the two switch levers is what will be given to the patient, for instance, if we place the left hand switch lever on 10 and the right hand switch lever on 20, the patient will be getting simply 10 cells. This arrangement is convenient as a doctor invariably uses up his first sixteen cells more than any of the others. Of course the Gaiffe board requires considerable wiring, in fact, a 25 wire cable from the batteries, but, as I have had considerable experience in fitting in these outfits, I find that in the long run this board gives much more satisfaction and a closer range of current than the various forms of carbon and water rheostats sold by some American firms to take the place of the Gaiffe board. The contact on the switch arms is so arranged that it slides on to one contact before breaking with the preceding one, and so on. A broken wire would cause the patient to receive a violent shock, which in internal examinations might prove fatal. A worse objection is, however, open to the straight current brought in from outdoors, viz —contact with a higher tension wire.

The treatment of Faradic current I need not dwell upon here. It is simply use your induction coil. It is employed for cases of rheumatism, paralysis and drowning. In the latter case the contraction of the diaphragm and chest muscles would serve to start respiration. Some medical men, notably those from Paris, go in for what is termed "Franklinism," which is to charge up a patient from a frictional machine, and after charging him full draw the current off from various portions of the body by various devices, but this is not much in use. A small ⅛ H. P. motor either direct or alternating can be used to drive the machine.

I had almost forgotten one item, i. e., heating apparatus, which is handy for a medical man, a hot water heater for his bandages, etc.

Before closing let me describe how I would propose to put in an outfit for a physician giving only the currents which we have in Montreal, viz —52 volt alternating, and 250 volt direct. I would proceed as follows —

I would have the 250 volt current run into the basement of the doctor's house and connected up to motor generator of the 1 H. P. type, which gives 500 watts at the secondary end. The primary would take 250 volts; the secondary would give it off at 52. This motor generator would be operated by means of switch and rheostat placed upstairs in the doctor's operating room above the basement. The 52 volt secondary direct current wires would go to the lower terminals of a double pole, double throw switch. The house circuit for lights, &c., would come to the connecting knives or central contacts of the same switch, and I would have the 52 volt alternating current run in and connected to the upper contacts of the same switch.

I purpose to leave the motor generator running during the daytime. The main switch would be down. There would be sufficient current for house lights, charging accumulators running cauteries, motors, Faradic coils, galvanic current, &c., from it, and as a reserve he can throw up on to the alternating current, which can still continue to light his house lights, work his cautery this time by means of small transformer, &c.

I think, gentlemen, that I have proceeded about far enough with these rambling remarks, but it may show that there is a bigger field for ingenuity than was imagined by catering for the fitting of a professional man's electrical plant. I should have preferred had time permitted to condense this rough draft of mine in some points, and explain more fully the electrical data, but being exceedingly busy for some weeks back I must plead this as an excuse for not doing so. I shall be happy to answer questions in so far as I am able, and thanking you, gentlemen, for your kind attention, I will now close this paper.

ALTERNATING CURRENT MOTORS.

By L. M. Pinolet.

The alternating current system possesses many advantages for the transmission and distribution of electrical energy, but until recently has labored under the disadvantage that it could only be employed for lighting, except in a few special cases, as there were no alternating current motors suitable for general use. This drawback has now been overcome, and self-starting alternating current motors of simple construction and high efficiency can be had. As the alternating current system is so extensively used and is so suitable for the long distance transmission of power, these motors have attracted much attention, and it is my intention to explain briefly in this paper the principles of construction and operation of some of the most important types of the motors.

It has been known for a long time that an alternating current dynamo of the ordinary single phase type, would run efficiently as a synchronous motor, if its armature were supplied with an alternating current and its fields were magnetized by a continuous current. To illustrate the operation of this type of motor let us take a four pole motor whose armature windings are connected with a source of alternating current, and are arranged to produce four poles to correspond with the four poles of the field, two of which are north poles and two south poles. The strength of the magnetic field necessarily varies uniformly in all the armature poles. If at a particular instant, one of the poles be a north pole, the two adjacent ones at right angles to it are south poles. At the next alternation of the exciting current, the first named pole will be a south pole and the two at right angles to it will be north poles, and so on the poles will change for successive alternations of the current. It is thus apparent that the action of the alternating poles of the armature upon the poles of the other element of the motor, is at one alternation of the current in a certain direction and at the next alternation is in the opposite direction. The attraction at one alternation is thus neutralized by a repulsion at the succeeding alternation, and consequently the motor will not move. But, if the movable element be rotated in either direction at a synchronous speed with the shifting of the magnetic poles of the armature, the armature poles can be brought into such a position with respect to the field poles that the attractions and repulsions between them are always in the direction in which the motor is running. The motor will then continue to run at a synchronous speed and will stand a considerable overload without being thrown out of step, or synchronism. A synchronous motor is usually brought up to speed by a small non-synchronous motor of one of the types described below. When the large synchronous motor is running at the proper speed, it is connected with the line by a switch and the load is thrown on by a friction clutch.

The difficulty of starting these synchronous motors has rendered them unsuitable for general use and a number of electricians have worked at the problem of making a self-starting motor for single-phase alternating currents.

One of the methods adopted is to provide one of the elements of the motor with two energizing circuits which produce separate sets of poles in the element. The alternating currents in the energizing circuits are caused to differ in phase and thus set up a rotary magnetic field in the element, as in a two-phase motor. The rotary field induces currents in closed-circuit windings on the other element of the motor, which currents cause the motor to run by their action on the rotary field. The difference of phase between the currents in the two energizing circuits can be obtained in one of the following ways.

Both circuits are connected to the same source of alternating current, but the circuits have different coefficients of self-induction, so that the current in one circuit lags behind that in the other. The difference in the self-induction of the two circuits may be obtained by inserting a condenser in one circuit and a self-induction in the other.

One only of the circuits is connected with the source of alternating current. The other circuit is closed on itself and is within the inductive influence of the first circuit. The alternating currents in the first circuit induce currents in the closed circuit, which differ in phase from the inducing currents.

In another type of single current motors, the rotary element is provided with normally open circuit coils, whose terminals are connected to a commutator, and the field of the stationary element is excited by an alternating current. By means of brushes, the circuits of the coils are closed when they are in such a position that the magnetic field of the currents induced in the coils by the exciting magnetic field, is assymmetrical with respect to the exciting field. The field of the induced currents is repelled by the exciting field, and thus the movable element of the motor is caused to rotate.

If the movable element of a motor of the above described type be provided with a number of closed circuits, the field of the currents induced in the closed circuits will be symmetrical with the exciting field when the motor is at rest. The repulsions will then be equally strong in both directions, so that the motor will not rotate. But, if the movable element be rotated in either direction, the fields become assymetrical with respect to each other, and the repulsions are greatest in the direction in which the movable element is rotating, so that it will keep on rotating when started, with a tendency to synchronism. These motors can be started by an extra energizing winding, used only at starting, in which the current is caused to differ in phase from that in the regular energizing circuit by one of the above-described methods. Or the motors can be started without a starting winding, if the circuits of the coils of the rotary element are open and are connected to a commutator. The motor is started, in the way already described, by closing by suitable brushes the circuits of the coils when they are in such a position that their magnetic field is assymmetrical with respect to the exciting field, and, when the motor has acquired its proper speed, the circuits of all the coils are closed. Prof. Elihu Thomson, who has done much to develop motors of this type, says in a recent article that they have attained a fair degree of perfection, though the writer of this paper is not aware that any reliable tests of their efficiency have been published.

Having examined the principal types of single current motors, we will consider the polyphase motors which are self-starting and of an extremely simple construction.

A polyphase motor consists essentially of a rotary and a fixed element, each provided with suitable windings. The windings of one of the elements are supplied with polyphase currents, which consist of two or more separate alternating currents having the same frequencies, but whose phases differ from each other. These currents set up a magnetic field in the element, which field is rotated, or progressively shifted around the element, by the combined action of the different currents. The rotating field attracts the field produced by currents in the windings of the other element and thus causes the movable element of the motor to rotate. This principle, upon which a polyphase motor operates, is analagous to that of a continuous current motor, for the commutator of a continuous current motor produces a rotation, or progressive shifting, of the magnetic field of its armature. The attraction between the rotary field of the armature and the stationary field of the field magnets, causes the armature to rotate.

In this paper, in order to avoid the confusion at present existing as to which element of a polyphase motor is the armature and which is the field, the element in which the rotary magnetic field is produced is called the armature, and the other element is called the field.

To illustrate the working of polyphase motors, we will take as an example a two-phase motor with a stationary armature provided with two sets of windings. The two windings are supplied with separate alternating currents and produce two pairs of poles at right angles to each other. The two alternating currents have the same frequencies, but one of them lags behind the other by 90 degrees, and, therefore, the magnetic field of one pair of poles is at its maximum strength when the field of the other pair is zero, or is neutral. If at any instant, a particular pole of the four poles be a north pole, one of the poles at right angles thereto will subsequently become, at the next instant, a north pole. Then, the opposite pole to that first named will be a north pole, and, at succeeding alternations of the exciting currents, the north pole and necessarily the south pole as well, will be rotated, or progressively shifted, around the armature in a certain direction. In this way a rotary magnetic field is produced in the armature.

Instead of an armature of this type, the armature may be an ordinary Gramme ring armature, but without a commutator, and the two currents may be supplied the windings at points 90 degrees apart (points 180 degrees apart being connected with the same circuit). The combined action of the two currents will set up a rotating magnetic field in the armature, similar to that produced in the armature of a continuous current motor when running.

If a pivoted copper cylinder be placed inside an armature of either of the above types in which there is a rotating magnetic field, the rotation of the field will induce currents in the cylinder, which, according to Lenz's law, will be in such a direction as to oppose the movement of the field. This opposition to the rotation of the field will cause the cylinder to rotate. As a copper cylinder would be unsuitable for use as the field of a motor, this element is usually composed of a cylinder of laminated iron mounted on a shaft. The cylinder is provided with copper windings parallel to its axis, which are connected together in a number of closed circuits. The rotary field induces currents in these closed circuits which oppose the rotation of the field, and these currents thus cause the motor to rotate.

The currents induced in the closed circuits are proportional to the number of lines of force of the rotary magnetic field, which cut them in a given time. The number of lines cut is greatest when the motor is at rest, and becomes less as the speed of the motor increases, until synchronous speed is reached, when no lines cut the closed circuits For example, if the exciting currents have a frequency of 60 periods a second, when the rotary element of the motor is stationary the closed circuits are cut 60 times by a north field and 60 times by a south field each second. When the rotary element has a speed of 40 revolutions a second, the closed circuits are cut 20 times by a north field and 20 times by a south field each second. The number of lines cut thus varies directly as the difference between the speed of the rotary element of the motor and that of the rotary magnetic field, and, when there is no difference in speed, no lines are cut and no currents are induced in the closed circuits. With no currents in the closed circuits, there is no magnetic field to act upon the rotary magnetic field. The motor, therefore, runs at a speed which is less than that of the rotary magnetic field, the difference between the two speeds being called the magnetic slip. The closed circuits have a very small resistance, so that strong currents are induced in them by the cutting of a comparatively small number of lines of force, and the magnetic slip is therefore small Anyone can easily satisfy himself that the currents induced when the magnetic slip is small, will produce a strong torque by exciting the field of a continuous current dynamo or motor and short-circuiting the brushes. On turning the armature by hand, the torque will be found to be considerable.

In practice, the variation in speed of a motor of this type between no load and full load is generally from 3% to 5% From the foregoing explanations it is evident that, if the field of the motor be excited by a continuous current, it will rotate synchronously with the rotary field Synchronous polyphase motors are constructed on this principle and keep in step with the alternations of the exciting alternating currents even if heavily overloaded. They are self-starting, but do not start readily, and for this reason are not capable of such extensive use as the non-synchronous motors, though they have been found to be preferable for large units. We will therefore confine our attention to the non-synchronous motors.

When a non-synchronous motor is running at full speed, the alternations of magnetism in the field are few, as already explained, and the hysteresis losses in the iron are correspondingly small, but in the armature the alternations of magnetism and the hysteresis losses remain the same as when the motor is stationary. As the rotary element of the motor contains considerably less iron than the stationary element, the hysteresis losses are decreased and the efficiency of the motor increased, by having a rotary armature and a stationary field, so that the most frequent changes of magnetism will take place in the element which has the least iron. But in small motors, and also in large motors where a slight decrease in the efficiency is not of importance, the armature is preferably stationary and the field is rotary, as this arrangement dispenses with collectors and brushes.

The field of a non-synchronous polyphase motor is usually the rotary element of the motor, for then brushes and collectors are not required, as already explained. The field then consists of a laminated iron cylinder mounted on a shaft. A number of stout copper wires or bars are threaded through holes near the periphery of the cylinder and parallel to its axis, or are embedded in slots in the cylinder. By this construction the air gap between the iron of the field and that of the other element of the motor can be made very small, which is essential to efficiency, for, if the magnetic resistance of the air gap be not comparatively low, a large magnetizing current will be required by the motor. The bars or wires are carefully insulated from the cylinder and are connected together at each end to a copper ring, which joins them together in a common closed circuit, or they are connected together in a number of independent closed circuits. When the field is stationary it usually consists of a cylinder or ring of laminated iron in the centre of which is the rotating armature. The windings of the field are arranged and connected together in the same way as when it is rotary, with the exception that the windings are on the inner periphery of the cylinder or ring.

The armature of a polyphase motor is preferably a ring or cylinder of laminated iron somewhat similar to the field core. For, as is apparent from the manner in which the magnetic field rotates around the armature, a ring of iron without projecting pole pieces facilitates the rotation of the field and also avoids injurious reactions caused by the projecting pole pieces One of the simplest forms of this type of armature is the Gramme ring armature already referred to, which has no commutator and whose windings are supplied with two-phase currents at points 90 degrees apart, points 180 degrees apart being supplied with the same current. The combined action of the two currents sets up a single rotary magnetic field in the armature The same result is obtained with three-phase currents by supplying the currents to the armature windings at points 120 degrees apart. The drum winding is, however, generally used instead of the gramme winding, and in this case the windings are connected together by conductors arranged around the ring near its periphery. The windings of this type of armature are imbedded in the iron core in the same way as those of the field, and for the same reason, viz to reduce the magnetic resistance of the air gap. A ring armature of this type can serve as either the stationary or rotary element of the motor. When it serves as the rotary element, the currents are supplied by collectors and brushes.

The armature windings are arranged to produce a greater or less number of poles, according to the speed at which the motor is desired to run The speed varies directly as the frequency of the exciting currents and inversely as the number of pairs of poles in the armature. For example, if a motor having two pairs of poles, be supplied with four pairs, the rotary magnetic field will then take twice as long as at first to make one revolution, and the speed of the motor will be reduced correspondingly, as it is governed by that of the rotary field. The same result can be accomplished without diminishing the number of poles, by reducing the frequency of the exciting current one-half, which reduces the speed of the rotary field so that it takes twice as long as at first to make one revolution A motor, therefore, must be adapted to the frequency of the current on which it is to be used and, in order to have a slow-speed motor without many poles, the frequency must be low. When the speed desired in the motor requires many poles in its field and armature, a stationary armature without projecting poles (similar to the field magnet of a continuous current multipolar dynamo) is generally used instead of the ring type of armature, as it is difficult to get many poles in an armature of the latter type.

The foregoing explanations show that polyphase motors are of an extremely simple construction, consisting only of a rotary and a stationary element of laminated iron with suitable windings, and usually without sliding contacts or brushes. They possess a number of good qualities, among which the most important is probably the absence of a commutator which must be used with continuous current motors and which requires much attention and is the source of much trouble The absence of a commutator practically limits the care and attention required by a polyphase motor to oiling the bearings.

The simplicity of construction ensures freedom from repairs as well as facilitates the insulation of the various windings. The closed circuit windings on the field are never subject to an electromotive force of more than a few volts, so that the insulation is not likely to break down The motors will stand a considerable overload without undue heating, and will also stand considerable abuse without damage. Regarding this point, Dr. Louis Bell, in a recent paper before the American Institute of Electrical Engineers, stated that he had never been able to burn out an armature coil or to seriously injure a polyphase motor by the severest tests.

The non synchronous motors start with a strong torque and run almost at a constant speed under large variations of load, and compare favorably in these respects with continuous current motors. Tests of polyphase motors of different various sizes show that their efficiencies are equal to those of continuous current motors of the same sizes.

It is no wonder that the two-phase and three-phase systems for the transmission and distribution of electrical energy are attracting so much attention when the good qualities of the motors are taken into consideration in conjunction with the fact that by these systems alternating currents can be furnished for light and power, and in addition continuous currents can be supplied by means of rotary transformers. The polyphase system is thus capable of universal application, as from it can be operated any kind of electrical apparatus for either alternating or continuous current and at any voltage.

THE POSSIBILITY OF SECURING BETTER REGULATION AT CENTRAL LIGHT AND POWER STATIONS BY MEANS OF FLY WHEEL ACCUMULATORS OF IMPROVED CONSTRUCTION.

By John Galt, C. E. and M. E.

The object of this paper is to indicate a simple means whereby considerable energy may be efficiently stored and restored to advantage for central power station purposes.

This at once suggests that a suitable accumulator capable of operating also as a regulator must be introduced.

Energy, as you all know, is only another expression for accumulated work, which may be done either by raising the body a given height, or impressing upon it a given velocity, the first example being the simplest idea of what is meant by the elementary measure of work.

When force acts upon a free body it will of course set it in motion, notwithstanding its inertia, which presents a resistance to be overcome Thus work is also done in impressing upon a body velocity either linear or circular, one of transition or rotation

The inertia due to mass is ever present, therefore work can be accumulated or stored up in a rotating wheel as surely as it can be in the ram of a pile driver, the bullet or ball from a gun, or the ponderous head of a steam hammer

A heavy rotating body as a fly wheel of an engine is simply a reservoir into which the work of the engine can be poured just as water into a reservoir, or some mechanically constructed accumulator, there to be restored when occasion demands

The following equation gives the estimate of work stored up in a body when moving or rotating with a given velocity.

When a velocity V is impressed on a body of weight W, the work done or stored up

$$= \frac{WV^2}{2g}$$

From this expression we can conclude that the work stored up in the separate parts of a body moving with any given velocity depends upon the square of the distance of each part from the revolving centre of axis of rotation

For example, one pound or one ton weight 3 feet from the axis of rotation has nine times as much work stored up as the same weight at a distance of 1 foot, provided the angular velocity is the same in both cases

There are very many examples in the arts of accumulating work by simple mechanical means, similar in principle to the one which I now propose for consideration.

The flywheel press which is used for cutting and punching material or stamping coin consists merely in the application of a revolving lever or wheel weighted at the ends, or the heavy revolving flywheel in a shearing or punching machine has the same principle applied for accumulating energy to assist in carrying the prime mover over its hardest work

Take the case of the tiny sewing machine, whether driven by hand or foot When the wheel is turned rapidly it runs steadily and uniformly, notwithstanding that the driving force is variable, this exhibits largely the function of a flywheel for ordinary purposes.

From what I have already stated a good deal may easily be learned about the nature of a flywheel.

Suppose two wheels exactly alike attached to each other on the same shaft, so as to make practically one wheel of double the weight, then the work stored up for any given speed per minute is doubled, thus showing the influence of weight alone.

Let, however, the speed be doubled by increasing the number of revolutions in a given time, or by increasing the diameter of wheel, then the work stored up is four times as great.

This latter case emphasizes the great importance of velocity.

Reverting to the original formula representing the energy stored in flywheel, viz $E = \frac{WV^2}{2g}$ then by differentiating $\Delta E = \frac{WV}{g} \Delta V$ or $\frac{g}{WV^2} \Delta E = \frac{\Delta V}{V}$ which is the fluctuation of velocity, and it is the function of the flywheel to keep this down within small limits This fluctuation may arise either from variations in the effort exerted by the prime mover or from variations in the load or resistance, or it may arise from both these causes combined.

When one flywheel is used it should be placed in as direct connection as possible with that part of the mechanism where the greatest amount of fluctuation originates, but when it originates at two or more points it is best to have a flywheel connected to each.

We can readily see from the original formula that a flywheel running with a considerable rim velocity can store a very considerable amount of energy

Take for example a wheel having a rim velocity of 75 feet per second, and weighing, say 20 tons:

$$\text{Energy of rim} = \frac{20 \times 75^2}{2g} = 1747 \text{ foot tons}$$

$$\text{Expressed in horse power minutes} = \frac{1747 \times 2240}{33,000} = 118.6 \text{ P.}$$

$$\text{Or direct from original equation} = \frac{WV^2}{948.8} = 118.6 \text{ P minutes}$$

This represents the ordinary safe speed of the present best design of cast iron flywheels Now if improved flywheel construction will secure an increase of speed say to 150 or 300 feet per second, the energy stored would of course be four times and sixteen times greater, viz, 500 to 2,000 horse-power minutes respectively, as against, say 120 horse, with a similar proportionate increase of energy available and ready to be restored for regulating purposes.

Column 2 of table I shows the total amount of energy stored for different rim velocities for each ton weight of rim

The energy is expressed as horse-power minutes instead of foot tons or foot pounds—in other words, if the energy of the flywheel were all used up in one minute the horse power given out would be the number there stated

Flywheels of the ordinary type in use occasionally fly to pieces without giving the slightest warning, making an utter wreck of the station, besides being very often accompanied by loss of life.

Of late years these accidents have become very numerous, and the reason is simply this, that prime movers and flywheels are called upon now to perform much harder duty than formerly, and any one who has studied the present requirements, especially for central power station work, must be more than convinced that some improvement in the line I am pointing out would be of immense advantage Little or no improvement in the design and construction of flywheels has taken place since the introduction of the steam engine, and this is all the more remarkable when we consider the many improvements which have taken place in almost every other direction and detail of mechanical science.

The consensus of opinion of both mechanical and electrical engineers and experts everywhere may be summed up in the statement by Dr. Edward Hopkinson, of London, England, in his late paper on Electrical Railways, viz:

"If an efficient accumulator, capable of working as a regulator, could be introduced, it would be possible to reduce the capacity of a generating plant by at least 35 to 40 per cent, and at the same time considerably increase its efficiency. Such an accumulater I venture to suggest is to be found in better wheel construction. With any electric railway on which there are a number of cars it always happens that at frequent close intervals of time the load is very much beyond the average power required"

The generating plant at the central station must of course be of sufficient capacity to meet the largest demand which may be made on it. Consequently without some source of accumulated energy to fall back upon, the prime movers must be made larger in order to handle with certainty the maximum loads.

Both in Europe and America the subject of improved flywheel construction is now beginning to receive the attention its importance deserves

The central station of the Union Railroad Company, from which are run all the trolley lines of Providence, R I, has lately installed cross-compound engines, with direct connected generators on engine shaft, having specially designed flywheels, the main object being the prevention of accidents, which have recently been of frequent occurrence.

Mr Sheldon the engineer, believed that he could make a wheel which would be absolutely indestructible, and prevailed upon the directors to insure themselves against the flywheel epidemic, by building it entirely of wrought iron and steel, with a large margin of safety—no attempt or claim, however, being made to secure better accumulation of energy, and consequent steadier regulation.

Its design and construction will be apparent from the drawings reproduced and illustrated in Fig 1.

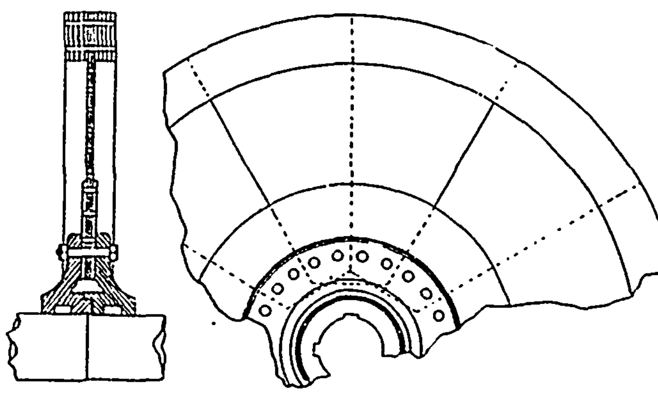


FIG. 1.

The steel rim is attached to a plain steel disc, which takes the place of arms or spokes, the whole being connected to shaft as shown by means of cast iron hub or nave.

This wheel, which must have cost a very great deal of money, has not been built to act in any better capacity as a regulator than the ordinary cast iron flywheel, and it surprises me that it was not designed and proportioned to operate also as a powerful wheel by merely increasing its rim velocity, even at the expense of a reduced factor of safety, which at 40 is altogether too high for requirements of safety alone, especially when wrought iron and steel is used, and not cast iron, which at the best is a most uncertain metal.

That there is a want for a powerful but light flywheel will be generally admitted

Some advocate heavy flywheels because of their power, others again condemn them because of their weight.

A powerful flywheel of ordinary design, meaning a heavy flywheel, has placed engineers between the devil and the deep sea.

Now a powerful and light flywheel deriving its power from its high speed should satisfy both sides

In prosecuting my enquiries I find that already a very good practical solution of this problem has been suggested.

Prof Sharp, B. Sc., Wh Sc., etc., a distinguished mathematician and engineer, of London, England, has taken up this subject, and actually invented and patented within the last month or so a new method of wheel construction, which appears to exactly fill the bill. This improvement covers the entire ground, and

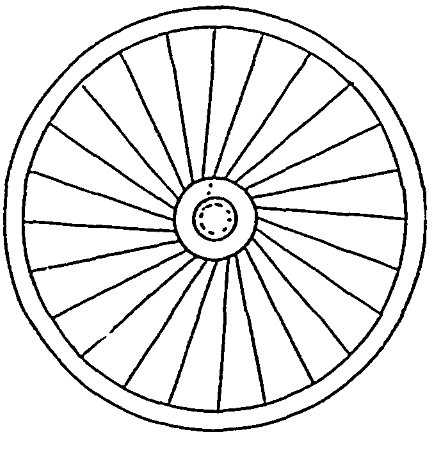


FIG. 2.

strange to say, is applicable to all kinds of wheels from the perambulator and bicycle wheel up to the pulley for power transmission, as well as large flywheels.

Having made this discovery, I at once entered into correspondence with Prof. Sharp, and have his letter of last month (August), stating that he is now arranging to have his new design introduced in some important contracts.

I am much indebted to him for his pamphlet giving a pretty accurate and full description of this new system of wheel construction, together with rules and formula on the "*Theory of the New Flywheel.*"

The principle of this new construction proposed is based upon the use of steel spokes instead of arms or disc, these spokes being tangent and attached respectively to the rim and nave.

This feature of tangent spokes, now so well and favorably known in bicycle wheel construction, is, it seems to me, one which can be advantageously applied and extended generally to all kinds of wheels, and it is in this direction where mechanical accumulators may be looked for. When any wheel built with radial arms or spokes is at rest, their direction passes through the centre of the hub, but when a driving effort is exerted, the direction at once changes, and instead of passing through the centre of the hub, passes along tangent to a small circle as illustrated in Fig 2.

This action causes continual bending to and fro of the spoke at the point where it leaves the hub and the stresses induced by bending are much greater than those due to the direct tension of the spokes. In fact a wheel with radial spokes is not a rigid structure, for before it can be driven the hub has to be moved through a small circle relative to the rim. If the direction of driving is reversed, the hub must first return to its original relative position and then be displaced an equal amount on the opposite direction before driving can take place. To obviate this injurious action, tangent spokes have been introduced of late into bicycle and other classes of wheel construction, and there is no good reason why this design should not be adopted for wheel construction generally and especially for pulleys and flywheels. These tangent wheels are built with the spokes such that they all permanently touch a certain fixed driving circle Half of the spokes are inclined in one direction and half in the opposite.

In a wheel constructed with spokes tangent to the driving circle, when the driving effort is exerted, the tension of one half of the spokes is increased and that of the other half diminished

Theoretically, then, a tangent wheel is much better than a direct or radial spoke wheel, since it approaches more nearly to a rigid structure, as the angle of displacement of the hub relative to the rim being very small and due entirely to the stretch of the spokes caused by tension due to driving effort.

A heavy flywheel which is too large to be cast in one, or two half pieces, is usually built up, the rim being cast in segments and the arms also of cast iron carefully fitted at one end to the nave and at the other to the segments of the rim, or in some cases the arms are cast on as part of the rim segments and only require attaching and fitting to the nave.

The cost of constructing a large flywheel in this way is very great.

Fig. 3 is a section of the rim with spokes attached for a flywheel pulley to be built in segments on the new system.

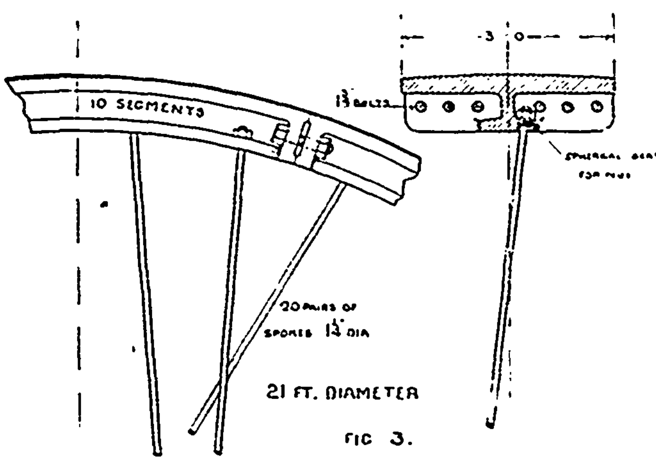


FIG 3.

With ordinary cast iron wheels the speed must not exceed a certain limit, as the centrifugal force due to the rotation produces forces on the rim acting radially outward. these are balanced partly by the tension on the arms and partly by circumferential tension on the rim. these combined forces produce bending on the rim similar to a beam uniformly loaded and fixed at supports, as shown in Fig. 4

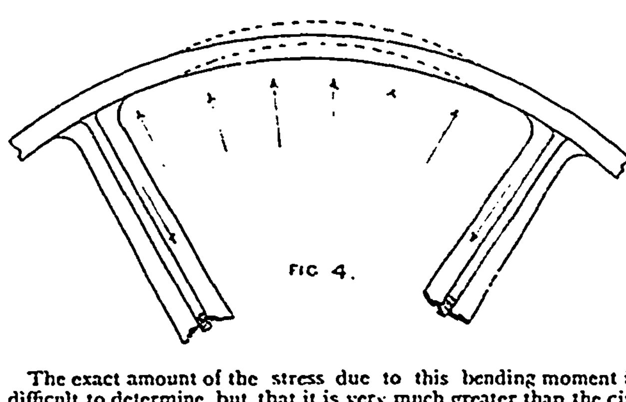


FIG 4.

The exact amount of the stress due to this bending moment is difficult to determine, but that it is very much greater than the circumferential tension on the rim is proved by the fact that a linear speed of rim of 100 feet per second (which is the highest speed allowable for a large flywheel), the circumferential tension on the rim is only ⅓ ton per square inch, whereas the breaking tensile strength of cast iron is from 10 to 12 tons Thus the stresses on the rim due to bending caused by the pull of the arms at a few points only, must certainly be very great

In flywheels with numerous steel spokes, Figs. 3 and 8, there is no very great length of rim unsupported, consequently this bending action is almost entirely eliminated, and therefore a much higher speed can be used with safety

In wheels with radial arms the arms or spokes which are straight when the wheel is at rest will each be bent as shown exaggerated at *a b* (Fig 5), when the effort is being transmitted from the nave to the rim in the direction indicated by the arrow If the direction of driving be reversed, or if the driving effort be lessened, and the rim overruns the nave the arms will be bent as shown by dotted line at *a b*.

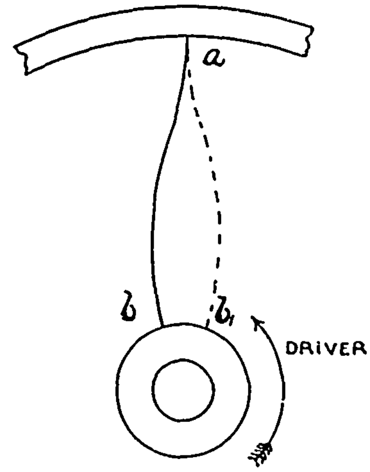


FIG. 5.

It will be seen therefore that radial spokes constitute a slightly flexible coupling between the rim and nave of the wheel, so that the rim may be moving with practically uniform velocity while the fluctuation of velocity of the nave may be considerable, whereas the action of the tangent spokes, being a rigid structure, is entirely different

In continuing the consideration of this subject further, I will refer almost entirely to Prof Sharp's system of wheel construction, because I find he has provided for the difficulty of attaching spokes to nave by a simple and efficient method of winding spokes in pairs around the nave in helical friction grooves

The distinctive features of Prof Sharp's new system of wheel construction are illustrated in Figs 6 and 7

The nave or hub of the wheel is attached to the rim by a series of loops of iron or steel, one loop forming a pair of spokes

Fig. 6 illustrates the elevation of a wheel with 24 spokes in 12 pairs One loop or pair of spokes is shown thickened.

The ends of spokes are fastened to the rim by means of nuts or nipples in any usual way

There is absolutely no fastening of the spokes to the nave beyond that due to friction

The ends of all spokes may lie in one plane, but as the spokes approach the nave they are spread out latterly in a similar manner to that usually seen in bicycle wheel

Fig. 7 is a section through the nave and rim and shows the lateral spread of the spokes. the nave surface may have a single or multiple screw according to the requirements

The pair of spokes *a, a*, Fig 8, is shown having an arc of contact with the nave of nearly half a turn, the part of the loop *a, a*, in contact with the nave, is formed spirally so that all ends of the spokes on one side of the middle plane begin contact with the nave at the same distance from the middle, and the other ends leave the nave nearer the centre or middle plane, Fig 7.

In the wheel illustrated in Figs 6 and 7 there are twelve pair of spokes, six pair being on each side of the centre or middle plane, so if the parts in contact with the nave lie in grooves, these grooves will form practically a six-threaded screw on the nave surface

The arc of contact of each pair of spokes with nave may of course be varied. Thus keeping the end *a* fixed in the position shown in Fig. 6, the end *a'* could be taken to the place occupied by *a* •

By making the spokes have a spiral arc of contact with the nave as described above, the positions of all the spokes relative to the nave are exactly similar, and thus the wheel is symmetrical, and the spokes are all of exactly the same length

This would not be the case if the arcs of contact were circles whose planes were perpendicular to the axis of the wheel, as the middle points of each of the pairs of spokes would then all lie at different distances from the middle plane of the wheel

The nuts or nipples fastening the spoke ends to the rim being screwed up until the necessary tension is on the spokes, there is ample friction between the spokes and the nave to prevent any relative movement, while the angle at which the spokes leave the rim remains always the same, consequently there is no injurious wrenching action on the rim joints

The rim joints can therefore give no trouble, however severe the work to be done by the wheel

In Sharp's wheels the action of the spokes is illustrated in Fig 10, and shows the relation of the pair of spokes to the nave and rim. When transmitting effort from the nave to the rim, in the direction indicated by the arrow, the pull F_a on the portion *c b* of the pair of spokes is a little greater than the initial pull, while the pull F_d on the portion *d e* is a little less than the initial pull. The difference between F_a and F_d is taken up by the frictional grip of the portion *b c* on the nave The difference $(F^a - F^d)$ multiplied by *r*, the radius of the hub, gives the twisting moment transmitted per pair of spokes Or the forces F_a and F_d, acting at *a* and *d* respectively, may be resolved into radial and tangential components T_a, R_a, and T_d, R_d respectively The radial components R_a and R_d have no effect in accelerating or retarding the motion of the rim.

so the resultant force accelerating the rim is (T_a — T_d) per pair of spokes

Now, in a flywheel suppose the effort at any instant to fall below the average resistance, as would be the case near the beginning and end of each stroke of the engine, the pull F_d on the portion *d c* would become greater than the pull F_a on portion *a b*, and the rim of the flywheel would supply to the nave the momentary deficiency of effort The only effect of this slight variation of stresses on the portions *a b* and *d c* of the spokes is that they are slightly elongated, the elongation being so small that the whole wheel—rim, spokes, and nave—constitutes a practically rigid structure Thus for a variation of stress of 1 ton per square inch, taking E. Young's

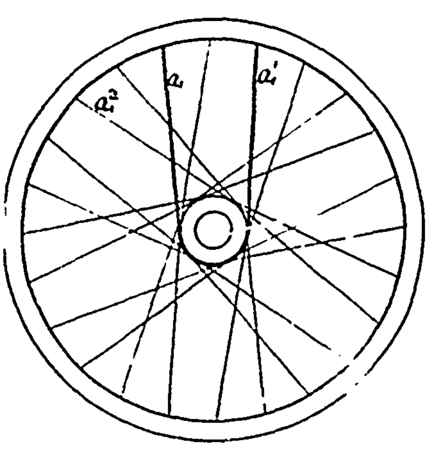


FIG 6.

FIG. 7.

modulus, 10,000 tons per square inch, the spokes will stretch periodically $\frac{1}{10000}$th part of their length In a wheel 20 ft. diameter this periodic stretch of the spokes will be

$$\frac{10 \times 12}{10000} = .012 \text{ in}$$

As regards the staunchness of the joints between the rim and spokes, the case is infinitely better than in the radial spoke wheel Whatever be the stretch of the spokes, they must always touch the nave circle of radius *r* Thus the angle at *a* or *d* at which the spokes leave the rim remains always the same, and there is consequently no wrenching action on the rim joints.

Fig 8 shows description of a high speed flywheel according to the new method of construction, Fig 9 showing enlarged section of rim

An exactly similar method of construction can be applied to flywheel pulleys where too large to be cast in one piece, as illustrated in Fig 3, the spokes and nave can be designed in a similar way to fig 8 with 10-threaded screws

This cast iron pulley (see Fig 3) is 21 ft in dia. and has 1½ in spokes The rim is in segments of cast iron and weighs in all 16 tons, nave 1 ton, and spokes 7 tons, these proportions of course will vary according to the requirements of design for different speeds

In order to illustrate more pointedly and fully the applications of these new designs let me take first the example of a gas engine working with the Otto cycle, the excess energy of which is very

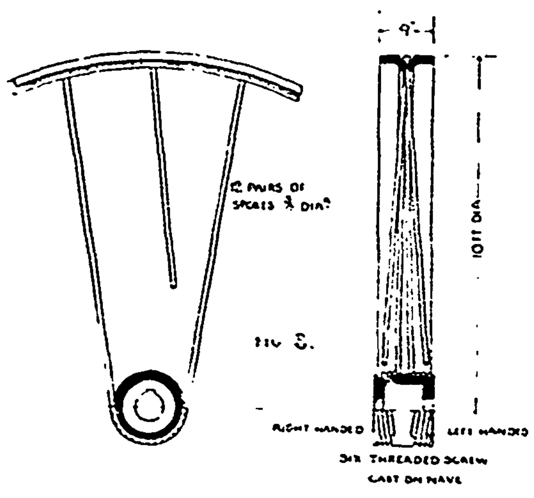


FIG. 8.

large, and to run steadily they must have very powerful flywheels

For electric lighting purposes a gas engine is sometimes employed to drive a dynamo direct

As an example, suppose a dynamo to make 240 revolutions per minute or 4 revolutions per second with a flywheel cast in one piece, taking the safe rim velocity to be 80 ft per second, its diameter would be 6.3 feet

With a wheel built on the new system, the weight of rim being the same as before, if the diameter were increased to 19 ft, the velocity would be trebled, and the fluctuation of velocity would be reduced to one-ninth part of its original value.

The governing of gas engines is obtained almost altogether by cutting out explosions So that with say half load (a necessity which exists often in central lighting stations), an explosion would only take place every three or four revolutions, causing great irregularity of running, unless specially provided against

What was wanted, therefore, was a gas engine that would give about as good and regular turning movement as the double-acting steam engine, and which might in most cases be easily coupled direct to the dynamo

By introducing a powerful fly wheel, say of increased weight and speed, a very steady effect could be secured, and if gas engines had always been provided with such flywheel accumulators, there would have been little trouble with belts and unsteadiness of currents from dynamos.

Column 2 of table I shows the amount of energy stored for different velocities for each ton weight of rim.

Table I has been carefully calculated and will be found most useful for designing fly wheel accumulators to satisfy given conditions

The available energy per ton weight of rim for a total fluctuation of 10%, will be found in column 3. If, however, still closer regulation is desired for special cases, then to provide for a total fluctuation of only 5%, *i.e.*, 2½ per cent. above and 2½%, below the average, then column 3 divided by 2 will give the horse-power minutes of energy available, and of course column 4 would require to be just doubled, the remaining columns, however, would remain unaltered.

By way of illustration, let me take another example where the extra power required at the generating station, corresponding with the starting of cars or running on up grades, etc., would be about 50 to 60 horse-power minutes.

From column 3 it will be seen that if a flywheel accumulator be built to run at a speed of 300 feet per second, with a weight of 3 tons in the rim, and with an allowance for a maximum fluctuation of velocity of 5%, above and 5%, below the average, this will supply the 60 horse power required.

Thus the engine and boiler plant may be of capacity corresponding to the average power required, provided this flywheel accumulator be used.

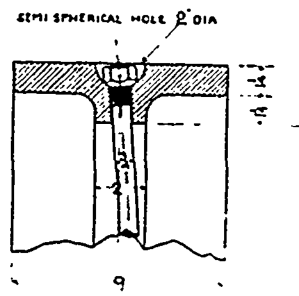


FIG 9.

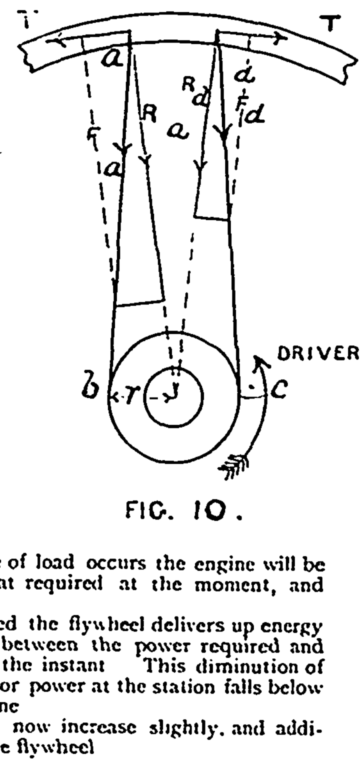


FIG. 10.

Thus when a sudden increase of load occurs the engine will be developing less power than that required at the moment, and the speed will diminish.

During this diminution of speed the flywheel delivers up energy corresponding to the difference between the power required and that developed by the engine at the instant This diminution of speed goes on until the demand for power at the station falls below that being developed by the engine

The speed of the engine will now increase slightly, and additional energy will be stored in the flywheel

Besides reducing the size of the engines and boilers at the station, such an arrangement will allow the engines to work steadily at or near their best maximum capacity, which is most important and advantageous where economy of steam consumption is concerned

The mechanism of the engine is subjected to far less stress since there is no violent fluctuations of speed, and the governor gear may in many cases be reduced to the simplest type, thus permitting often considerable increase in the number of revolutions per minute of engine, which would assist somewhat in securing the necessary higher rim velocity of flywheel.

In many cases a flywheel might also be attached direct to the dynamo shaft, with some suitable friction interposed between it and dynamo, so that in case of short circuiting the armature of the dynamo might be pulled up while the flywheel continues to revolve, thus merely corresponding to the breaking of the belt in the case of a belt-driven dynamo

Taking a speed for a dynamo shaft to be 600 revolutions per minute, a wheel 11½ feet in diameter would give the necessary rim velocity of 300 feet per second, and for the requirements of last example give the necessary 60 horse-power minutes of available energy

From an examination of load curves from several power stations taken from meter readings, the period of time from average to maximum load seldom exceeds one minute, and in average-sized and well-developed railway systems this period is very much reduced, and falls within 15 seconds

The load curve for example from the Toronto Street Railway power station showed at one time a fairly uniform load line of 2,000 average horse power, the readings being taken, I think, every 15 minutes, and even then the ordinary average was tabulated after all the violent and momentary fluctuations on ampere meters had ceased

Had the load curves been drawn out to readings of 15 seconds instead of 15 minutes, the variations would have been clearly marked, as it was, however, I found that within periods of half minutes, more or less, the extra power required varied from 20 to 30 per cent above the average, viz., from 2,000 to, say, 2,500 horse power. And it would be further apparent to any observant mechanic that the entire machinery in the station from the revolving armature in the generators, down through the mechanism of the engine and its governing gear to the very steam inlet valves of cylinders, and along through steam pipes to the water in boilers, had to accommodate themselves directly to this sudden demand upon them, simply because there was no form of accumulated energy attached to the driving machinery to fall back upon in order to carry it over the momentary maximum load resistance.

The engines in this station are five in number, each of say 500 horse power, of the Armington & Sims design, cross compound with double cast-iron flywheel pulleys, each 8 feet in diameter, and revolving at about 275 revolutions per minute, belted direct to generators for a much higher speed.

For the purpose of comparison it will be sufficiently near the truth to assume that both flywheel pulleys have rims both weighing together about 4 tons, running at 100 feet per second. This, according to table, will give 40 horse-power minutes, and with a total variation of $2\frac{1}{2}$ per cent. above and below the average speed, the total available enery will be 4 horse-power minutes, or a total available energy for road regulating purposes over the entire 5 engines in station of 20 horse power.

This amount is of course entirely inadequate for anything beyond the mere work and the functions of an ordinary flywheel.

You will now appreciate the value and importance of having accumulators, designed for storing and restoring from 20 to 30 per cent. extra power beyond the average requirements, and you can also understand that there is no difficulty or trick about having flywheel accumulators attached to properly handle such conditions, especially as additional wheel accumulators could be applied to the generator shafts as well as to the engine shafts if necessary.

This plant, by way of comparison, as it stands, therefore, should be good for an average of about 2,500 horse power, but if designed with proper flywheel accumulators it could handle with ease an average of 3,000 horse.

Now, coming to the case where generators are connected direct to engine shaft, the problem is much easier and cheaply solved when the speed runs from 300 up to 600 revolutions per minute, but when the rotative speed is down as low as 100 revolutions per minute, the problem of attaching efficient and suitable flywheel accumulators becomes much more difficult and costly.

What I have said already will fully explain and provide for the case of direct connected high rotative-speed generators, but by way of variation let us consider the case of slow-speed generators, for example, the large horizontal cross compound Corliss engines of 1,200 horse power being built for the Toronto Railway Company, to the engine shaft of which the generators are attached.

Each of these engines is provided with a specially built-up flywheel, 20 feet in diameter, and having an effective rim weight of say 30 English tons, now running at 90 revolutions per minute, or 1.50 per second, the rim velocity will be 90 feet per second.

The total energy stored in flywheel

$$= \frac{WV^2}{948.8} = 250 \text{ horse-power minutes.}$$

Giving 25 horse-power available energy, corresponding to

$$\frac{\Delta V}{V} = \frac{1}{20} \text{ for regulating.}$$

Here also it is at once apparent how helpless this flywheel is to permit of a sudden variation of load without calling upon the entire mechanism and governing gear of engine to act and react, so as to control the proper distribution of steam.

In other words, as there is no great accumulated energy the engine indicator cards will vary very much in the same degree as the load resistance.

Although the weight of revolving armature, etc., will add to the energy stored, the engine will still be subject to the varying stresses due to the continually changing load.

Now suppose one or two flywheels of the same weight were built to run at double this velocity, or better, say 200 feet per second, the total available energy for the above fluctuation would be increased to 250 horse power, or fully 20 per cent. beyond the average power of engine, viz., 1,200 to 1,450 horse power.

In other words, the engines as designed will average normally 1,200 horse, whereas with engines designed for 125 revolutions per minute, with two flywheel accumulators would give a working average of about 1,500 horse, with greater ease and much better results as to economy.

The following theory of the new flywheel by Prof. Sharp, with certain examples and cases worked out, will be found most useful and valuable for reference:

THEORY OF THE NEW FLYWHEEL.

Let W = total weight of rim in tons
W' = weight of spokes
V = average velocity of rim in feet per second
E = kinetic energy stored in rim in foot-tons
N = kinetic energy stored in rim H.P. minutes
N' = Available H.P. minutes corresponding to η
r = the radius of the rim in feet
f = tensile stress on the spokes, tons per square inch
a = angular velocity of wheel
ΔV = difference between maximum and minimum velocities
$\eta = \frac{\Delta V}{V}$ = fluctuation of velocity
s = weight of 1 ft length of spoke, 1 square inch section = 3.38 lb = .00151 tons
a = sectional area of a spoke, square inches
w' = weight of one spoke.

Energy of Rim.—

$$E = \frac{WV^2}{2g} \qquad (1)$$

Differentiate, then approximately $\Delta E = \frac{WV}{g} \Delta V$

$$\frac{WV^2}{g} \frac{\Delta V}{V} = \frac{\eta WV^2}{g} = 2\eta E \qquad (2)$$

$$N = \frac{2240E}{33000} = \frac{WV^2}{948.8} \qquad (1b)$$

$$N' = 2\eta N = .1358\, \eta E \qquad (2b)$$

Energy of Spokes, considered radial.—Consider a small piece of a spoke of length dx, and distant x feet from the centre of the shaft, its weight will be $s\,a\,dx$, its velocity $a\,x$, and therefore its kinetic energy stored in it is $\frac{s\,a\,a^2 x^2}{2g}\,dx$.

The kinetic energy stored in one spoke will be

$$\frac{s\,a\,a^2}{2g}\int_0^r x^2\,dx = \frac{s\,a\,a^2 r^3}{6g} = \frac{w_1 V^2}{6g} \qquad (3)$$

Thus the kinetic energy stored up in the spokes is one-third that due to their weight, if concentrated at the rim.

Centrifugal Tension in Spokes, due to weight of rim only.—Suppose that the centrifugal force of each element of the rim is transmitted to the spoke, so that when the flywheel is revolving there is no circumferential tension of the rim. Then the total tension on the spokes is—

$$\frac{WV^2}{g\,r} = \frac{2E}{r} \text{ tons} \qquad (4)$$

The total sectional area of the spokes will be

$$\frac{2E}{rf} \text{ square inches} \qquad (5)$$

The total weight of spokes is—

$$\frac{2sE}{f} = \frac{E}{331f} = \frac{WV^2}{21340f} = \frac{N}{22.47f} \qquad (6)$$

Thus from (6) it seems as if the centrifugal forces due to the weight of the rim be entirely taken up by the spokes, the necessary weight of the latter depends only on the kinetic energy to be stored in the rim, and on the working stress to which the spokes are subjected.

Centrifugal Tension in Spokes, due to their own weight only.—Suppose that the forces due to the weight of the rim are balanced by a circumferential tension in the rim, as in the case of a plain ring revolving about its geometrical centre. The tension in a spoke will then be due to its own weight. Consider a spoke of 1 square inch sectional area; an element of it distant x feet from the centre, and of length dx, will have the weight $s\,dx$, and the velocity $a\,x$. The tension in the spoke balancing the centrifugal force of this element is $\frac{s\,a^2 x}{g}\,dx$.

The total tension at the centre (considering the spokes radial) will be

$$\frac{s\,a^2}{g}\int_0^r x\,dx = \frac{s\,a^2 r^2}{2g} = \frac{sV^2}{2g} = \frac{V^2}{42800} \text{ tons per sq in} \qquad (7)$$

In the limiting case, when the stress due to centrifugal force of spoke is equal to f, the safe tensile resistance of the material, we have $V^2 = 42800f$. If the value of f must not exceed 10 tons per square inch, V must not exceed 654 ft per second.

Circumferential Tension in Rim due to its own weight.—If the centrifugal forces due to the weight of the rim are balanced by a circumferential tension in the rim, this tension is (see Unwin's "Machine Design")

$$\frac{sV^2}{g} \qquad (8)$$

Table I. has been calculated from the above equations, and is useful for designing a flywheel to satisfy given conditions.

Case in which the Centrifugal Forces due to Weight of Rim are Balanced partly by Circumferential Tension in Rim, and partly by Tension in the Spokes.—A numerical example will perhaps illustrate the treatment of this case most clearly.

Suppose the rim velocity to be 300 ft per second, the stresses in rim and spokes at this speed to be 3.5 and 5.10 tons per square inch respectively. (These two values of the rim and spoke stresses must be, of course, assumed, respectively, lower and higher than the values given in the table.)

The tension on the spokes due to their own weight is, from equation (7), or from the table 2.10 tons per square inch, leaving 3 tons per square inch tension on the spokes to resist centrifugal forces of the rim. Let W_1 be the weight of the part of the rim whose centrifugal forces are taken up by the spokes, then from equation (6) the weight of spokes is

$$\frac{W_1 \times 300^2}{21340 \times 3} = 1.406\, W_1$$

Let W_2 be the weight of the part of the rim whose centrifugal forces are resisted by the circumferential tension of the rim. If this tension existed only over the part W_2 of the rim, it would, from equation (8), or from the table, be equal to 4.20 tons per square inch. Being spread over the whole rim $W_1 + W_2$ of the intensity, 3.5 tons per square inch, we have

$$3.5\,(W_1 + W_2) = 4.2\,W_2$$

from which $W_2 = 5W_1$

Thus taking $W_1 = \frac{1}{2}$ ton, W_2 will be $2\frac{1}{2}$ tons, the total weight of rim will be 3 tons, and the weight of spokes ·703 tons.

The energy stored, from equations (1 *b*) and (3), is

$$\frac{3{\cdot}234 \times 300}{948{\cdot}8} = 306{\cdot}7 \text{ horse-power minutes}$$

Provided the initial tension on the spokes be correctly adjusted, the stresses on the rim and spokes would be 3·5 and 5·10 tons per

TABLE I.

Velocity of rim. V	Total energy stored per ton weight of rim. N	Available energy per ton weight of rim, $\eta = \frac{1}{5}$. N'	Weight of rim required for 100 H.P. minutes available energy, $\eta = \frac{1}{5}$	Ratio of weight of spokes to weigh of rim, $f = 5$ tons per sq. in.	C'ntrifugal stress in rim due to its own weight.	C'ntrifugal tension in spokes due to their own weight.
Ft. per sec.	H.P. mins.	H.P. mins.	Tons.		Tons per sq. in.	Tons per sq. in.
50	2·63	·527	189·7	·023	·117	·058
100	10·54	2·108	47·43	·094	·469	·234
150	23·71	4·742	21·08	·211	1·05	·525
200	42·15	8·43	11·86	·365	1·87	·935
250	65·87	13·17	7·59	·585	2·92	1·46
300	94·85	18·97	5·27	·843	4·20	2·10
350	128·9	25·82	3·87	1·15	5·73	2·84
400	168·6	33·73	2·96	1·50	7·48	3·74
450	213·0	42·69	2·34	1·89	9·47	4·73
500	263·5	52·70	1·897	2·34	11·68	5·84

square inch, while the wheel runs steadily with a rim velocity of 300 ft. per second. Taking the number of revolutions per minute 500, the diameter of the rim would be

$$\frac{300 \times 60}{500\pi} = 11{\cdot}5 \text{ ft.}$$

Circumference of rim 36 ft

Section of rim $\frac{3}{2174 \times 36}$ square feet,

2174 tons being the weight of a cubic foot of wrought iron – that is, the section of the rim would be 55·2 square inches.

The total sectional area of the spokes is

$$\frac{{\cdot}703 \times 144}{{\cdot}2174 \times 5{\cdot}75} = 91 \text{ square inches;}$$

say 48 pairs of spokes $1\frac{1}{16}$ in diameter

Initial Tension on the Spokes – Let A_s be the total sectional area of spokes (that is, equal to the sectional area of each spoke multiplied by twice the number of pairs of spokes), let A_r be sectional area of rim, f_s and f_r the tensile stresses on the spokes and rim respectively when the flywheel is running at its proper speed, F_s and F_r the corresponding stresses when the flywheel is at rest. Then, evidently,

$$A_s F_s = 2\pi A_r F_r \quad \ldots \ldots \quad (8)$$

the negative sign on the right-hand side of the equation indicating an initial compression on the rim corresponding to an initial tension on the spokes. When the flywheel is running, its radius will be slightly larger than when at rest. Let $x r$ be the increment of the radius, E_r and E_s the moduli of elasticity of the rim and spokes respectively. Then the additional tensile stress on the spokes, due to the increment of the radius, will be $x E_s$, and the additional tensile stress on the rim will be $x E_r$. Therefore

$$f_s = F_s + x E_s \quad \ldots \ldots \quad (9)$$

$$f_r = F_r + x E_r \quad \ldots \ldots \quad (10)$$

Eliminating x from (9) and (10) we have—

$$(f_s - F_s) E_r = (f_r - F_r) E_s$$

or, substituting for F_r its value from (8),

$$(f_s - F_s) E_r = \left(f_r + \frac{A_s F_s}{2\pi A_r}\right) E_s \quad \ldots \quad (11)$$

or, $$F_s (2\pi A_r E_r + A_s E_s) = 2\pi A_r (f_s E_r - f_r E_s).$$

If the maximum stresses on the spokes and rim f_s and f_r be given, equation (11) serves to determine the proper initial tension F_s to be put on the spokes.

In the example worked out above, $f_s = 5{\cdot}10$ tons per square inch, $f_r = 3{\cdot}5$, $A_s = 91$, $A_r = 55{\cdot}2$, and equation (11) becomes

$$F_s (2\pi \times 55{\cdot}2 + 91) = 2\pi \times 55{\cdot}2\,(5{\cdot}10 - 3{\cdot}5).$$

From which $F_s (346{\cdot}8 + 91) = 346{\cdot}8 \times 1{\cdot}6$

$$F_s = 1{\cdot}26 \text{ tons per square inch.}$$

The corresponding initial compression on the rim will be—

$$F_r = \frac{91 \times 1{\cdot}26}{2\pi \times 55{\cdot}2} = {\cdot}33 \text{ tons per square inch.}$$

Friction between Spokes and Nave – Let f be the tensile stress in tons per square inch on the spokes when the flywheel is running steadily.

During acceleration of the flywheel rim let the stress on one end of each pair of spokes rise to f_1 while that on the other end falls to f_2. Let θ arc of contact of spoke and hub, and μ the coefficient of friction. The horse power required to accelerate the rim is

$$\frac{2240}{550}(f_1 - f_2)\frac{A_s}{2} \cdot \frac{R\,V}{r} \quad \ldots \quad (12)$$

R being the radius of the hub. If the spokes are just on the point of slipping on the hub,

$$\frac{f_1}{f_2} = e^{\mu\theta} \quad \ldots \ldots \ldots \quad (13)$$

Assuming that $f_1 + f_2 = 2f \quad \ldots \ldots \quad (14)$

From (13) and (14),

$$f_2 = \frac{2f}{e^{\mu\theta} + 1}, \quad f_1 = \frac{e^{\mu\theta}}{e^{\mu\theta} + 1}\, 2f.$$

Substituting in (12)—

$$\text{H.P.} = 4{\cdot}07\, f \frac{A_s R \,.\, V}{r} \left(\frac{e^{\mu\theta} - 1}{e^{\mu\theta} + 1}\right) \quad (15)$$

an equation giving the maximum power that can be transmitted to the flywheel rim.

If the power transmitted at any moment be less than that indicated by equation (15), there will be no slipping of the spokes on the nave.

In the example worked out above (fig. 16,) taking μ for iron on iron (dry surface) 0.2, and an arc of contact of $1\frac{1}{2}$ right angles, $\theta = 2{\cdot}356$ and $e^{\mu\theta} = 2{\cdot}603$. Equation (15) becomes

$$\text{H.P.} = \frac{4{\cdot}07 \times 5{\cdot}10 \times 91 \times 5{\cdot}5 \times 300 \times {\cdot}603}{5{\cdot}75 \times 12 \times 2{\cdot}603} = 10440,$$

which shows that the chance of the spoke slipping round the nave during the ordinary working of the flywheel is very remote. Perhaps the greatest probability of the spokes slipping will be in the case of a bicycle driving wheel, but here again the practical experience of the last eighteen months shows that this possibility may be left out of consideration.

Bending Stresses on the Rim.—There will be a bending moment on each radial section of the rim. Considering the portion of rim between two adjacent spokes, neglecting the curvature, the distribution of bending moment is the same as in a beam loaded uniformly and fixed at the supports, so that the elastic line at the supports is horizontal.

Let b = width of rim, h = thickness of rim measured radially, and l the length of rim between the two adjacent spokes, all expressed in inches. Let P be the total pull on each spoke in tons, which will also be the load distributed on the rim between two adjacent spokes. If this portion of the rim were free at the ends, the bending moment on the section midway between the spokes would be $\frac{Pl}{8}$ inch-tons; but the ends being fixed, the bending moment on this section is $\frac{Pl}{24}$, while the bending moment on the sections at the spokes is $-\frac{Pl}{12}$. (See Cotterill's "Applied Mechanics." The maximum and minimum stresses due to the latter bending moment will each be $\pm\frac{Pl}{2bd^2}$.

In the example worked out above the spokes are $1\frac{1}{16}$ in diameter and are subjected to a tensile stress of 3 tons per square inch at the rim. P is therefore = 2·66 tons; l is = 9 in., b = 9 in., and d = 3 in. The greatest tensile stress due to bending is therefore

$$\frac{2{\cdot}66 \times 9}{2 \times 9 + 9} = {\cdot}148 \text{ tons per square inch,}$$

showing that the stresses in the rim due to bending are practically negligible.

In closing this paper I must apologize for its being unnecessarily long and so much repetition, but my object was to make this treatise on the subject as complete as possible, and above all to emphasize the necessity for, as well as the many advantages to be derived from, the adoption of improved flywheel construction.

The city council of Montreal are said to be considering the installation of an electric light plant alongside the new garbage incinerator, with the object of using the surplus steam from the incinerator to operate the plant. It is believed that in this way sufficient power can be had to light St. Gabriel ward and Point St. Charles, and thereby effect a saving of $5,000 per year.

THE ELECTRIC BRAKE IN PRACTICE.

By Elmer A. Sperry.

Examination of accounts of the electric street railway companies of our large cities reveals the fact that the item of damage, already very great, is one of growing importance. Investigation of the circumstances and detailed statements of numerous items taken at random from the damage account, points at once, and in no uncertain way, to the inefficiency of the present hand brake. In many instances, could the car or train have been stopped within a comparatively short distance, the accident and resultant damages would have been entirely averted. The first investigation led to others with the same result, and in consequence the writer is prepared to show that nearly 85 per cent of the accidents directly occurring, are due to the inefficient operation of brakes. The growing fre-

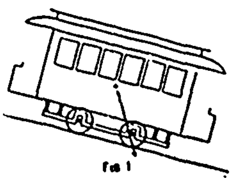


FIG. 1

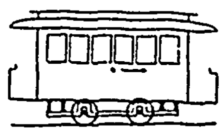


FIG. 2

quency of accidents and the constantly increasing demands of the public for damages, are indications that have not been made to impress the mind of the engineer, or I am sure adequate means would have been forthcoming for the correction of so grave a fault inherent in all the present systems of power-operated street cars. Some of our municipal authorities are taking action with reference to the increasing frequency and severity of accidents, and although no thorough scientific investigation of the matter has been published, yet it is a startling fact that with the present hand brake no electric or other equipment to-day stands provided with anything in the line of an emergency brake.

Enterprise in America for the public convenience of her citizens is truly phenomenal, and reaches its highest expression in conveniences for travel. The per capita investment in the cities and larger towns of this country for electric street railway work is much larger than is often realized; in some no less than $55 is invested for each man, woman and child for accommodation in intermural travel. The enormous aggregate sum thus invested has given a stimulus to engineers resulting in wonderful advancement and refinement in means for mobilizing the thousands of tons of human freight that are hourly seeking transport. Vast skill and almost untold resource have been devoted to perfecting means for overcoming inertia and quickly accelerating cars and trains which are ever increasing as to their weight and capacity, with patrons constantly more exacting as to speed and smoothness of operation, and especially as to safety. It is proverbial that while these advancements have been going forward, comparatively no attention has been paid to the mechanism for retarding and quickly but smoothly bringing the cars and trains to a stop.

As the practice of the steam railroad engineer as to roadbed, speeds and weights is gradually approached, his experience in the solution of this most important problem of braking should be studied with care. In so doing, however, the features wherein the street car company is differentiated from the steam road problem should be kept prominently in mind. We must remember that the locomotive engineer is provided with a complete, expensive and somewhat intricate apparatus with which to de-energize his train. The periods of its application are comparatively infrequent, and as to personal capabilities, he is schooled and trained for years before ever being allowed to touch either the throttle or the air valve. While working, his pressure gauges allow him to adjust the brake application to a nicety. Moreover the time allowed for the total retardation and final stopping of his train is usually very long compared with that allowed in street railway practice.

Of the two, the street railway problem is the more exacting, and in the hands of far less experienced operators, and yet we are told that the mechanism involved in its solution must bear only a small ratio to the cost of the total equipment. Owing to the recently developed relation between effective braking and the accident and damage account, the purchaser will be spurred on to careful investigation as to the brake applied to his cars, and will be willing to spend sufficient time and money to effectually control the retarding as well as the accelerating car. To be sure, as little expense should be incurred here as possible, but enough to fully meet the requirements. Especially is this true now that ample power for applying the heaviest brakes is at hand, and even if used in a wasteful and extravagant manner, in the largest amount possible, is entirely without cost, and its means of control already at hand. The importance of this proposition should at once command the attention of all, and commend the problem as such to the engineer.

The popular appreciation of this point is illustrated by the growing frequency of its discussion by the daily press in our larger cities. The following is an extract from an editorial recently appearing:

"The number of deaths due to motor cars has alarmingly increased since the trolley system liberated the slow-going horse and mule. Not that the deaths are due to the electric current. The 'deadly trolley' notion has properly been exploded. It is the car wheels that are doing the deadly work. Now that motors and trucks have been in a measure standardized, managers of large roads, especially, are being asked by their patrons why they do not adopt proper precautions so that the death rate may be cut down. There is no one part of electric or cable railroading so important as the ability to stop the cars quickly. At such times hand-brakes show their inherent inadequacy."

In so grave and urgent a case what can be done in the line of remedy? The question naturally arises, will any system of braking worked upon in connection with the ordinary wheel of a vehicle by sufficient for the stop required? What is the maximum efficience obtainable by the brake working through the wheels? Is it sufficient to arrest the car before accident in case of emergency? Can it be made in any event a sufficient accident preventer? The popular notion that most accidents are due to brake failure is true, but in a way that is little understood, the failure being one of degree. It may not be known that under proper and standard conditions any car or train may be brought from a speed of ten miles an hour to absolute rest inside of ten feet. It is not generally appreciated that the wheel brake has ample capacity to accomplish this. The former investigations of the writer with reference to adhesion under conditions of acceleration and retardation, climbing and descending hills, afford ample proof that the rail adhesion through the wheels gives the wheel brake more than capacity sufficient to accomplish this result. For instance, assuming any weight and load, say 17,000 lbs. the stored up energy, 64,426 foot lbs., can with ease be dissipated within twenty feet for the ordinary equipment, and less than half of this distance, or a little over 9 feet under conditions of coupled drivers, or if the wheels are compelled to revolve in unison. This latter consideration will be seen to have quite an unexpected as well as pertinent relation to the problem. It will be seen by a glance at the figures that the centre of gravity of the mass is far above the wheel contact with the rail. The retarding effect takes place on the base line in a plane below that of the centre of gravity, really the farthest projection downward of the mass as a whole. A sudden stop operating on this base line tends to pitch the upper portion forward bringing nearly all of the weight, and with it the retarding capacity, upon the front pair of wheels. The brakes on the rear pair in the ordinary equipment will have but little effect; if, however, by any practicable method they are coupled to the forward drivers, the brakes on this rear pair still remain active and of full effect. This is true even if the back pair should be lifted clear of the track. With increased weight upon the forward drivers comes ample increased adhesion, thus preserving the full tractive effort of the total weight intact for purposes of stop, which is impossible in the ordinary equipment. These effects are all aggravated in case of short wheel base. The present tendency toward a longer wheel base is a step decidedly in the right direction, and should be encouraged. The effect of shifting the load in reference to the axles will be especially noticed in descending hills, as shown in Fig 1, where the momentum of the rapidly retarded mass tends to shift the load centre still further forward, in some cases almost wholly on to the front drivers. It will be seen to have less effect in *ascending* grades. Here in stopping, the inertia tends to correct the position of the shifted load, whereas going down, in stopping, the momentum, as stated, tends to still further aggravate the condition. The practical effect of this may be seen whenever an ordinary street car, mounted upon springs of fair resilience, is quickly stopped. The car will be seen to suddenly right itself, having been pitched forward in the process of stopping (see Fig 2), the front springs being depressed and the rear springs extended. These considerations all go to show in a new light the advantages to be derived from coupled drivers for general street railway service.

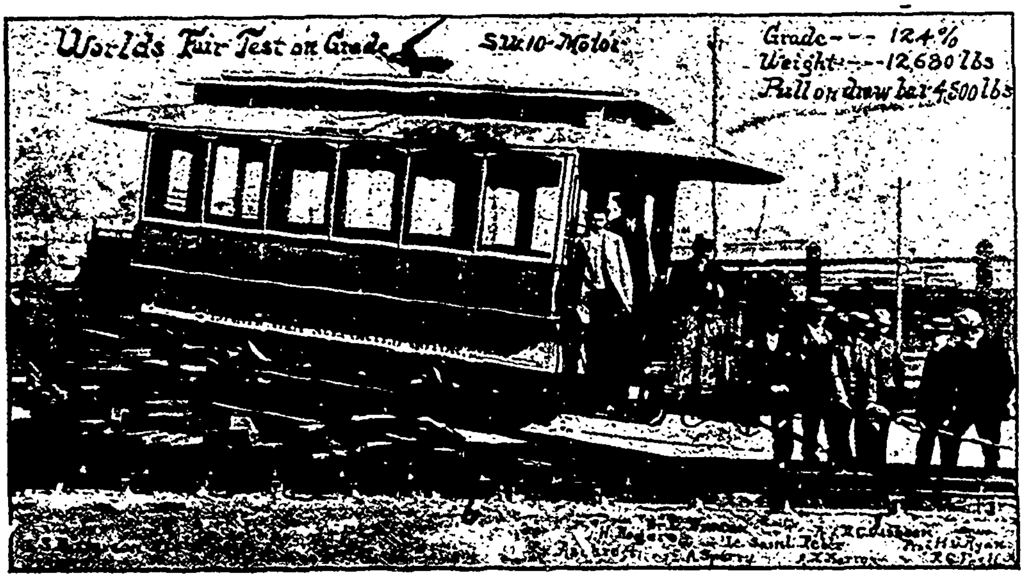
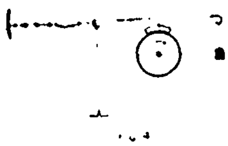


FIG. 3.

In a paper presented at the last annual meeting of the National

Street Railway Association, the writer gave the results of an original investigation relating to the relative tractive value, expressed in draw bar pull of the two styles of street car equipment, viz., with separately driven axles and with coupled axles A grade was built consisting of 45 lb T rails rising from a spur of level track giving a mean grade of 12 4 per cent Upon this grade was run first a double motor equipment weighing 17,935 lbs A dynamo meter was attached to the rear draw bar and back to the track, in such a line as not to either lift the car or drag the rear end downward in the test Current was then applied through a variable resistance, gradually allowing the car to strain upon the dynamo-meter until finally the wheels slipped Care was especially exercised on the point of gradual application of the strain so as to eliminate all elements of inertia or lunging forward upon the dynamo-meter It was found that a series parallel controller is entirely useless for this purpose After slipping of the wheels had commenced it was observed



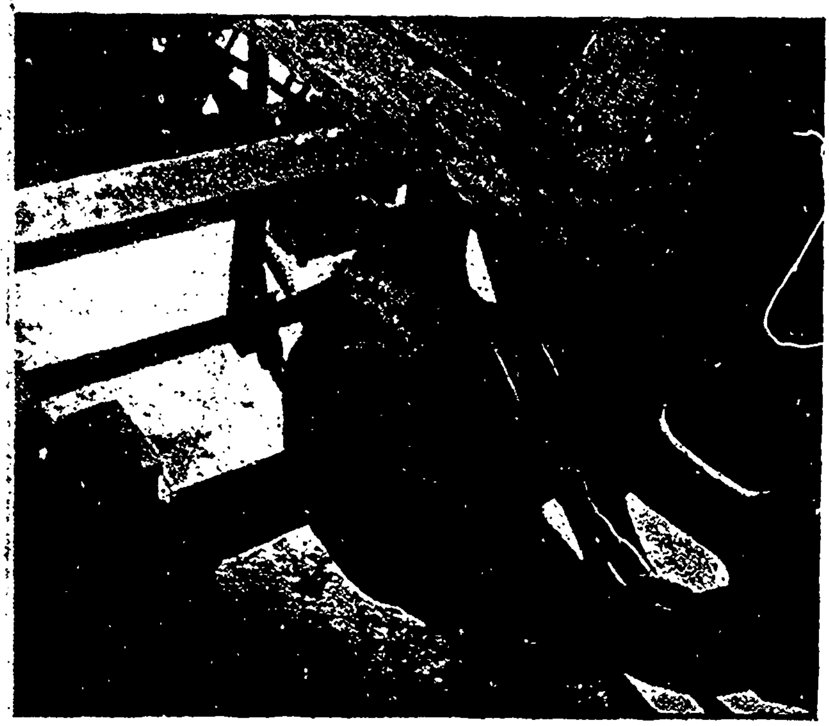


FIG. 5

the same way and the same controlling rheostat and source of current was used as in the previous experiment, the axles in this equipment being coupled by bevel gears and to a single motor The following table gives the means of five sets of readings taken from this car

Coupled Axles, Single Motor Equipment, Draw-bar Pull on Dynamo meter Car standing upon

12 44 per cent grade weight of equipment, 12,685 lbs

Group of tests	Average amperes	Average draw-bar pull	Ratio draw bar pull to weight
1	200	3125 lbs	24 per cent
2	240	3750 "	30 per cent
3	230	4075 "	32 per cent
4	220	4500 "	35 per cent
5	200	4375 "	34 4 per cent

The same operator applied current to the cars in all tests, and every condition of electrical pressure, track and weather remained identical throughout Other equipments of each class have since been tested substantiating the above results The accompanying cut, Fig 3 shows a car standing on the grade with dynamo-meter attached

Bearing these facts in mind, let us turn for an instant to the that the car would slide in each instance to the bottom of the grade The values in the following table are each the mean of four sets of readings

Independent Axle Two Motor Equipment, Draw-bar Pull on Dynamo meter, Car Standing on

12 44 per cent grade weight of equipment 17,935 lbs

Group of tests	Average amperes	Average draw-bar pull	Ratio draw-bar pull to weight on drivers
1	200	1625 lbs	9 per cent
2	280	2250 "	12 5 per cent
3	240	2150 "	12 per cent
4	230	2075 "	11 per cent

This car was run off the grade and replaced with one in which all the wheels are compelled to revolve in unison, but of much lighter weight, viz., 12,685 lbs The dynamo-meter was attached in ordinary hand brake The ratio in the brake levers will be found in the modern trucks to be anywhere from 6 to 11¼, averaging about 8½ to 1 The lever arm of the brake staff will be found to be anywhere from 6" to 13" Assuming 11" as the average, the radius from the centre of the brake chain to the centre of the brake staff will be 1¾", giving thus 6 28 to 1, or a total leverage of 53 4 to 1 from the operating handle to the brake beam Two elements now have to be assumed First, the friction co-efficient of the brake shoes acting upon chilled wheels. Second, the power upon the brake staff The writer has endeavored to cover both of these unknown quantities by actual experiment, giving the results in the tables Table III was taken by a dynamo-meter being fastened directly to the brake staff handle in line of the pull of the motorman, a cast iron brake wheel 16" diameter from centre to centre of a 1¼" rim bearing the handle A number of experienced motormen were invited to test their strength upon this handle and careful readings were taken It was noticed that the right arm of the more experienced motormen was much more developed than the left, a fact which, I think, has been pointed out before The extent of this development in the forearm is cer-

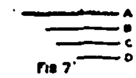


Fig 7

Fig 6

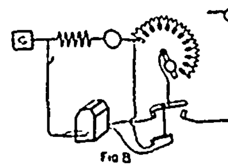


Fig 8

tainly quite marked, showing that the gripping muscles and weight of the body are the elements brought most into play

TABLE III

No of Motor man	Weight of Motorman	Gradual pull with one hand	Jerk with both hands on hand wheel	Emergency jerk with both hands on hand wheel.
6	140	112	135	275
58	200	135	275	385
264	287	145	235	312
62	175	125	212	285
123	153	125	245	310
69	185	150	200	300
26	170	150	275	350
96	155	135	210	325
246	135	110	175	325
287	135	125	250	350
66	160	125	250	405
4*	176	100	200	400
266	185	175	250	475
		Avg 131 7	224	338 23

* 9 years in service

Right arm { Circumference of forearm, 12¾"
" biceps, 14¼"

Left arm { " forearm, 11⅝"
" biceps, 13⅝"

Columns 1 and 2 indicate respectively the No of the motorman and his weight

Column 3 indicates the greatest possible steady pull with the right hand on the handle, bringing into play all possible weight of the body

FIG. 9.

Column 4 indicates the same condition as Column 3, the motorman in this case grasping the hand wheel with both hands, some motormen using gloves to prevent their hands slipping None of the men could maintain these values for more than ½ second

In Column 5 is indicated an "emergency stop" The motormen were told to "break the machine" if possible In this test the body was braced, sometimes with the knee against the dasher rail, the needle registering the highest jerk usually given with a sudden lunge of the body

It will be seen that the power applied by the steady pull of the average motorman is about 131.7, and can be made to run up in case both hands and the weight of the body are used to about 224 average, but this value cannot be maintained. The average values of column 5 cannot be used in these calculations, for the reason that although they show the pressures it is possible to reach jerking upon the hand wheel, these pressures cannot be maintained, and therefore cannot be depended upon for braking effect The tests show that the full power that can be maintained upon the brake

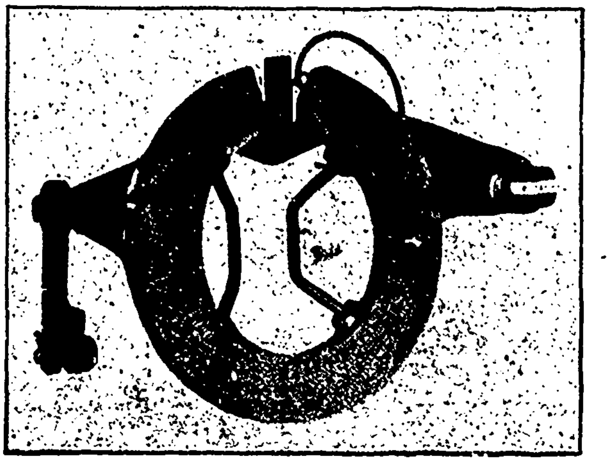


FIG. 10.

lever for a sufficient length of time for the purposes in hand does not exceed an average of 180 lbs

TABLE IV.

Speed, Revolutions per minute, 33" wheel.		Brake pressure.	Traction.	Coefficient
Varying,	150	900 lbs	87 4 lbs	9 7 per cent
	125	"	91 7	10 2
	100	"	99 8	11 1
	78	"	118	13 2
	56	"	133	14 8
	38	"	150 4	16 6
	20	"	154	17 1
	4	"	174 6	19 4
Constant,	105	300	29 4	9 8
		500	50 5	10 1
		750	91	12
	100	1150	125	11 2
		1500	178	12
		2200	305	14.4
	94	3780	488	13 2

Table IV was obtained as shown in Fig 4 A brake shoe that had been run in service about three or four days was taken with the axle carrying its co-operating wheel, lifted out of the truck and placed between the centres of a lathe, the load upon the brake shoe accurately measured, and the shoe held from movement around the wheel by a dynamo-meter Every precaution was taken to avoid handling the periphery of the wheel or the face of the brake shoe, and even the dust was left upon it so as to conform as nearly as possible to the normal conditions of practice Tracing our 180 lbs application to the brake beam with allowance for loss by friction, we have 3840 lbs applied to each of the two shoes, which upon the chilled surfaces are found under ordinary circumstances by Table IV to give a coefficient of about 12 per cent This would give a retarding effect of 460 lbs, which is less than one-third that easily obtainable were the power needful for its application at hand The coefficient under these conditions would have been about 37 per cent to realize anything like the total value of the retarding effect of the wheel This under conditions of chilled and glazed surface is entirely out of the question, showing at once the necessity of power in the application of brakes if anything like their full value and use is to be obtained This is also amply borne out in practice, as those who have tested this point well know, that under ordinary applications it is next to impossible to slip the wheels of a motor car by the hand brake

In the electric brake, on the other hand, the fact that the truck parts are not bound up and locked into a solid mass by the enormous pressures of the heavy break levers and shoes, is found to prevent racking and straining the truck as well as jumping the track and curves when the breakes are set The axles and truck parts are perfectly free for easy and normal movement even when the brake is exerting its full power Great reduction of wear at the pedestal journals is also found, owing to entire absence of all of the usual heavy pressures of the brake shoes We can all see that by applying adequate power and control to the wheel brake, this element of the equipment may be raised to the position of an indispensable safeguard, the value of which can only be appreciated as its hitherto undeveloped resources are brought out, demonstrated and rendered simple and easy of application and control In practice the greatest necessity for maximum brake application exists at the higher speeds From Table IV it will be noticed that just at this point the failure is greatest, the coefficient being least, increasing as the speed decreases This has always constituted the one grave fault of the air brake in railway service The intensity of its application should be greatest when the speed is greatest, and decrease as the speed drops off As will be shown further on, this point has been fully covered in the electric brake, which is the first time that the varying application has ever been embodied in practice, and especially in such a manner as to perform its important function automatically

A plan, especially one pertaining to electrical matters, after having been proven mathematically to be feasible, is far from being realized Many are the practical difficulties to be surmounted before a thorough commercial or anything like a standard apparatus has been produced Especially is this true in the electrical field Many subtle influences and energies are at work which well nigh overwhelm the experimenter In a new field but few precedents are at hand, and these are apt to be extremely unreliable and in the nature of a blind leader of the blind The practical application of the electric brake, although probably no exception to the general rule, amply illustrates the wide distance to be spanned between the conception of the idea and the commercial apparatus itself For years the writer has believed that electricity was vastly preferable to any other force for the application and control of brakes Working first on the solution of the continuous brake problem for railway trains, he built his first electric brake apparatus in '82, and has studied and experimented on the problem in its various phases almost continuously since that date, with more or less encouragement in line of substantial progress As to its application to electric cars, the apparatus was successfully applied on some double truck cars in Illinois, one of these cars weighing as much as 12 tons The first of this apparatus, similar to that shown in Fig 5, was constructed some five years since This apparatus has been constantly undergoing alterations and been experimented with, until for the past eighteen months a constantly increasing number of electric cars, equipped with the electric brake apparatus, have been in regular service, some of these cars running with change of motormen on each of 13 daily trips, the same motorman having the car once in about three days, making it impossible for the men to become familiar with the operation of the brake During this time one car has made upwards of 70,000 miles, hauling a trailer about 48,000 miles, during some special weeks of tests making from 178 to 220 miles daily It is only under such rigorous conditions of actual operation that rapid progress can be made in reduction to practice All machinery and apparatus must pass this ordeal successfully before it can be brought into thorough commercial shape

At the mention of electric brakes, the engineer at once admits that they should be entirely feasible, and usually adds that there is plenty of electrical energy at hand from the central station to retard and control as well as propel the car This, however, is not the method undertaken by the writer To employ the central station current for operating the brakes would be to limit very materially their usefulness and certainty of operation The braking current, although used at comparatively infrequent intervals, and then only for a short period, should, for this reason, be absolutely certain and unfailing in its action, and not subject to any "heart failure" of the central station, or sudden cessation caused by the opening of the circuit breakers, the interruption of the line, the flying off of the trolley, failure of the fuse, or failure at other more or less vulnerable points The electric brake under discussion has been operated over a year on equipment upon different roads from electricity generated *per se*, being entirely independent of the trolley connection, the braking current not being derived from the central station, but produced by the power of the moving car, which power it is desired to get rid of or destroy The brake thus operates equally well with the trolley off, and, as will be understood from the following description, the trolley current has nothing at all to do with the car while the brake

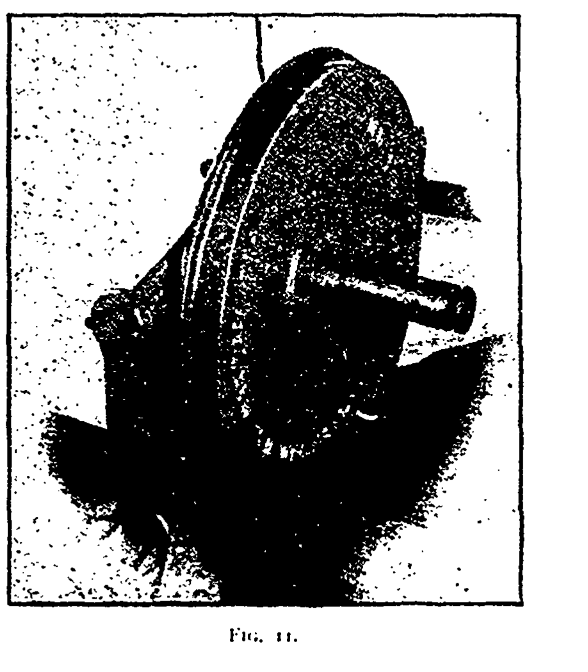


FIG. 11.

is being operated, except possibly to maintain the light circuit The electric brake at the same time is entirely independent of the hand brakes, which may or may not be present upon the equipment The braking action being altogether independent of the ordinary brake shoes, it is not found necessary to employ them in connection with the electric brake, although in the earlier forms they were used, and in the case of trail cars, especially in heavy service and on grades, some engineers prefer to use them at the present time in connection with apparatus such as shown in Fig 5 The current employed by the writer for operating the brakes is developed by automatically turning the motor or motors into generators As these are driven forward by the moving car they develop current which is controlled as to intensity by the starting rheostat of the car The braking current is thus produced at the expense of the mechanical energy stored up in the moving car, which, being consumed, causes a retardation and final stopping of the mass as a whole The current so generated may be farthermore led through a brake magnet as above seen, to apply the brake shoes it may arrest the motion of the car direct by magnetic adhesion or develop heavy retarding currents in the moving metallic mass by magneto-induction When an active local circuit is used, the latter method is usually employed for reasons which will be made more apparent

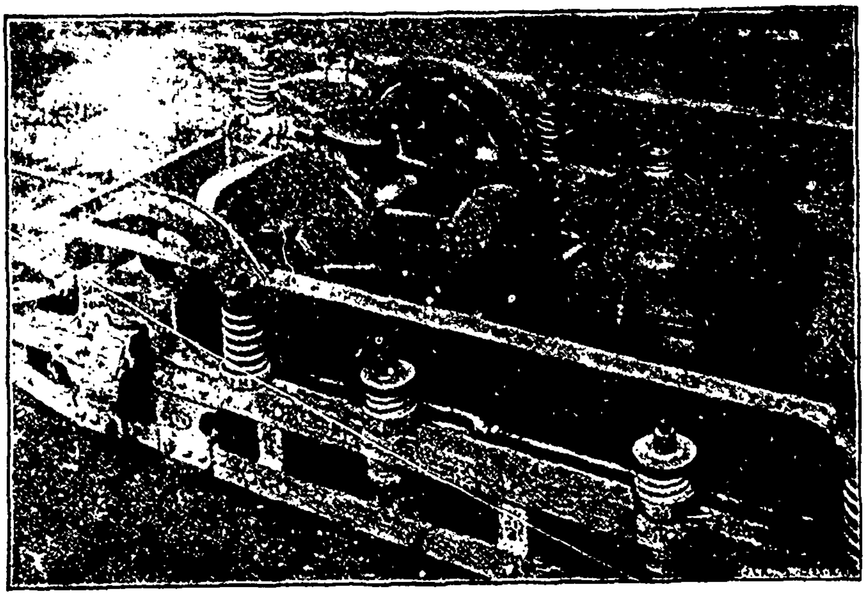


FIG. 12.

In developing this system the point which seemed fraught with the most difficulty, and which has finally received the simplest solution of any in connection with the problem, was that of obtaining always and with absolute certainty sufficient current at the lowest speeds without the aid of the trolley current Teaser coils were at intervals resorted to, maintaining connection with the trolley circuit "Artificial teasers" were also used, being a device by means of which the trolley circuit was entirely done away with, and which worked well Observations made from time to time in connection with these experiments led to an exhaustive investigation of residual magnetism, in consequence of which structural means were adopted to utilize to the full the residual magnetism of the motor This supply is constantly being renewed with every energizing of the car This method was found to be the simplest as well as the most effective The connections, and in fact the whole arrangement of the electric brake upon the car is extremely simple This is shown by the fact that only one small wire extra needs to be run to the controller in addition to the ordinary wiring of the standard equipment without the electric brake The certainty of operation is evinced by the fact that at the present writing over 150 of the equipments have been placed which are making upwards of ten thousand miles daily in regular service

Early in the experimentation a phenomenon was observed in reference to the persistence of the current even after the motor had stopped This is due to the slow action of the decreasing magnetization, taken together with the reaction or self induction effect of the fields and any brake coil or coils that may be in the circuit The movement of the magnetic lines which persists after, and in fact long after, the motion of the motor has ceased, generates potential In many instances it is possible to draw an arc from the rupture of the brake circuit one second after the motion has ceased, showing the presence of current in the local circuit Diagram Fig 6 has been developed from the average stop to show the curve of current in reference to the motion, the black lines indicating the period of motion during the application of the brake, and the curve indicating the current intensity and its duration The current flowing after motion ceases, though small is found exceedingly useful in holding the car from starting to move, even on quite a heavy grade, as only a small quantity of energy added to the already great friction of quiescence will prevent the car from starting This persistency of current is also found useful to kill or destroy the magnetism of the brake magnet in case it is desired to suddenly move the car forward again The tendency on the part of the windings at the moment of rupture to generate an opposing electro motive force tends to suddenly free the magnet from its face, a purely accidental feature which is of great value and utility in this connection The wonderful energy of the withdrawal of the lines of force being in its manifestation a phenomenon of magnetic viscosity is illustrated by the following fact With a perfectly dry track a great force is required to shear the adhesion and start the wheels slipping A car going down a grade under these conditions where no brake magnets are present, will, with a sudden application of the electric brake, generate sufficient current to not only arrest the motion of the wheels, but start them going in the opposite direction, the reverse motion being maintained through an interval truly remarkable, in some instances running as high as 1¼ seconds. It will be borne in mind that all the above phenomena are entirely independent of the central station current, the trolley connection having been severed before the brake is applied

The current required to be developed to stop a car when no other breaking apparatus is used, is found to be only a fraction of that required to accelerate the car in the same interval This may be easily illustrated by the lines in diagram figure 7, A being the electrical energy applied in a given acceleration, B the resulting mechanical energy stored in the car after deducting all wastes in the motor and between the motor and the momentum, C the average mechanical energy in the car at the time of applying the brake, D being the electrical energy required to be developed for retardation after the efficiency losses have all been provided for out of the quantity C Thus it will be seen that the so-called efficiency losses act in a two-fold sense, between A and B and between C and D, to reduce the amount of current required to be generated for braking purposes

As to the effect of the electric brake on the total temperature of the motor, the following experiments were made A car and trailer were operated over the line in regular service 41 1 miles without the brake The temperature of the atmosphere was noted every half hour during the test, and the temperature carefully taken of all parts of the motor at the end of the run The succeeding day a similar run was made with the same trailer over the same track and in the same length of time, but with the electric brake in use, braking direct on the simple local circuit without brake magnets The difference in the average atmospheric temperatures during the two days was 6½ degrees, and the difference in the average temperature of the motor parts was 7 degrees, making only a difference of one-half of one degree Centigrade as the total increase of temperature from the use of the brake Observations in reference to the heat in the rheostat were made, although no temperatures were taken, and no difference could be observed in reference to the heating of this portion of the equipment The explanation will be found in the comparatively small amount of current as seen above, and the relative infrequency of its application and short duration at the time of each application The following wattmeter readings have also been taken

	1st trip	2nd trip, trailer
Reading of wattmeter, leaving Lake View	392,538 9	392,542 25
Reading of wattmeter, end of round trip	392,542 25	392,547 1
Number of full stops	55	53
Number of slow-ups	42	37
Time	1 40	1 35
Difference in reading	3 35	4 85

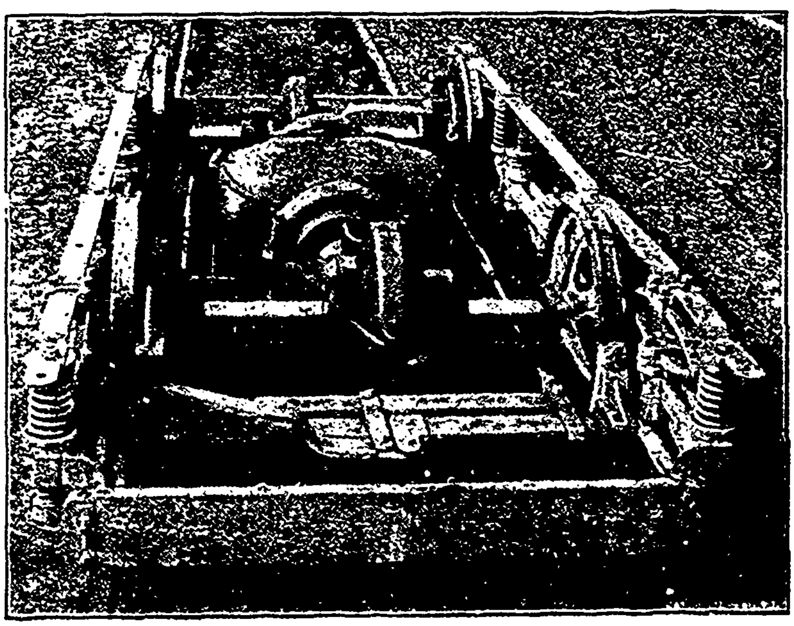


FIG. 13.

Constant of wattmeter equals "22", total watts both trips, 180 4

Diagram No 8 indicates the connection of the wattmeter in the circuit

Automatic resistances were even at one time used in the endeavor to relieve the motorman of *all* responsibility in connection with the control in applying the brake, but superlative simplicity was found to be much more desirable than the superlatively automatic, and the automatic devices were seen to be entirely unnecessary, the apparatus as at present constructed being of great simplicity

The diagram of the braking current in Fig 6 shows the automatic decrease in the intensity of the brake application so desirable with the decreasing speed referred to above As the speed decreases the generator runs more slowly and consequently produces less and less current

With this style of brake the life of the wheels is increased from two to three-fold, thus affording a saving in the item next in cost to the electric maintenance itself, to say nothing of the entire saving in brake shoes This is emphasized by the fact that the brake shoes are being constantly besmeared with sand and grit thrown from the wheels, and when in this condition, they are brought against the wheels with the tremendous pressures noted above A better method could hardly be devised for reducing both wheel and shoe We little realize the great number of brake applications necessary in a day's run Careful record has been kept of this point, giving in three days an average of 1377 brake applications for a run of about 164 miles

Another interesting feature in this connection is that a flat wheel from skidding is an impossibility It will readily be seen that should the wheels stop, the generator connected with the axles ceases to produce current, and none therefore exists to farther apply the brake, and though they may be sliding forward on the rail, yet the wheels continue to rotate more or less and constantly present new surfaces for the sliding contact

The braking action is two-fold and is especially efficient The rotating armature of the motor, instead of tugging ahead by its

FIG. 14.

momentum, is itself pulling back and more or less powerfully braking the car through the gears by the retarding effort of the magnetism of its field while generating the braking current The power required therefore to perform this work is taken from energy of the moving car which it is desired to destroy, not only is the car thus retarded, but the electric brakes arrest the motion of the wheels direct with a force that is remarkably powerful and under perfect control of the motorman

Two forms of braking magnets are used, one for winding up a brake chain usually employed in connection with the trailer, shown in Fig. 5, and another for directly arresting the motion of the axles, one magnet only being used in connection with each axle, as shown in Figs 9, 10 and 11 These magnets are truck mounted, not an ounce of their weight being directly on the axle, and are so supported that their gravity acts to automatically retract them away from the braking face, see Figs 11 and 12, the latter showing the link standing out of the vertical The brake face is automatically lubricated to a slight degree, receives a high polish, and does not cut or rapidly wear The brake is noiseless in its operation It will be seen from the cuts that inasmuch as it does not revolve no commutating or contact device is necessary Its crescent form accomplishes important technical functions and also eliminates the necessity of pulling off a wheel for its attachment, removal or inspection The brake is shown in position on truck in Fig 13 Its face is *solid unbroken metal*, with no grooves or interstices for catching grit or sand, which in part explains the absence of wear above referred to The brake magnet is practically indestructible, a few turns of stout wire constituting its one coil entirely enclosed and sealed in metal. No harm nor moisture can reach it As to moisture, it is immaterial, as the electromotive force at which it works is extremely small, seldom reaching six volts The lubricator for the brake is dry, not sticky or adhesive, and does not gather sand or dirt and retain it upon the braking face No mechanical pressures whatever are employed to arrest the car, and hence no strain or shoulder wear comes upon the journals In constructing the brake magnets their propor-

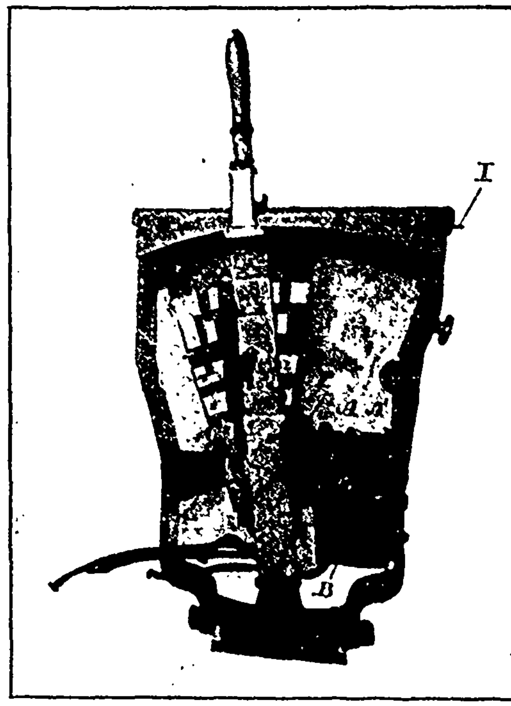


FIG. 15.

tions and the arrangement of the magnetic circuits received considerable study It was during some preliminary experiments that an unexpected phenomenon was noticed, namely, that the retarding effect when speed is an element, is very much more than would have been expected from the coefficient of friction due to magnetic attraction or adhesion, this latter being a known and definite quantity Farther experiment, made to ascertain the cause, showed it to be due to Foucault or Eddy currents set up in the masses The conditions and structure of the brake magnet were therefore varied in a number of particulars, especially such as would be expected to give the greatest result in Foucault currents produced The result was immediately successful It was found that the retarding effect of the brake magnet is due very much more to the generation of

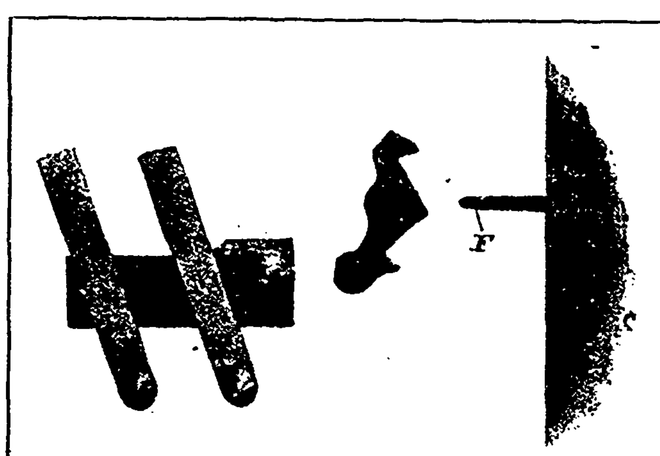


FIG. 16.

these currents than to the direct effect of the coefficient of friction resulting from direct magnetic adhesion, the amount of which I find can be relied upon accurately when employed by itself Some of the forms of brake magnets experimented with were provided with numerous poles of opposite polarity which were worked upon three different kinds of armature two of which had radial teeth of different number relative to those in the magnet and one being a plain disk armature The toothed armature while it causes a series of sudden jerks and is also unsatisfactory in the total retardation resulting from a given input, is found also upon rupture of the magnetic circuit to impart to the magnet coil certain counter electromotive-forces which materially cut down the current supply and thus the capacity of the device A magnet formed of a continuous disk with an annular groove sunk in its face, is found to give very satisfactory results, but is much heavier and requires an armature twice as heavy for a given number of lines than the double circuit magnet shown in the figures Furthermore, the relative rotation between such a magnet and its armature affords no point in the masses where the lines are interrupted or changed, and the Foucault currents, or reactionary effect set up, is very much inferior to those in a magnet where a gap or cessation of magnetic stress is easily produced As a result of these investigations the crescent form shown in the figures has been adopted, the opening in the crescent giving the effect referred to, as well as affording an excellent method of attachment and removal of the brake magnet, and at the same time supplying a gap for easily reaching the face for inspection and lubrication A lubricator, see Figs 9 and 10 is shown as occupying this space The belief that the extra retarding phenomenon is that of Foucault or other eddy currents, is borne out by the fact that a conducting lubricant, such as graphite, is found to considerably increase the effect, also metal filling between the polar faces is almost indispensable for the best results, while at the same time effectually protecting the coil from all damage These observations would seem to indicate that the eddy currents, however produced, circulate in both masses near the surface and traverse back and forth across the air gap whenever ample provision is made to allow them so to do The practical value of the combined action of all these forces in increasing the retarding effect results in necessitating but a small magnet and a smaller current expenditure considering the work performed

TABLE V.

Amperes.	Volts.	"A" Pull due to magnetic adhesion or traction friction coefficient 10%.	"B" Pull on brake chain obtained Graphite lubrication.
5	1	7 6 lbs.	125 lbs
9	1 8	18 3	300
9 5	1 9	36 4	608
15	3	121	1976
16	3 2	149	2432
20	4	158 4	2584
23	4 6	167	2736
25	5	186	3040
31	6 2	207	3385
35	7	213	3490
35 5	7 3	214	3500
41	8 5	223	3650

The assumed values are based on a traction of 28 26 lbs. per square inch for 45,000 lines per square inch, being the assumed values at the knee of the curve easily recognized as occurring between 16 and 20 amperes in the table

By reference to Table V the result in retardation gained through the eddy or other currents may be plainly seen, column "A" indicating the retarding effect which should be expected from a friction

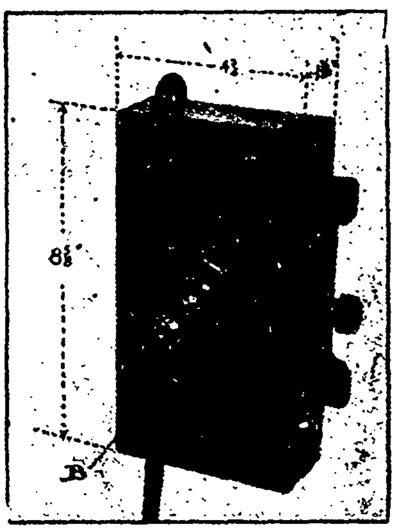


FIG. 17.

coefficient of 10%, between the lubricated surfaces due to magnetic traction of the lines actually circulating; and column "B" indicating the values of retardation actually obtained on the dynamometer

That the important position and trying circumstances under which the motorman often labors are appreciated, may be seen by the space devoted to it in the daily press An editorial in an evening paper reads thus

"One trembles to think what consequences may follow if a motorman gets rattled or has a fainting fit when trying to wind up his hand brake in time Muscles grow weary and relax at a critical time Even when a man is in fine working condition, the strain upon him is severe when compelled to handle the grip lever or current controller and hand brake simultaneously"

As to the arrangement for application and control of the brake by the motorman, about a year ago the following appeared from the hand of the writer

"Considering the inexperience of the operator and the responsibility which at times well nigh overwhelms him, I think that, as engineers, we should be willing to set a very high mark to be attained in the ideal brake for electric street railway service, namely, the use of but a *single controlling handle for everything*, starting, accelerating, retarding and braking, the trailer or trailers and all Let the motorman have nothing to think of except one handle, and two-thirds of the accidents now occurring will be prevented Let this handle require no more exertion in its operation than the present controlling handle Let the motorman fulfil his function with as little physical exertion as possible, he will then have a greater reserve for mental application when necessary A motorman required to exert an enormous amount of brute force, constantly grinding at the brake, has but little left to apply in case of emergency I agree with a prominent writer on this subject, where he says that a multiplicity of handles is fatal in time of emergency"

At the time the above was written, equipments controlled as therein set forth, namely, by the use of a *single controlling handle for everything*, had been in operation for upwards of a year The methods employed for accomplishing this have been varied, but the form most in use at the present time is that shown in Fig 14, where the resistance contacts are employed in a two-fold manner, the controller handle is made to operate back and forth over the same contacts for controlling both the application of the current to the motor and braking the car A self-correcting and interlocking device is also provided, shown at "A A," Fig. 15, so if the motorman does not throw the handle clear over, the transformation is completed automatically before the movement of the lever can reach the operating contacts.

At one point, where a number of equipments were started last summer, a newspaper correspondent described the operation of the brake as follows:

"The connecting beam was taken from the trolley wire several times, and the car brought to a sudden stop with the electric brake alone, within three-quarters of a car length. And it was not a sharp, jerky stop, but something as if the car had run into a big feather tick"

The smoothness of even a sudden stop by the electric brake is quite aptly described by this droll statement. It seems as though the car was running into an air cushion.

It will thus be seen that the brake is automatic and does its work without any special act or even the knowledge of the motorman. He simply "works a single handle" back and forth, and electricity "does the rest." Suppose the motorman wishes to stop his car, he turns off the current by simply swinging the lever over to the right This operation is made to automatically convert the motor into a special dynamo for generating currents at very low speeds, and also simultaneously to cut off all connection with the trolley current. The brakes are then applied by simply swinging the handle back over the path it has just traversed; the farther it is swung to the left the stronger the brakes are applied. The act of releasing or letting off the brakes again automatically re-establishes connection with the trolley and re-converts the dynamo into a motor. Fig 16 shows the switches used in part for the conversion of the motor, and also the finger "F" mounted upon the lever forming a part of the alternate stroke operating device. The trolley brake-switch "B" is shown open in Fig. 15, and closed, with dimensions, in Fig. 17. The same rheostat and contacts are employed to control the motor while running the car and also to control the slight amount of current generated by the transformed dynamo which is sufficient to brake the train.

The motorman cannot turn on the current before the brakes have been released, nor can he apply the brakes before the current has been turned off. This is a result of construction, and constitutes a feature of merit in the new electric brake, effecting an economy in current and a saving in wear and tear. Freeing the conductor of all care in this connection, and leaving the running and especially the braking of the train, including trailer or trailers and all, solely in the hands of the motorman—by placing at his command a power with which he may with the utmost ease accomplish his task—constitutes an important advance in the art of control of electric railway equipment

It has been found that the electric brake is practically incapable of abuse by the motorman—an advantage which never before has been attained in any power brake—from the fact above named, that no amount of over-application can cause flattening of the wheels or any harm whatever to any part of the equipment through locking and skidding of the wheels.

The application of the brake, its regulation and also the running of the car, all by a single operating handle, is a result that has only been accomplished by the severest application It has involved much pioneer work and been rendered possible through the use of new mechanical movements original with the writer. The principal moving parts are simple and durable, being only two in number. The arrangement may be easily seen in the controller and parts exhibited, as well as in Figs. 15, 16 and 17. The various portions of the controller have been subjected to the severest tests possible, one test made in 1893 consisting in 518,700 consecutive brake applications without appreciable wear, the parts being in regular service at the present time. An indicator at the right side of the controller at the top (see I, Figs. 14 and 15) shows when the controller is in condition for brake or is being so used.

Operating the brake in this manner, it will at once be seen that the system is one of the utmost certainty of operation, surer even than the hand brake, air or other power brake, from the fact that every time the car runs, the motor, which is depended on for the braking action, receives a test, and its fitness and capacity for the next brake application is constantly being demonstrated. On the other hand, the motorman never knows whether his hand brake is sure to operate when called upon for the next application. An accident came under the observation of the writer on Case avenue hill in Cleveland. Here the last hand brake application was successful in every way, but before the brake was called into action again a nut dropped off from a brake rod upon the truck, rendering the brake useless The motorman continued to wind on his brake staff, and before he realized what the trouble was, his car was going at a tremendous speed into a short curve at the foot of the hill There were a number of casualties and also six demands for damages as a result With the air or other power brake this liability to failure is increased in direct proportion to the complexity and number of parts

The advantages found to result from the practical use of the electric brake, as compared with former brake systems, its qualities as an accident preventer, as well as its general commercial value, may be recapitulated as follows

1 The certainty of its operation

2 The enormous power at instant command and under perfect control

3 The absence of all power absorption at moneyed cost from the central station

4 Its high efficiency, being far superior to compressed air amply proven in numberless instances where electricity has replaced air (The air requires a direct application of energy, amounting to an immense aggregate power-absorption during the day from the central station, the working parts of the air machinery are attached to the car axle and require a large quantity of energy, not only while compressing but at other times as well)

5 Its extreme simplicity

6 Observed saving in wheels two to three fold

7 Entire saving in brake shoes

8 Lubrication of brake face, practically no wear -either wheel or magnet

9 Absolute silence of operation and release (No hissing to frighten horses on streets)

10 The low electro-motive force at which it operates

11 The ease of its application and control

12 Conserving strength and prolonging the usefulness and life of the motormen

13 The smoothness of its operation

14 Cannot cause flat wheels

MUNICIPAL ELECTRIC LIGHTING.

By E. Carl Breithaupt.

The question of how industries that are to a greater or lesser degree carried on for the accommodation and benefit of the general public, can be conducted to the best advantage, has always been one of national economic import, and the idea that they shou'd be owned and operated by the public body corporate is not altogether a new one.

The principle is enunciated by economists that industries of this nature, such as transportation, the transmission of intelligence, the supply of water, and of artificial light, are monopolies inherently and essentially ; they are therefore classed as natural monopolies. All of these industries are primarily under the control of the State, and for this reason, it is claimed, they should be owned and operated by the Government.

The advantages claimed for such ownership are that the work would be more economically performed, the margin of profit which a private company derives from the business being saved to the public treasury, and that the service rendered would be a more efficient one. Moreover, it is held, that private ownership of these industries encourages corruption, particularly among legislative bodies, and that under government ownership this would be done away with. To the public mind the word monopoly conveys the idea of an autocratic power which leads to abuse of privileges and advantages enjoyed, and consequent abnormal returns on capital invested. Prof. Richard T. Ely, of the University of Wisconsin, holds that private monopoly is a menace to the public, and that men are not good enough to be entrusted with such a despotism as that which monopoly confers.

It is the purpose of this paper to consider the question of government ownership of natural monopolies only in so far as it concerns works for the supply of artificial light, and particularly such as is wholly for the public use, viz , the lighting of streets and public buildings.

It is proposed that these works be owned and operated by the Municipal Corporation, and many cities and towns have been considering the advisability of the plan. The question has been hotly argued on both sides, and it is to be regretted that these discussions are not always conducted in a fair-minded, liberal manner Arguments advanced by men interested in private lighting companies are denounced by their opponents as prejudiced opinions ; the cry of "Monopolist" is raised to enlist public favor on the side of municipal ownership, and the same offence is thus committed as is charged. It is but natural that persons having capital invested in any particular enterprise should strive to protect their investments, especially in a case of so serious a nature where the threatened danger means inevitable destruction. On the other hand there is much to show that the arguments put forth by the advocates of municipal ownership are not always inspired by pure and unselfish motives. If these discussions are to accomplish any good the opinions advanced by either side must be honest and unbiassed, and above all the facts and figures cited must be truthful, for the outcome of the case really hinges thereon.

The burden of proof lies with the advocates of municipal ownership, and the arguments in favor of their claim are identical with those of the complete scheme of government ownership.

Can a Municipal Corporation perform its own lighting service cheaper than a private company can supply it? Figures are given showing the cost of the service where the plant is owned and operated by the municipality, and estimates are made on the cost of building and operating proposed plants, nearly all of which are so surprisingly low that they must at once arouse suspicion in the minds of thoughtful men. According to these reports the cost of public lighting, where it is done by the municipality, averages about one-half of the price usually paid to private companies. One town in Illinois having 120 electric lamps on its streets, even reports that these cost nothing, that the expenses of operating are all paid by the profit received from commercial lighting. It is a significant fact, however, that these figures rarely represent the actual total cost. There is a tendency on the part of the advocates of municipal ownership to underestimate or entirely ignore any items which are not cash actually paid out, such as depreciation in value of plant due to wear and tear, and to the fact that new and improved apparatus and methods are constantly coming into use interest on acpital invested, insurance, taxes, and in some cases water supply. The town treasurer's statement of expenditures incurred in operation is often the only outlay considered, and even this may be incomplete since municipal authorities do not always analyze accounts so as to show a full statement for each department. Insurance and similar expenses may be debited to separate ledger accounts and not appear at all in the statement of a particular department. Other items are charged to the department where they belong, but under the wrong heading. As a case in point, we may cite the financial statement of Toronto Junction for 1893. Under receipts and disbursements authorized by by-laws for issuing debentures on account of electric light construction, we we find an item for rebuilding engine bed of $162.93. This was a repair and properly belongs to maintenance.

Now, it is plainly unfair to compare such figures with those paid to private companies and say that a municipality operating its own plant saves the difference. To compare results intelligently we must agree on a basis of comparison. If the price paid a private company is remunerative to them, it includes depreciation, interest, insurance and taxes, and we must therefore debit a municipal plant therewith. The municipality may for a number of years persuade itself to believe that these expenses are imaginary, but it must meet them in the end, and no matter to which account they are charged they are incurred by the lighting plant

Mr. M. J. Francisco, now president of the National Electric Light Association, last year published a large amount of data on the cost of street lighting, which is of interest in this connection. He gives figures from municipal plants scattered over nearly the whole territory of the United States, and computes the cost per lamp, adding interest depreciation, insurance and taxes ; he states that the original reports signed by the city officials are on file and open to inspection by any person who may desire to test the accuracy of his figures. The most economical station cited is Marshalltown, Iowa, where 64 lamps of 1,200 nominal c.p. are lighted 300 nights each year until 12 o'clock, at a cost of $51.87 per lamp. The plant is run in connection with the water works and the cost of coal and labor is divided between the two departments. Of these 76 plants only ten show a cost of less than $80.00 per lamp per annum ; five of them using 2,000 c.p. lamps until midnight ; one, 2,000 c.p. lamps until 2 o'clock a.m., and four using 1,200 c.p. lamps. The average price paid is $116.46 per lamp per annum and 5 6 10 cents per lamp per hour. Compare these figures with Canadian contract prices In statistics compiled by the Citizens' Telephone and Electric Light Company, Lt'd, of Rat Portage, Ont., and published last month, we find eleven towns and cities reported where a 2,000 c.p. arc light is furnished until midnight at prices ranging from $45 00 to $80 00, twelve towns and cities where a 2,000 c.p. light is furnished all night at prices ranging from $65.80 to $162.00, but only one of these, viz , Winnipeg, exceeds in price the average cost of $116 46, for municipal plants as above stated. In the town of Arnprior a 1,000 c.p. light is furnished until midnight for $54 75, the motive power being water and steam, while in Berlin the same light is furnished for $45.00.

In a report to the Committee on Works by City Engineer Keating, of Toronto, dated May, 1894, Mr. Keating includes a table which he compiled from reports directly received, showing cost per annum for street lamps where the lighting is done by the municipalities.

NAME OF CITY	LAMPS		COST PER ANNUM	
	Number	Candle Power	As given by Mr Keating	As given by Mr Francisco.
Savannah, Mo	25	1,200	$25 00	$150 00
Danville, Va ...	90	1 200	44 00	53 90
Ashtabula, O.	70	2,000	90 00	117 85
Bay City, Mich ..	181	2 000	49 00	92 65
Aurora, Ill	119	2,000	68 00	117 33
Hannibal, Mo ...	120	2,000	65 00	118 37
Ypsilanti, Mich ..	88	2,000	34 67	97 73
West Troy, N Y ..	103	2,000	70 00	114 67
Easton, Pa	113	2,000	77 95	147 22
Bloomington, Ill ..	225	2,000	61 00	122 55
Lewiston, Me	100	2,000	43 00	87 50
Topeka, Kan	184	2,000	93 00	129 00
Bangor, Me	156	2,000	45 00	91 30
Jamestown, N Y ..	130	1,200	50 00	69 24
Chicago, Ill.......	1112	2,000	96 64	104 89
Allegheny, Pa	519	2,000	59 51† / 72 00†	92 15

†Includes interest and depreciation

Mr. Keating states there may be a difficulty in such cases in arriving at absolutely correct figures, and that an allowance should be made for interest and depreciation in order to arrive at a fair comparison. The figures he gives are so materially lower than those of Mr. Francisco that we can infer they do not include this allowance. I therefore reproduce them side by side in the above table to show the difference in results obtained by the two methods of computation, and the unreliability of municipal reports.

The other data given do not agree in all cases. Mr Keating's table contains some evident errors: e.g., for Savannah, Mo., he gives the total operating expenses as $2,500.00, making a cost of $100 00, instead of $25.00 per lamp.

Again, Mr. Keating's estimate of running expenses is altogether too low, especially in the amount it includes for labor. The Secretary of the Fire Department estimates the annual cost per lamp for 1,300 lamps at $103.85, while the price at present paid for about 1,000 lamps is $108.58, leaving a difference of $4.73 per lamp in favor of the city. This is certainly a small margin to warrant an investment of $310,000, particularly as it is only an estimated margin.

The city of Philadelphia lately had under consideration the advisability of doing its own lighting. Chief Walker, of the Electrical Bureau, estimated the cost of 2,000 c.p. lights at 23 to 25 cents per night, but the Committee of Council after an investigation in which they took evidence from all available sources, figured the cost as about 43 cents and recommended the council to abandon the plan.

In Topeka, Kansas, the work of street lighting has been done by the corporation for some time and the plant has been under the superintendency of careful, competent men. The City Engineer has compiled very complete returns covering a period of 38 months, according to which the average cost per lamp per annum is $93, not including depreciation, taxes and water. It is admitted that the plant is not proving satisfactory and that the local companies would furnish the same light at a cost of 20% to 30% less.

The Town of Seaforth, which until lately supplied its own light, reported in 1892 that they were satisfied the light could not be run as satisfactorily or as economically by the corporation as by a private company, though it was operated in connection with the water works. Now they report that they have just sold out to a private firm.

The *Electrical Engineer*, an independent electrical journal, has just published the results of an investigation made under its auspices on the cost of municipal lighting. In commenting thereon the editor remarks that "in no respect do these figures justify the statements that have been made as to the superior economy of municipal plants."

Can a municipal corporation perform its lighting service more efficiently than a private company can? A successful manager of a central station for the supply of gas or electricity must possess no small amount of general engineering ability. He must have a technical knowledge of gas and electric matters as well as a thorough acquaintance with all the details of the plant under his charge. All this requires years of special training and experience. A municipal plant is managed by a committee of the council. When the size of the plant warrants it, a superintendent is appointed, otherwise the clerk or other town official, or the chairman of the committee has it in charge. In either case it is under the jurisdiction of the committee, a body of men who hold office for only one year, and who, while they are probably well versed in their own private business, usually have no knowledge of gas or electric light matters. Is it reasonable to suppose that a business will be better conducted so than under the management of men who devote their whole time and energy thereto.

Among the answers received by the writer in reply to enquiries regarding municipal plants, one states: "The greatest drawback to the town owning the plant has been too many bosses;" another quoted by the *Electrical Engineer* complains that everybody tries to run the plant and says: "The mayor and committee, with the assistance of a leather-headed clerk, all dictate what shall be done and where supplies shall be bought" Truly the lot of a municipal superintendent seems a hard one. The same writer says further, "with eight years experience, I would advise all towns to hire their light, which is by far the cheapest."

The question of economy and efficiency are interdependent. The managing committee of a municipal plant lacks the motive to effort, the incentive to economical operation and to close personal attention that a man finds in his own private business. Would you risk an investment in any industry under the management of a committee of a municipal council? If not, then why risk under such management an investment of funds which you must help to supply and in the expenditure of which you have therefore a personal interest at stake?

As to the claims regarding corruption:

The opportunities for corruption connection with contracts between municipal corporations and private companies for the supply of light are very limited; moreover the prices paid for street lighting in Ontario are not near high enough to sustain a corruption fund.

In municipal ownership, on the other hand, there is a great temptation to crookedness. Mr. Francisco quotes an article from the *Forum* that of the members of a typical city council one third will vote as they think, regardless of advantages, the votes of another third are merchandise pure and simple, and the remaining third are debatable men. This characterization may be somewhat severe; let us hope it is, but there are usually some men in a council who are not above accepting a bribe, and these always endeavor to get themselves appointed on committees having in charge the management of public works. The opportunities for dishonesty are apparent. Besides this there is invariably some preference shown in appointments to office. Mr. Francisco quotes an interview with an official of the Chicago municipal plant in which this gentleman complains that men in his department were turned off without cause to make room for favorites, and that there was "no possible way to get on the service without a political pull."

There are other additional arguments against municipal ownership of lighting plants. The function of a government is to regulate and control and to encourage enterprise on the part of its citizens by extending a protecting hand over the industries they establish. When a number of citizens band together, therefore, to carry on a business which is at best an uncertain one, one in which their works and plant are liable to serious injury from various causes, and in which they are not free to trade where and with whom they choose, but are restricted to localities, a business which confers a benefit to the community and which is already more or less subject to municipal and legislative control, then it is obviously unjust for the municipality to establish and operate a plant in opposition to that of the private company. If a municipal corporation decide to enter into a field of commercial enterprise in which some of its citizens are already engaged, it is only simple justice that it shall offer to take over their works and plant at a fair and equitable price.

Again, the wisdom of a municipality engaging in a commercial enterprise may be questioned, indeed it is a grave question whether the corporation has the moral right to risk the money of its citizens in an undertaking which is attended with such hazards, and in which the advantages to be gained are in any event small and uncertain.

Many cities and towns have been persuaded by incomplete reports and alluring estimates to undertake the experiment, but it still remains to be proven that a municipal plant can supply a cheaper light than a private company In towns which are not large enough to make the business remunerative the installation of a plant by the corporation may be justified because street lighting is a public necessity, but where private plants already exist that are able and willing to supply the municipality at a fair price, the outlay cannot be regarded otherwise than as an unnecessary expenditure and a waste of public money.

DUPLEX TELEPHONY.

By T. R. Rosebrugh.

In considering this question I propose to do so with reference only to the principles involved, the question of priority of invention of any of these being left untouched.

The name "duplex telephony" though not altogether exact as a description of the methods to which I intend to refer in this paper is nevertheless very near to the meaning.

It will be as well to consider at the outset how the telephone problem differs from that of the telegraph, for one might naturally suppose that the known methods of duplexing telegraphic transmission would be available for the telephone. Actually there is little in common.

The electrical impulses which are used in telegraphy are of definite and predetermined character as to polarity and strength of current while they last, and differ only in their duration and grouping in time, while those of telephony are, of course, from the point of view of the electrician, entirely uncontrollable. Besides this in telegraphy, at the receiving end the only information really given by the sounder, is the interval during which its corresponding key at the transmitting end was raised or depressed, and this is sufficient; whereas at the receiving station the waves of telephone current must be received in very nearly their original form. This means then of increasing the working capacity of telephone lines is not available, while in ordinary practice in telegraphy, the distinction between change of polarity and increase of current, doubles the capacity of the line. In the second place in any system of transmission, telegraphic or telephonic, it is possible so to arrange the circuit that a receiving instrument is shielded from the effect of the transmitter at the same station while responding to that at the distant end. This may be done in several ways, the "bridge" method being most usual; in this method the two wires which enter the station, or the wire and the earth conductor, are connected as though their resistance was to be measured in the usual way, the receiving instrument taking the place of the galvanometer, so that when properly balanced it only responds to the transmitter at the distant end. Three reasons prevent this method from being useful for telephonic purposes: a satisfactory balance would be more difficult to obtain owing to the capacity and self-induction of the line, and self-induction in the instruments at the other end; besides this only a fraction of the current would be employed usefully; and probably more important than either of these, is the fact that while the telegraph may be used for the continuous transmission of messages in one direction, the telephone is intended essentially for conversation, so that even if a pair of simultaneous transmissions in opposite directions over a line were established, a single conversation would demand the use of both.

The third difference consists in the well known fact that on account of the sensitiveness of the telephone the circuit in which it is placed must be as nearly neutral as possible to outside influences both electrostatic and electromagnetic, as well as to the direct action of differences of earth potential; and this can only be done by a return metallic conductor traversing practically the same path as the first.

For these reasons then, it happens that given a single metallic conductor extending between two distant points, with access to an earth connection at both points, used as a telegraph circuit in the ordinary way, four messages may be transmitted simultaneously, yet the same conductor will only suffice for a single conversation in a very unsatisfactory way.

Since two wires are necessary for the proper transmission of one message by telephone it might hastily be assumed that this is a constant ratio, that is that the conductors must always be twice as many as the number of messages that are to be transmitted simultaneously. The fact is, that it is the difference and not the ratio which is constant. There is no doubt for example, that if it were necessary, ten messages could be transmitted simultaneously by eleven conductors without interference, although in that case it is exceedingly doubtful whether the complexity of the system would not preclude its use.

The most natural way of proceeding to increase the transmitting capacity of telephone conductors is to regard the already existing two wire metallic circuits as the units out of which to construct metallic circuits of a higher order, which I will term derived circuits.

It is necessary then that two points be obtained on a two wire metallic circuit, satisfying the condition, firstly, that no difference of potential be produced between them by the action of the transmitters already in that circuit, and secondly, that no effect be produced in the receivers of the cuit by the entrance and exit of current at these two points The first condition may be satisfied in two ways according to the arrangement of the instruments already in circuit. If intermediate transmitting instruments are to be in series they must be divided into two similar parts, one in each line as in Fig. 1 are D and E, two secondary coils of transmitter T1, arranged so as to contribute at each instant electromotive forces equal and in the same sense with regard to the metallic circuit, and therefore in opposite directions with regard to the line.

If the two sides of the metallic circuit have the same resistance it will be seen that no difference of potential can be produced between the points where the two lines unite, as in Fig.

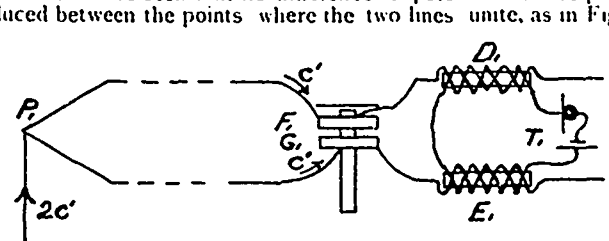


Fig. I.

1 at P1, and the corresponding point at the other end of the line. If, however, the transmitting instruments are only at the terminals or are bridged across between the two sides at intermediate stations, as in Fig. 2, no such modification in their structure is necessary, for their action cannot produce any difference of potential between points which are at the middle of any bridges between the lines.

It is not true, as might at first be supposed, that every bridge has a middle point, for such a point must divide both the resistance of the bridge, and its inductance, if there be any, into two equal parts, and there will not in every case be such a point. In the case of a secondary of a repeating coil it will be necessary also that the two parts have equal mutual inductance with regard to the primary before the point between the two coils satisfies the condition of having the mean potential at every instant.

Since in any case the currents introduced on the lines of the two wire metallic circuit must divide equally and flow parallel to one another in the same direction, we find the condition that the receiving instruments of the original metallic circuit should not be disturbed by such currents to be, either that the currents should not flow through the coils at all—which may be attained by bridging them between opposite points on the two lines, or, if the introduced current on one line flows through a coil of the receiving instrument, then that on the other line must flow through a coil in the opposite direction, which is just capable of neutralizing the magnetic effect of the first As for instance in Fig. 1, the introduced current 2c' entering at P1, divides into two parts c1, which circulate in opposite directions through the coils F1 and G1 of the receiver, and produce no effect, and similarly also in the coils F2 and G2 on the same line. Supposing the bridge method selected as being applicable more generally, let us look at the different ways in which it may be carried out. In Fig. 2, L1 and L2 are two lines which are supposed to be already in use as a metallic circuit, T1 and S1 being the transmitter and receiver at one end, and T2 and S2 at the other. L3 and L4 are similarly two lines of another metallic circuit. Between the points A and B are connected in series two equal non-inductive resistances R. At their common point P1, a wire connects through telephonic apparatus T5 and S5 with P2, a similar wire on the same metallic circuit, including also at the second end the telephonic apparatus T6 and S6, or it may connect with Q1, which is a similar connection on the second metallic circuit, and similarly P2 with Q2, both connections including telephonic apparatus. Each of these bridges has then a resistance 2R, but owing to the line resistance it would generally be incorrect to say that they are equivalent to a single shunt of resistance R. The current on the derived circuit passes through the coils of each pair of resistances in multiple, and each is therefore equivalent to ½R. It is to be noted that currents arriving at A and B from P1, on the derived circuit, do not divide at these points as

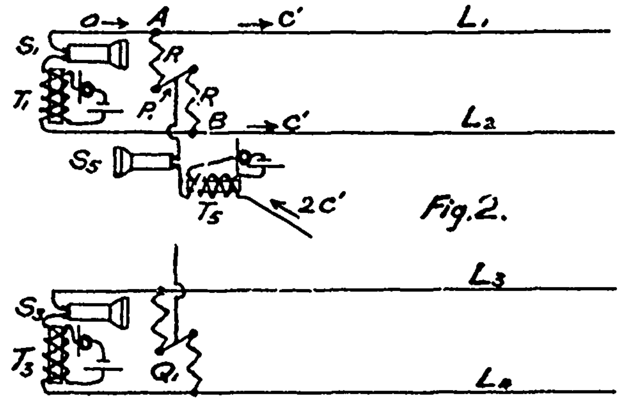


Fig. 2.

might be supposed, but that portion of the circuit at the end between A and B, including T1 and S1, is left entirely dead, since, due to such currents, there is no difference of potential between A and B. The same thing applies also to T2 and S2, and to any other telephonic apparatus of this circuit bridged across between L1 and L2, which is not provided with an exit at its middle point.

As a first improvement on this construction it may be suggested that a self inductive resistance would be better than a purely ohmic resistance, if not connected exactly at the ends of the line, for it would partly compensate the effect of electrostatic capacity between the wires.

The next step in advance is to put the two coils R together on the same core as in a telegraph relay, Fig. 3, so that while the leakage current passing from A to B through the two coils in the same direction around the core, reinforces the magnetism of the core and experiences consequently a high impedance, that from the derived circuit which enters at P, the middle point, and divides there, passing in opposite directions around the core in the two coils, affects the magnetic circuit comparatively little, and has therefore low impedance. In the case of an ordinary box relay of 150 ohms we would have in series from A to B a resistance of 150 ohms, and an inductance of 4.8 henry, while from P1 to A and B in parallel we have 37½ ohms and .49 henry, or to the note "middle C" an impedance of about 7730 ohms to currents leaking through its coils in series, and 790 to the derived currents dividing from the middle point outwards, making a total impedance of 3160 ohms in addition to the ohmic resistance of the derived circuit. Better results than this could be obtained by superimposing the windings instead of having them on the separate limbs of the magnetic circuit. The best possible results, however, will be obtained when the derived current forking at P1 to A and B traverses practically identical courses in opposite directions around the magnetic core, and has therefore a non-inductive path, while the leakage current from A to B passes over this course twice in the same direction, experiencing the maximum impedance. This may be accomplished most exactly by twisting the wires together and winding the double conductor on the coil. A coil made in this way, Fig. 4, measured 480 ohms and 4.6 henry to the leakage current, or an impedance of about 7400 ohms to the note "middle C," while to the derived current entering at its middle point it was practically a non-inductive resistance of 120 ohms. In good modern construction it is necessary on circuits of moderate length to transpose the wires on the poles, in order to expose them equally to outside disturbing influences. In addition to this transposition,

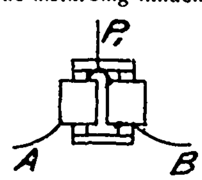


Fig. 3.

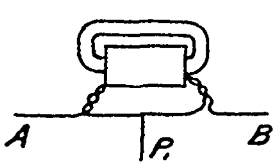


Fig. 4.

to get the best results it is often desirable to transpose the circuits among themselves; this transposition of the metallic circuits is more necessary when derived circuits are formed from them, for in that case transposition on the poles is as important as it is for single conductors to which they are then equivalent. For this reason the derived circuit should not be applied to a pair of circuits differing materially in length.

The underground cable system connecting stations in the same city affords an excellent opportunity for the application of the above principles, for a large number of metallic circuits between the same two points are in continual demand and are quite expensive. A redistribution of the positions of the wires in the cable being made at every manhole, the transposition must be quite thorough.

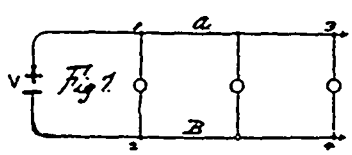
Coils such as are indicated in Fig. 4 have been in use in Toronto for some time on the cable between the main office and the Yorkville station; they afford an extra speaking circuit for each pair to which they are applied, in which as well as in the two original circuits, speech is perfectly transmitted. The same thing is true of a pair of metallic circuits between Toronto and Hamilton, when the circuits are free from long extensions.

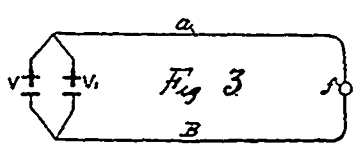
It appears quite probable that on very long lines the decreased conductor resistance and self induction of the derived circuit as compared with the originals would fully counterbalance the increased electrostatic capacity, and give, for example, between New York and Chicago, three speaking circuits for every four conductors, instead of two, the transmission being unimpaired in any of the circuits.

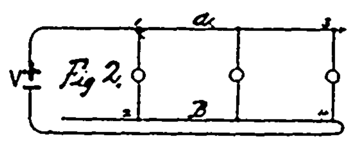
A METHOD OF DISTRIBUTION WITH EQUALIZATION OF POTENTIAL DIFFERENCE.

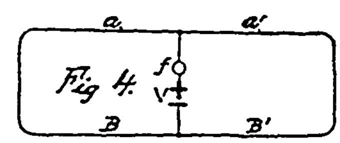
By D. H. Keeley, Mem. Inst. E. E., Ass.-Mem. Can. Soc. C. E., Mem. Canadian Electrical Association.

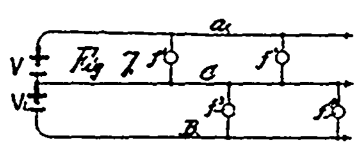
Perhaps it wouldn't be a bad idea to preface what is to be submitted in this paper by a claim that the method of distribution, herein dealt with, affords an equalization of potential difference without increasing the volume or the total weight of conductor in any two-wire system; and that it affords the same equalization by the addition of only 25 per cent. more wire in any three wire system, the importance of which latter feature might be emphasized by presenting a reminder of the fact that a three-wire system calls for a conductor that is only as 3/8 is to 1 compared with a system in which but two wires are employed. And since there are adaptations of the method to two different systems of wiring to be considered, it will be convenient to examine them separately after a general survey o[f]

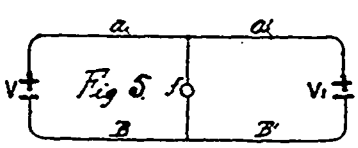


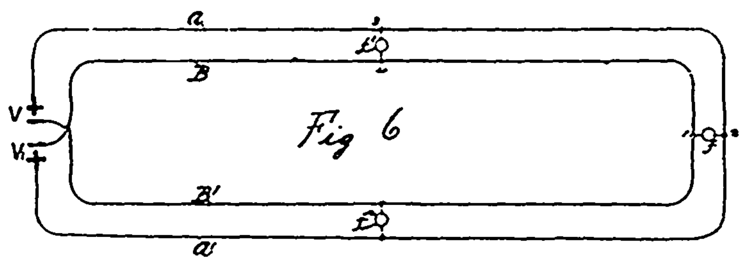


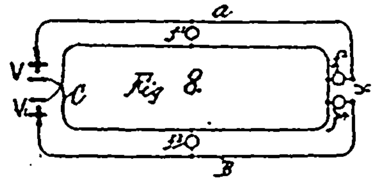


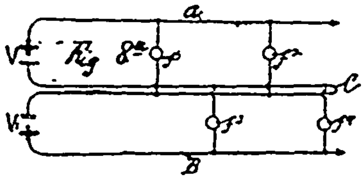












THE GROUNDWORK.

In view of the enormous saving of wire and of lamp life that could be effected by obviating the necessity for a multiplicity of circuits to satisfactorily supply various groups of consumers more or less irregular in their demands, the securing of a uniform E.M.F. at all points of a distribution system is manifestly desirable; and as from what has just been implied it would appear this desideratum can be economically attained, it is thought worth while to present the subject somewhat in the light of a theoretical study, in order that the writer's notions of what leads up to the practical conclusions arrived at may be clearly conveyed. It will be well, therefore, to give some consideration to

THE PRINCIPLES INVOLVED.

The simple parallel or two-wire system is illustrated in Fig. 1. It will be seen on examination of this figure that the potential difference between the mains A B will fall, owing to absorption of E.M.F. in the mains, the further a given point along their length is removed from the source of current. Hence a lamp or other instrument connected in derived circuit across the mains at 3, 4, will be operated upon by a lower E. M. F. than one connected across the mains nearer the source as at 1, 2, would be.

To obviate this difference in fall of potential the simple parallel system is modified, as illustrated in Fig. 2, wherein one of the mains (B) is doubled back upon itself, and the connections are made between the single main (A) and the half of the doubled one (B) that is furthest from the source of current (V). Comparing this arrangement with that shown in Fig. 1 it will be seen that whereas in Fig. 1 a lamp or other instrument connected across the mains at 1, 2 being nearer the source of current as measured along the mains, will receive more E M F. than the one connected across at 3, 4, which is further away; the lamp at a corresponding point 1, 2, in Fig. 2, will only receive the same amount of E.M.F. as the one at 3, 4, because the same total length of conductor as measured along the mains is between them and the source of current.

Hence, with a conductor of the same sectional area connecting similar sets of lamps or other instruments at corresponding distances, it is evident that when the circuits are arranged in simple parallel, as in Fig. 1, the lamp in a derived circuit nearest the source will receive more current than the one furthest away, and when the circuits are arranged with the doubled main, as in Fig. 2, a uniform current will be supplied to the lamps in the several derived circuits, but this current will not be greater than what is received by the furthest lamp in the former case.

The only result obtained, then, by doubling the length of one of the mains, is the absorption of the E. M. F. that would otherwise operate in excess on any lamp or other instrument in circuit (derived) near the source of current. The additional length of conductor in this doubling of one of the mains is thus shown to be a mere dead resistance in the circuit. This dead resistance with its attendant disadvantages however, it will now be shown, may be eliminated by an adaptation of the fundamental principle that *in a circuit supplied with E. M. F. from more than one source, the current or amperage developed at objective points in such circuit is proportionately contributed to from the several sources of the E. M. F.* An exposition of this principle is afforded by Fig. 3, and it will facilitate explanation to regard the internal resistance of the generators V, VI, as negligible; and consider only what takes place in the mains A, B, and the lamps or other instrument connected across them at F.

Putting the figures for the generators or sources of current V, VI, at 100 volts each, the total resistance of the mains A, B, at 1 ohm, and the resistance of the lamp or other instrument through which the circuit is completed, at 99 ohms, the current developed with only one of the generators (V) connected in circuit is $\left\{\frac{100 \text{ volts}}{99+1 \text{ ohms}}\right\}$ 1 ampere, and its production (1 x 99) 99 volts is absorbed in the lamp or other instrument F and (1 x 1) 1 volt is absorbed in the mains A, B. If now both of the generators V, VI, are connected in parallel, in the circuit as shown, the potential difference of 100 volts at their junction with the mains A, B, will remain unaltered. The current developed in the circuit, and the allotment of absorption will therefore remain the same as before; but it is evident that in this case the work is shared by the generators V, VI. The out-put of each of them respectively is only half of what it would be were it acting alone, and the practical effect is the same as if the circuit resistances were doubled by the presence of the second generator.

Bearing this in mind, a further view of the fundamental principles involved will be found in a comparison of Figs. 4 and 5.

When a double circuit is arranged, as in Fig. 4, with a single source of current, V, it is evident that the current generated by V will circulate in both divisions of it; +V, F, A, B, V−, and +V, F, A', B', V−, and if the circuit wires A, B, and A', B', are alike, the amperage will be the same as if there were but a single circuit with a wire (A, B,) of twice the sectional area of A, B, or A', B'.

From this it follows that when a double circuit is arranged, as in Fig. 5, with two equivalent sources of current V, VI, the resultant amperage manifested in the lamp or other instrument F, conjointly supplied by them, will be determined not by the separate resistances of the two divisions but by the joint resistance of the circuit wires A, B, and A', B'. Hence with a double circuit so arranged, the wires used need have only half the sectional area of what would be required in a single circuit to produce the same result.

It is seen then with the aid of these figures, 3, 4 and 5, that in a double circuit supplied with current from two equivalent sources, the current emanating from either source is only half of what it would be were it operating alone in a circuit of the same resistance. It is further seen, however, that the halving of the E.M.F. from each source begins only at the point where the leads from the sources of current connect with the conductors in which the currents conjointly operate; hence, the half of the current is in each case transmitted by the full E. M. F. from its source. And it is also understandable from the foregoing that the total amount of absorption or drop of the E. M. F. in the leads, from the sources of current up to the point of junction with the conductors that convey the current to the lamps or other instruments, is determined by the joint resistance of these leads and is, therefore, only half of what it would be were the current transmitted from one source alone.

THE TWO-WIRE PLAN.

Now with these three conditions obtaining, it becomes practicable to arrange a complete system of distribution according to the plan of Fig. 6, and it is something remarkable to find, as will be seen from a merely superficial inspection of that figure, that the method thus evolved virtually consists in splitting the two mains of the simple parallel system described in Fig. 1, so that four wires, of the total sectional area of the two therein shown, are obtained, and these are so connected with the sources of current that an equalization of potential is secured throughout the system without involving the use of the additional volume of conductor comprehended by the doubling of the main B, in Fig. 2, that has heretofore been necessary to attain the same end. For, to follow up the examination, if, in Fig. 6, the point of junction, of the leads from the sources of current, V, VI, and the circuit to be supplied, is taken to be where the lamp F is connected across, it will be seen that the + phases of the currents from V, VI, traverse the mains A, A, to the point 2, while the − phases of the currents traverse the mains B, B', to the point 1; and these + and − phases conjointly produce, through the joint resistances of A, A', on the one hand, and of B, B' on the other hand, a potential difference between the points 1, 2, that will affect the lamp or other instrument in derivation (connected across between the mains) at F, in precisely the same way and to the same degree that it would be affected were + and − phases received from V alone through a single pair of conductors the sectional area of which corresponded to the combined sectional areas of A, A', and B, B', or twice the size of A, and twice the size of B. Again, if, in Fig. 6, the point of junction of the leads from the sources of current and of the circuits to be supplied, is taken to be where the lamp, F', is connected across, it will be seen that the difference of potential between the points 3 and 4 is the same as between 1 and 2, and obviously the same potential difference will be found everywhere throughout the system, because the conditions of the current distribution from each of the sources, V, VI, is precisely the same as that already described at length with Fig. 2: for the same total extent of conductor exists between the points 3 and 4 and the sources of current, V, VI, respectively, as exists between the latter and the points 1 and 2. Hence, the effect of the currents emanating from the sources V, VI is uniform throughout the mains, and the equalization of the difference of potential is rendered absolute.

THE THREE-WIRE PLAN.

It will now be in order to go on and find that what has been thus far under consideration as adapted to a two wire system, is equally adaptable for current distribution according to the well known three-wire system, thereby securing for it an equalization of potential difference at all points.

The distinguishing feature of the three-wire system represented in Fig. 7, as compared with the simple parallel, Fig. 1, is that in the three-wire system the current for a given number of lamps is transmitted in two circuits, each of them embracing half the number, whereas in the single parallel the whole number is supplied in one circuit.

As at present in operation, there is in the three-wire system (Fig. 7) a fall of potential all along the leads constituting the main conductors from the sources of current. In the figure (7) V, VI, are the two generators or sources of current connected in series between the mains A and B with a neutral return wire C common to them both. It will be understood without repetition, what has already been gone over, that the action obtaining in either circuit is the same as what obtains in the simple parallel, Fig. 1, and what is needed to be introduced is the equalization of the potential difference between the mains as affected by the plan described with Fig. 2. This combination is effected in a practical way as represented in Fig. 8 (Fig. 8a shows electrically the same combination but in a form that can hardly be looked upon as practically available) and it will readily be seen in view of what has already been established by the aid of Figs. 1 and 2, that the neutral return wire, although doubled, is still common to both circuits for the currents emanating from V, VI, while at the same time the lamps or other instruments F1, F2, and F3, F4, are all equidistant from the sources of current as measured along the conductors, and are therefore supplied with current at a difference of potential which is the same for all points of the system.

By this combination, therefore, the three-wire system is made to afford the same advantageous result as is attained by the other method of construction that has been considered, but it will be seen that it is arrived at in a distinctly different way in each case, and is due to the operation of two different principles underlying the problem of current distribution. For, according to the first method, each of the two sources of current contributes half of the resultant current operating in each and every lamp or other instrument embraced in the system; while according to the method comprehended in the three-wire system each of the two sources of current separately supplies half the number of lamps or other instruments embraced in the system, supposing the total number to be evenly divided between the two circuits. At the same time it is seen that this combination whereby the equalization of potential difference is secured for the three-wire system virtually consists in separating the sources of current, V, VI, and introducing between them (Fig. 8 or 8a) a loop constituting a return conductor common to both circuits, instead of having them joined directly in series (Fig 7) and tapping the junction with a single conductor to complete the circuits as heretofore. And again it so works out that the arrangement of circuits shown in Fig. 8, while, as we have seen, depending on totally different conditions for its operation, is precisely the same as that shown in Fig. 6, excepting that the outer main, A, A1, is cut or divided at the point X. This disruption throws each of the two sources of current, V, VI, into separate circuits, and obviously it is immaterial, as far as the operation is concerned, whether the sources, V, VI, are opposed or in direct series, but it is preferable to put them in opposition, as shown in the figure, in order to obviate the excessive potential difference that would otherwise obtain between the ends of the loop common to both circuits and necessitate the doubling of its sectional area for a given drop in the E. M. F. transmitted. Similarly it is recognizable that the electrical conditions obtaining in the arrangement of circuits shown in Fig. 6 would obtain in the arrangement shown in Fig. 8a, if the extremities of the mains, furthest from the sources of current, in Fig. 8a were joined together. If so arranged, however, the circuits would evidently be complicated and unwieldy, whereas when arranged as shown in Fig. 6 and Fig. 8 the circuits according to

BOTH PLANS

are simple and flexible and afford the greatest degree of convenience, in that two wires, leads or mains, may be carried from the sources of current in any desired direction through a given building or district and by another route returned to the sources of current, and these two mains may be tapped at any number of points and the same potential difference will be found to obtain between them at all points, whether in close proximity to, or at the furthest distance from the sources of current. Hence, there is hereby afforded a means for knowing at a supply station the actual conditions of supply at any moment in a given circuit; for, if an indicator of any suitable description is connected between the mains at the station, it will show the difference of potential obtaining, and if the circuit demands an increased current at any time, the fall of potential difference due to increased absorption of E. M. F. in the mains will be instantly shown by the indicator which will necessarily be affected in a measure corresponding exactly to what is taking place at every point throughout the system. It will of course be readily conceived that as regards the sources of current, these may be of any form of direct current generator or may be the secondary wires of separate converters or transformers, or separate secondary wires on a single converter, the primaries or primary of which are or is in circuit with a source or generator of alternating currents, and that this method of circuit construction constitutes at once, in either of its forms, Fig. 6 or Fig. 8, a system for the distribution of current direct from a generating station, or a system for either primary or secondary circuits or both primary and secondary circuits for alternate current distribution.

A STEP FORWARD

Now, having got to the bottom of the whole idea and acquired an exact knowledge of the results attainable by an arrangement of circuits in either of the two ways described, we can rise to a proper appreciation of its utility, and the first question to be asked will naturally be: How is it, this method of circuit construction has not been heard of in practice? Well, the fact of the matter is it hasn't had a chance to put in an appearance. In the shape here presented for consideration, it may not improperly be regarded as something brand new and original. It is offered in that sense. But the surprising fact obtains that one of the plans has already reached the hoary age of three years, for precisely the same arrangement of circuits as is shown in Fig. 6, is found to have been anticipated in a U. S. Patent granted as far back as 1891. Unfortunately for its development the plan as patented appears to have been arrived at along a line of reasoning different from that which has been followed in this paper, and the specification shows that the inherent virtue of the arrangement has been handicapped by a little over-dressing in the shape of a "preferred form" comprehending a cross-wire that practically relegated the improvement back to the operative conditions of the simple two-wire circuit. While this is to be regretted, it cannot be said to have done any more harm than a dam does to a river. Water eventually finds its level, even if driven to the opening up of new channels to that end, and in the same sense the attainable in our electrical field forces its way through our minds and brings whatever is of utility to the surface. That's how it comes about that inventions are re-invented and conceptions are re-conceived. In the present instance, the writer was for awhile under the agreeable impression that the method we have been examining according to both plans had been devised solely by himself, until it was found some of the ground had been already covered in the way that has been mentioned. However, it is hoped a step forward is about to be achieved. The opportunity to bring the matter to the attention of this useful and progressive Association was embraced with grateful enthusiasm, and if this paper is provocative of any profitable discussion, whatever expectations are entertained of an early and widespread adoption of these plans will in all probability be realized.

ELECTROLYSIS.

By Jas. A. Baylis.

"Electrolysis" has been announced as the subject of my paper, but it is too comprehensive a term to be applied to it as it is to the electrolytic corrosion of underground pipes and electrical conductors by stray earth currents, that I wish to confine my remarks.

During the last year or two the attention of the electrical fraternity, and the public generally, has been frequently and forcibly directed to this subject, and several interesting and valuable articles and papers have appeared in the columns of the electrical press, or have been read before electrical societies. Up to the present time, however, no paper on this important matter has been presented to our Association, and I believe that a thorough discussion of the subject at this meeting will be productive of much good to all interested, if my paper (for which I do not claim much originality) serves as a basis for such discussion, it will have well served its purpose. In preparing it, I have freely consulted the transactions of the various societies and the columns of the technical press, and must acknowledge the great aid they have been to me in so doing. This paper, therefore, is more of a resume of what has been done by others in this field, than the result of personal experience.

One of the first places to suffer from the evil effects of stray earth currents was Boston, Mass. Almost three years ago the New England Telephone and Telegraph Co. found that the insulation of some of their underground cables had broken down; upon investigating, it was discovered that the lead sheathing had been eaten through in spots in some of the manholes. The matter was carefully looked into, and it was proved beyond a doubt that the current from the rail side of the street railway circuit had leaked on to the sheathing of the cables at various points, and leaving the cables at others, had, at the points of leaving the lead, eaten it away to such an extent as to allow water to penetrate to the core, thus destroying the insulation of the wires.

It was soon found that the destruction of the telephone cables was but an item of the damage being done by these stray currents; water and gas pipes were being eaten through in a number of towns in which single trolley street railways were being operated. After careful experiment it was shown that only where the current left the pipes to pass to earth (i. e., where pipes were electro-positive to the earth) was any damage being done. The explanation given and the one generally accepted as correct was that electricity passing through a conducting liquid from the anode to the cathode, decomposes the liquid, and in the case of water which contains enough foreign matter to make it a conductor, the hydrogen is carried, as it were, and liberated at the cathode, while the oxygen is set free at the anode, which, if it be of an easily oxidizable material, will soon be attacked, nascent oxygen being a very active agent.

The truth of this has lately been questioned in a most interesting and valuable paper on this subject by Prof. D. C. Jackson, read before the Western Society of Engineers, July 11, '94. After a series of careful experiments Prof. Jackson came to the conclusion that the oxydation of the metal as before mentioned played an unimportant part in the destruction of the pipes and that the corrosive action was due entirely to the electrolysis of the substances held in solution in the water of the soils. The gravity of the corrosion of the pipe depends on the amount of current flowing from a given area and the nature of the salts in the soil.

What happens in the case of buried pipes is this: the current which has leaked from the rails passes on to the pipes, and will leave them and flow to earth at points from which the resistance of the earth circuit to the power house is less than by the metallic one. The soil of cities contains more or less moisture holding in solution chemicals, which, when their components are set free, are of a more or less corrosive nature.

To decompose acidulated water between two platinum electrodes an E. M. F. of about 1.5 volts is necessary; with lead plates a smaller voltage, and with iron and zinc still less, as the affinity of the metals enters into the reaction. Metals buried in moist earth containing impurities may be about at the point of corrosion, a very slight potential difference being enough to set up marked action. This accounts for the destruction of pipes where only a fraction of a volt P. D. was found between them and the surrounding earth, because the P. D. is under one volt is no surety that action will not take place, not so rapidly or violently of course, but just as surely.

What forces the current to leave the rails and pass to the earth? Undoubtedly because of the too high resistance of the rail circuit, due to imperfect bonding, either the bonds are too small, or, what is more likely, the contacts between the rails and the bonds are not good. Sometimes the rails are connected to the water pipes of a town, if this is done care must be taken to have the water mains connected to the dynamo at the power house, otherwise if the negative pole of the dynamo be grounded or connected to the track, a path of low resistance has been provided for the current to get on to the pipes, but to return to the dynamo it must pass through the earth, and damage is sure to follow.

Very many remedies have been suggested and tried. Here are some of them:—

1st. Grounding the positive pole of the dynamo and putting the negative to line. This only has the effect of changing the location of the district in which the pipes are positive to the earth from the immediate vicinity of the power house to more distant points, and while the action is not so violent, it is spread over a much larger area and the trouble is much more difficult to deal with.

2nd. Breaking the metallic continuity of the pipes and cables has been suggested. This is impracticable, of course, not only because of the enormous expense of changing all the pipes at present in the ground, but from the fact that current would leave one section of pipe, pass to earth, and back on to the next section.

3rd. Frequent reversals of the polarity of the street railway currents. This would only retard the action, not stop it altogether. Various other more or less impracticable remedies have been proposed, but it will be unnecessary to notice them.

The only sure cure for this trouble, as far as we know at present, is in the adoption of some other street railway system than that of the single trolley with track return;

such as a double trolley system, storage batteries, or alternating currents, if a practical motor can be constructed. A method of street railway construction was described by Mr. W. Nelson Smith in the Street Railway Gazette of Feb. 17, '94, which does away with the track return, being practically a double trolley road, operated under the three wire system, using the earth and rails as a neutral. Another system was described by Mr. Nelson W. Perry in the Engineering Magazine for March, '94. Many, if not all, of the proposed underground conduit systems would have as an additional recommendation, freedom from attendant electrolytic effects.

The discussion of the merits or demerits of these various systems, their practicability or impracticability, is outside the province of this paper; suffice it to say, that there seems to be more than one way of operating street cars, without destroying pipes, &c., already under ground.

Nevertheless, the fact remains, that there are very many single trolley roads in operation in this country, and that something should be done to protect the pipes of the municipalities under whose franchises the street railway companies operate.

Absolute protection, as far as is known, it is impossible to have, but to ensure the greatest freedom from destructive action, the track circuit must be of the lowest possible resistance. This can only be accomplished by the best of bonding and frequent cross connections of rails. Electrically welded rails should be of great service in this connection. The rail circuit should be reinforced by overhead returns connected to the rails at intervals, as is done with the trolley and feeder wires. The negative pole of the dynamo should be grounded, and the various systems of underground pipes connected to it by conductors of large carrying capacity.

These are the principal safeguards that can be adopted.

The telephone companies having underground wires have been among the sufferers from the electrolytic corrosion of the lead of their cables, and a brief description of the method used in the United States for their protection may be of interest.

A map of the underground conduits and manholes is made, and on it are marked the differences of potential between the cables in the manholes and the earth, also the direction of the current, whether to or from the cables. In this way the "danger district," or section where the cables are positive to the earth, may be seen at a glance. In this district, the sheathings of the cables are carefully connected together by large wire, and a heavy wire (or wires) is run from the negative pole of the dynamo, which is to ground, to the nearest manhole in the danger district, and if the current is of great volume, to several of the manholes. As far as I know, in every case, this has changed the direction of the current, causing it to flow from the earth to the cables, thus giving adequate protection in an inexpensive way. Unfortunately all pipes cannot be protected to the same extent in the same way, and the responsibility of doing proper track construction rests with the street railway companies.

Finally, because in a town there may be but small differences of potential between pipes and the surrounding earth, and decomposition of them does not set in as soon as the street railway current is turned on, we should not be deceived into a feeling of false security, for though the destructive action may be slow in coming, come it will, none the less surely.

NOTE ON POSSIBLE REDUCTION OF STATION PLANT ON SMALL ELECTRIC RAILWAYS BY MULTIPLE SERIES CONTROL OF MOTORS.

By John Langton.

The only efficient method of controlling electric street cars is to vary the volts at the motors according to the speed required. The facility for doing this with storage batteries, by means of grouping the batteries differently, is one of the strong points of battery traction. In a trolley or conduit system with constant line pressure the same thing is arrived at by grouping the motors in series or in multiple. With only two motors to deal with, as in an ordinary street car, this makes rather an abrupt stop, which is eased off to a more gradual change by slowing them down by a resistance in series, or speeding them up by cutting out part of the field winding or shunting it by a resistance. This method was used in the early days of electric railroads, but was abandoned, not because it failed to give the results expected, but because it introduced a new complication at a time when there were so many troubles with everything, that simplification was the pressing need. These early difficulties having been surmounted, multiple series control has been successfully revived.

The figure usually accepted for traction on street railway tracks in average condition, is 30 lbs. pull on the drawbar per ton weight of car, moving on a straight and level track. To start the car from rest requires a much greater effort. Dynamometer experiments show a starting pull of from 90 lbs. to 120 lbs. per ton, equal to the traction needed for ascending grades of 3 % to 4½ %.

When the car is started with the motors in parallel, controlled by the simple process of wasting in a rheostat the volts that are not needed at the motor terminals to give the amperes required for the traction, the demand on the station for power is greater when the car is being started than at any other time of its run, except on roads with heavy grades. But putting the motors in series for starting greatly reduces the power required. The torque of the armature, which gives the traction, is a matter of amperes, and with the motors in series the same traction is obtained with one half the current from the line required when the motors are in parallel. The power consumption from start to full speed is rather more than one half, apparently because the accelerating force is more irregularly applied, so that it takes rather longer to get up to speed: or to put the same thing another way, in order to get up to speed in the same time, rather more than half the average amperes are needed for motors in series, as compared with motors in parallel. The actual figures seem to be about two-thirds the maximum power, and two-thirds the total power consumption, in starting and getting up to speed in the same length of time. This method of starting then takes a maximum current, which if divided between the motors in parallel would only give the traction needed for ascending grades of from 1½ to 2 %, and as almost every road has steeper grades than these, the heaviest power demand on the station comes, not from starting, but from moving up grade at full speed. But if we are content to go up such grades at a considerably reduced speed, we can get, as in starting, the necessary traction with half the amperes, by putting the motors in series. The motors are then working with good efficiency on half the line volts and running at about half speed. There is of course no saving in the total power consumption—the energy; the car takes half as much current, but also takes twice the time to cover the distance. But there is a great reduction in the maximum power required, which would be about the same on a 5 % grade with motors in series as on a 2 % grade with motors in parallel, or about the same as the maximum power required for starting with motors in series. The motors must carry the same current in either case and must therefore be the same size, but the maximum demand on the power station from any one car is reduced nearly one-half.

On large roads the principle of averages may be relied on to a great extent, and the station capacity per car may approximate the average power taken by the car, but on small roads it is in general only safe to provide a station capacity per car of very near the maximum car demand. On small roads, therefore, a reduction of the latter means a reduction in size of station plant. Even if the station capacity per car of large roads were appreciably affected by multiple series control it could hardly be availed of. The most valuable reduction is that on grades, which may last for some minutes whilst starting is a matter of a few seconds. But rapid transit is a principal reason of the existence of large electric roads and a prominent source of their income, and they cannot afford to go slowly up hill. For large roads the principal value of multiple series control is the ability to run slowly with good efficiency in crowded streets, and the saving of wear and tear on switch and rheostat at such times and at starting. On small roads with a few cars running on fifteen to twenty minutes headway is more a question of communication than of continuously rapid transit; and, as has been shown, by sacrificing speed up hill a substantial reduction in the first cost of power plant may be achieved, without any sacrifice of ability to run at high speed on the level and low grades. The horse power hours drawn from the station would be the same per car trip in either case, but by easing off the starting current and slowing up on grades, the power would be drawn more uniformly, with the tendency to reduce the variations of load on steam engines. This should give better economy in steam consumption, but it is not at all probable that there would be any noticeable effect on the coal bill. The load diagram of the station would still be badly serrated, but the peaks of the diagram would be of more uniform height, and the highest of them lower than with motors always in parallel.

There is nothing new in this paper, and the facts and conclusions seem fairly obvious, but similar simple engineering considerations are continually either not observed or not appreciated in projected works, with the result of paying an extravagant price for some quality which brings in an inadequate or no return.

CANADIAN ASSOCIATION OF STATIONARY ENGINEERS.

PROCEEDINGS OF THE FIFTH ANNUAL CONVENTION.

The most successful Convention in many respects that the above Association has ever held, took place in Toronto last month. The proceedings of this fifth annual Convention of the Association extended over four days, commencing September the 5th and closing on the 9th. The deliberations of the Convention were presided over by the Executive President, Mr. Geo. Hunt, of Montreal.

The delegates present representing the various Subordinate Associations throughout the Dominion, were as follows:—

J. Robertson, H. Nuttal, and J. Murphy, from Montreal No. 1; R. Drouin and A. Menard, from St. Laurent (Montreal) No. 2; E. C. Johnson and E. Robertson, from Hamilton No. 2; E. J. Philip, A. M. Wickens, W. Phillips, N. V. Kuhlman, and G. Fowler, from Toronto No. 1; Jas. Walker, from Kincardine No. 12; Wm. Jamieson, from Dresden No. 8; W. Wilson, from Peterboro' No. 14; C. J. Jorden, from Guelph No. 5; J. Devlin and R. King, from Kingston No. 10; J. F. Cody from Wiarton No. 13; J. R. Uttley, from Berlin No. 9; F. G. Mitchell and Thos. Mungall, from London No. 5; J. H. Thomson and T. Wensley, from Ottawa No. 7; Arthur Ames, from Brantford No. 4; Thomas Ryan, provincial deputy for Quebec; A. E. Edkins, provincial deputy for Ontario; A. M. Wickens, district deputy for Toronto, and F. G Mitchell, district deputy for London; George Hunt, executive president; Wm. Sutton, executive vice-president; W. G Blackgrove, executive treasurer, Thos. King, conductor, and F. Robert, doorkeeper.

Richard Shapland, London; O. E. Granberg, Montreal; John Campbell, Montreal; J. Langdon, Hamilton; R. Stuart, Hamilton; W. F. Chapman, Brockville; Oliver Shantz, Geo. C Mooring, W. L Outhwaite and others, were present as visitors.

In the absence of Mayor Kennedy, Ald. Burns extended to the Association on behalf of the city of Toronto a hearty welcome, and invited the delegates to take part in a carriage drive and luncheon at Reservoir Park, for which preparations had been made by the Council at 10 a.m. on the following day. He had no doubt they would see much while in the city to interest them and call forth their admiration. He referred to the fact that ex-Ald. Bell, of Toronto, was now a member of the C. A. S. E. The following reply, drafted by Bros. Ryan, Jamieson and King, was read:

"We, the undersigned committee, on behalf of the fifth annual convention of the Canadian Association of Stationary Engineers, held in your city in 1894, in reply to your address of welcome so cordially extended to us by Ald. Burns, beg leave to express the most sincere thanks of our convention for the hearty welcome extended, and the preparations made by you for our entertainment and pleasure during our stay in your beautiful city. We esteem these courtesies all the more from the fact that this is the first time that our conventions have been officially recognized by any civic body in this manner. Trusting that Ald. Burns and confreres may long be spared to look after the interests of the Queen City of the West."

Ald. Burns retired amid hearty applause.

Bro. E. J. Philip, President, of Toronto No. 1, on behalf of the local association, heartily welcomed the delegates. In doing so he referred to the fact that Toronto was the birthplace of the organization, the first association having been formed there with only eight members. The present large attendance was a satisfactory evidence of the growth of the Association.

After the reading and confirmation of the minutes of the last meeting, the following committees were appointed:

Auditing Committee—Bros. D. Robertson, chairman; Robert King, C. C. Robertson, C. J. Jorden and A. Menard.

Constitution and By Laws—Bros. James Devlin, chairman D. Robertson, A. Ames, F. Robert and R. Drouin.

Good of the Order Bros. J. F. Cody, chairman; Robert King, E. C. Johnson, F. G. Mitchell and Ed. J. Philp.

Mileage—Bros. Joseph Robertson, chairman; J. H. Thompson, F. W. Donalson, E. C. Johnson and E. J. Philp.

Credentials—Bro. W. G. Blackgrove, chairman; A. E. Edkins and A. M. Wickens.

The annual address of the President, Mr. Geo. Hunt, read at this stage, was as follows:

I have the honor to welcome you to this our fifth annual convention of the Executive Council.

I do this knowing that your lodges in selecting you as their delegates have done so that you will do what you consider best, and to the advantage of our beloved order; and feeling that it will be the most important meeting ever held by our society, not only on account of the greater number of lodges represented, but also because of the magnitude and importance of the subjects to be brought forward. May our proceedings and deliberations on the various subjects be so conducted as to be to our credit, and that harmony and good-will may prevail throughout our session.

I trust you will accord me the hearty support that has always been granted by you to the occupant of this chair, and which will result in profit to ourselves and increased prosperity to our order.

We have, during the past year, made gratifying additions to the number of our lodges, four of which have been instituted, and my experience has been that the organizers have very generally adhered to the principles of careful selection of members and useful officers, and I here tender my heartfelt thanks to the many brethren who, though often so little known, have quietly spread the tenets of our order, and as a result founded new lodges.

Whilst we have added largely to our membership, substantial progress and improvement has been made in the general conduct of the lodges; the officers perform their duties more intelligently, and the ritualistic and secret work is done better. I am pleased to hear that in many lodges the use of books is not necessary, and when caution is used to avoid straying from the text, the result will be added impressiveness to the ceremony and increased respect for the officers.

There is a growing desire on the part of brethren to make lodge meetings more enjoyable by the introduction of lectures, discussions, music and other educational methods, and I find that where this system has been carried out most successfully there is greater harmony and less unnecessary argument, better attendance, more initiations and a nearer approach to perfection in the work than in lodges that make no effort in this direction.

I am pleased to report that many of the district deputies have done yeoman service, and have been of great assistance to the grand executive.

Some deserve special mention. They have given evidence of an enthusiasm in the performance of their duties and an interest in the well-being and growth of the order, which should earn for them the gratitude of this grand body. I am of opinion that their valuable assistance, and especially the persevering and successful efforts of the majority, have not received the recognition which they deserve.

The order is now becoming too large and widespread to be handled, as in earlier years, directly by the executive, and as a necessary consequence the duties of the district deputies will become more onerous and the office more responsible. It is therefore imperative that the appointments be judiciously made, their duties clearly defined, their annual report duly handed in and their services receive more recognition.

In conclusion brethren, allow me to admonish you to be ever watchful of our order, guard well the doors of the lodge, cause strict examination to be made into the character of all candidates, suffer none to be admitted whose reputation is not pure and spotless. Recollect that the future success of our order depends very much more on the character than the number of its members. I feel exceedingly grateful to you for the honor conferred upon me a year ago when you elected me to the very honorable position of president of this society, so deserving of the patronage of our fellow-countrymen

Brethren, I have already occupied too much of your time and attention with such remarks as seemed to me applicable to the present occasion, and will, therefore, only add, in closing, that it is my heartfelt wish and desire that your deliberations at this meeting may be so conducted towards each other that whatever we may do will redound to the honor of the C. A. S. E. Commending you to ask wisdom in your legislation from that Great Being who rules and guides us in our every thought of word and work All of which is respectfully submitted.

Bro Edkins presented the report of the committee on credentials, which was found satisfactory

The report of the Secretary, Mr. John J. York, stated there have been formed during the past year five new associations, viz.: Kingston, Winnipeg, Kincardine, Wiarton and Peterboro', with a total membership of 115. All the new associations are founded on the best possible basis, with men of well-known ability, sound judgment and integrity, at the head of affairs. An improved form had been prepared for the use of secretaries of subordinate associations in sending in their semi-annual reports. The system of book-keeping in use by many of the associations was very defective, and something better should be insisted on. Notwithstanding the dullness of the times, the membership and finances of the several branches had increased, as showe by the following statement:

Name of Association.	Members, 1893	Members, 1894	Inc	Dec	Cash, 1893	Cash, 1894	Total Assets, 1894	Liabilities, 1894.
Toronto No 1	80	112	32		$316 14	$467 80	$617 80	...
Montreal No 1	76	75		1	120 17	190 68	806 66	
St Lawrence No 2	60	60			68 92	28 85	40 85	$25 00
Hamilton No 2	35	31		4	2 90	5 45	163 59	76 30
*Stratford No 3								
Brantford No 4	15	15						
London No 5	25	15		10	11 52	5 11		
Guelph No. 6	16	16			32 51	11 11		
Ottawa No 7	33	36	3		45 85	52 86		
Dresden No 8	18	17		1	66 16	23 22		
Berlin No. 9	14	12		2				
†Kingston No. 10		39						
Winnipeg No 11		40						
†Kincardine No. 12		7				1 05	6 80	0 63
†Wiarton No. 13		15						
†Peterboro No 14		14						
	372	504	132					

* No report.
† New associations.

The report was received and referred to the Auditing Committee.

The annual report of the Treasurer, Mr. W. G. Blackgrove, for the year ending September, 1894, was as follows:

Receipts.

8th Sept., 1893,	balance on hand	$210 71
13th " "	stationery (Berlin)	70
28th Oct., "	per A. E. Edkins, Kingston charter	15 00
12th Jan., 1894,	Toronto No. 1 per capita tax	22 50
13th Feb., "	cash, J. J. York, ex-secretary	96 50
15th June, "	per A E. Edkins Wiarton and Peterboro charters	30 00
9th July, "	A. M. Wickens, Kincardine charter	15 00
24th Aug., "	stationery Toronto No 1	1 40
30th " "	Toronto No. 1 per capita tax	28 00
3rd Sept., "	cash, J. J. York, ex-secretary	120 61
		$540 42

Disbursements.

9th Sept., 1893,	mileage rates	$161 55
" "	rent of hall for convention	5 00
2nd Nov., "	A. E. Edkins, expenses, Kingston	2 00
4th Dec., "	J. J. York, for emblems.	50 00
8th Feb., 1894,	" postage and express	5 23
9th July, "	A. M. Wickens, expenses, Kincardine	9 50
25th Aug., "	Toronto No. 1, on account	25 00
		$258 28
	Balance cash on hand	282 14
		$540 42

The report was referred to the Auditing Committee.

On motion of Bro. Edkins, seconded by Bro. King, it was decided to send, through the President, a telegram of congratulation to the National Association of Stationary Engineers of the United States now sitting at Baltimore. The Executive Secretary read a letter from that Association regretting their inability to be officially represented at the dinner, but wishing the sister organization all prosperity.

A letter of regret was read from Bro. Hartenstein, of Montreal, who could not be present.

An invitation was given the members by Bro. Philp to inspect the steam and electric plant of the T. Eaton Co.

The committee on good of the order reported recommending that the charter for Brandon be recalled, and that a new charter be issued in the case of Portage la Prairie, should a branch be formed there. In the case of the Stratford branch, it was recommended that the district deputy be asked to visit them, with a view to reviving the branch.

The report was adopted.

The district deputy for Quebec, Bro. Ryan, stated that he expected to organize associations shortly at Sherbrooke, Quebec and Levis, and an interesting winter's work was in prospect.

The district deputy for Ontario, Bro. A. E. Edkins, reported that new associations would probably be formed at an early date in Brockville, Carleton Place, Chatham, and other Ontario towns.

Mr. W. F. Chapman, of Brockville, announced his purpose of doing all he could to institute an association in that city.

EVENING SESSION.

At the open session in the evening, papers were read by Bro. J. Murphy, of Montreal, on "Steam Jackets and Steam Separators," and by Bro. O. E. Granberg, of Montreal, on "Stationary Engineers, Real and Imaginary," for which the authors received a hearty vote of thanks. At 9.30 a visit of inspection was made to the power station of the Toronto Electric Light Co.

SECOND DAY.

Wednesday was enjoyably spent in viewing the city and the Industrial Exhibition from carriages placed at the disposal of the visitors by the City Council, luncheon being partaken of at Reservoir Park. In the Board Room of the Industrial Exhibition Association, an interesting paper was read by Bro. A. E. Edkins, on "Injectors," which will be found on page 120 of this issue.

THE ANNUAL DINNER.

The annual dinner took place in the spacious dining hall of the Palmer House on Wednesday evening, and was an occasion of much enjoyment. The chair was occupied by Bro. E. J. Philip, President of the local association. Among the visitors were Mr. Joseph Tait, ex-M. P. P., and Mr. J. J. Wright, Manager Toronto Electric Light Company, and President of the Canadian Electrical Association. Letters of regret were read from Mayor

Kennedy and Mr. O. P. St. John, President of the Marine Engineers' Association.

After sufficient time had been given for the discussion of an excellent menu, the lists of toasts was proceeded with. The toasts, "The Queen," and "Canada Our Home" were honored by the singing of the National Anthem and The Maple Leaf.

Mr. Joseph Tait in replying to the latter toast, referred to his efforts to secure the legislation which the Association desired, and regretted that he had not been more successful. Such legislation was now difficult to obtain owing to the abuse of their privileges by certain classes.

A fitting acknowledgement of the toast "Toronto, the Queen City of the West," was made by ex-ald. Bro. Wm. Bell.

Mr. Samuel Rogers replied on behalf of "The Manufacturers," expressing his sympathy with the men, who in this organization were endeavoring to educate and fit themselves for higher positions. By keeping a good purpose before them, he trusted they would find chances of climbing up the ladder, and that they would all achieve an honorable position in life.

Mr. John J. Main, responding to the same toast, said he could observe in the faces of the members of the Association year after year their growing intelligence. The Association should bring young men in, and try to educate them and make them capable.

The toast to "Kindred Societies," was responded to by Mr. J. J. Wright, who extended an invitation to as many of the members as could do so to visit the convention of the Canadian Electrical Associaton in Montreal—by Mr. J. C. McLean, of the Toronto street railway, and Mr. John Campbell, of the Montreal street railway.

"The Executive" was responded to by Bro. Hunt, Executive President, who said that while at one time the fate of the Association seemed to hang by a slender thread, it was now on a satisfactory and progressive basis.

The Canadian Association of Stationary Engineers drew responses from representatives of various associations.

Bro. Wickens mentioned as an illustration of the growing importance of the engineers, that out of about 9,000,000 horse-power on the continent of America at present nearly three-quarters was the growth of the last ten years. The constant developments of machinery required the engineer to be studying all the time, and this was where the usefulness of an association came in.

Bro. York could say to young men that his knowledge of engineering had increased 100 per cent. since he became a member, and he could assure outsiders that their minds would never be narrowed nor their intelligence decreased by being in this Association Young members should never be ashamed of asking questions, as it was by this means that knowledge was gained and new points brought out in discussion.

Mr. Drouin on behalf of St. Laurent No. 2, of Montreal, acknowledged the kind hospitality extended to him, and regretted that his limited knowledge of English did not enable him to speak at greater length.

Bro. Shapland, of London, Bro. Green, of Guelph, Bro. King, of Dresden, and Bro. King, of Kingston, also responded, giving encouraging accounts of the work being done by their Associations.

Bro. A. E. Edkins, replying to the toast "The Ontario Association of Stationary Engineers," sought to remove the misconception that the Ontario Association was an organization entirely separate from the C.A.S.E. and proceeded to explain the objects of the bill passed by the Ontario Legislature under which the O. A. S. E. was formed. In Quebec, they now had a government licensing law which is compulsory and no doubt that law would be the means of raising the standard of qualifications of engineers in that province. If Ontario would pass an act under which the government would issue certificates, they would be willing to let the Ontario Association lapse in its favor.

The Executive Secretary, Bro. York, then read the following reply to the address of welcome presented by Toronto No. 1:

E. J. Philip, President, Toronto No. 1.

DEAR SIR AND BROTHER,—We, as a committee appointed by the 1894 Convention of Canadian Association of Stationary Engineers, on behalf of that convention, tender to you, as representative officer of Toronto No. 1, our cordial thanks for your hearty welcome extended to this convention. And also their very great appreciation of the efforts of your entertainment committee in providing a programme for the entertainment and amusement of this convention—a programme which has certainly never been equalled and could hardly be surpassed. On behalf of the convention, we trust they will accept our sincere thanks.

Committee—Thomas Ryan, William Jamieson, Robert King.

At intervals during the evening a number of excellent sentimental and comic songs were rendered by Messrs. Geo. Grant, James Fax, John Alexander, and W. G. Blackgrove to whom a hearty vote of thanks was tendered.

THIRD DAY.

Thursday was pleasantly and profitably spent at Niagara Falls, under the direction of the following Committee:—Bros. A. E. Edkins, E. J. Philip, Wilson Phillips, W. L. Outhwaite, J. Fox, Wilford Phillips, J. C. McLachlan, J. G. Bain, W. G. Blackgrove, W. Bell, with A. M. Wickens as chairman, H. E. Terry, secretary, and Geo. Fowler, treasurer. The trip was made on the steamer Chippewa and over the Niagara Falls Park and River Railway. The power canal of the Cataract Construction Co., was inspected under direction of the engineer in charge, Mr. DeCourcey May.

On the Canadian side the power stations of the Niagara Falls Park and River Railway Co. were also visited and inspected under the guidance of Mr. Ross Mackenzie, the manager, J. C. Rothery, Assistant Superintendent, and W. Phillips, Mechanical Superintendent.

FOURTH DAY.

The convention re-assembled for the completion of its business at 10 a.m. A report was handed in by the Committee on good of the order, advising against the adoption of the proposal to issue graded certificates to members. The report was adopted after some discussion.

The Committee on Constitution and By-Laws reported as follows:

1 Your committee recommend that Sec 1., Art. 5, be amended to read thus. "That it be constitutional hereafter to have the nomination of candidates for office on the executive council precede the election of said officers, and may be taken up at any time after the opening of the annual convention, providing notice thereof has been given."

2 Your committee recommend that a new section be added to Article II., to be known as section 2, whereby subordinate associations shall issue to any member in good standing a withdrawal card, which, upon presentation thereof, shall entitle the holder to the full privileges and membership in any other association in the locality to which he may remove without the payment of initiation fee, and that Article II., section 1, on the laws of subordinate associations, be so amended

3 Your committee also recommend to this convention that the executive committee formulate some scheme of insurance and benefits for members; the executive to be instructed to draft such scheme, and that the secretary of this convention notify each of the subordinate associations of the same not later than two months previous to the annual convention next ensuing.

4. That Article IV, sec 2, on the laws of subordinate associations, be corrected, also that sec. 2 of same article (which is omitted from one edition of the constitution) be inserted, and that Art. III., section 4, be amended by erasing all after the word "each," and inserting instead the words "semi-annual."

It is the opinion of your committee that the rule appointing district deputies be more closely adhered to, there being no need for provincial deputies A certain number of district deputies should be appointed at each convention, such appointments to be made by vote of the convention.

The first paragraph was thrown out, as well as the second and third clauses. The fourth clause was adopted.

The appointment of deputies was declared to be the prerogative of the President.

The auditors reported having found the books and reports correct, and recommended a refund of \$3.87½ to Kingston Association of per capita tax.

The receipts of the souvenir were reported by Bro. York to be \$842.50, and the estimated profit \$300; this profit to be applied to defraying the expenses of the present convention.

Ottawa was chosen as the place of next meeting.

The following are the officers elected for 1894-5:

President—John J York, Montreal.
Vice-President—W. G Blackgrove, Toronto (acclam.)
Secretary—James Devlin, Kingston (acclam.).
Treasurer—Duncan Robertson, Hamilton (acclam.).
Conductor—E. J. Philip, Toronto.
Doorkeeper—J. F Cody, Wiarton.

Upon the installation of officers, the newly-elected president appointed the following as district deputies.

For Quebec—O. E Granberg, Montreal.
For Ontario—A. E Edkins, Toronto.
For Manitoba—Chas C. Robertson, Winnipeg.

The proceedings were brought to a close with the presentation to Bro. Hunt of a jewel in recognition of his valuable services as President, followed by brief speeches from the newly-installed officers.

THE TORONTO INDUSTRIAL EXHIBITION.

BELOW will be found particulars of some of the exhibits at the recent Toronto Industrial Exhibition in which the readers of the ELECTRICAL NEWS are likely to be most interested :—

The Ballard Storage Battery Co., of Toronto, made an interesting show of fans, worked on the storage system, as well as a surgeon's battery.

Robin & Sadler, of Montreal and Toronto, presented an attractive showing in the east end of the Machinery Hall, of samples of all kinds and sizes of leather belting, laces, belt dressing, &c.

Kay Electric Works, Hamilton, had a well arranged and instructive exhibit, showing a 20 H. P. dynamo—an exciter for the alternator which worked the welding and heating machines, and for heating iron in water.

The Canadian Mineral Wool Co., Ltd., of Toronto, presented neat compact samples of their asbestos goods, steam packings, cotton waste, gaskets, steam and boiler covering. The Company is now manufacturing its wool in Toronto, thus reducing the cost of its material.

The Dodge Wood Split Pulley Co., of Toronto, placed before prospective purchasers a large variety of their well known split pulleys; also for the transmission of power and for hoisting purposes their tallow laid manilla ropes. They have specially made a new pulley for dynamos and motors. All their pulleys were running at high speed and attracted a good amount of attention.

The Johnson Electric Co., of Toronto, exhibited four motors, driven by the Wheelock engine which furnished the motive power to light the Main Building. The Company also provided the incandescent lights by the National alternator, producing 1,000 lights—the machine making 1350 revolutions to the minute. They likewise showed nine motors from ⅛ to 5 H. P., search light, &c

Barber & Watson, of Meaford, Ont., had on exhibition one of Barber's Canadian Turbines, which is apparently easy to handle, quick to respond, steady and sturdy in motion. The firm also manufacture gearing, hangers, shafting, pulleys, saw mill machinery and machinery and castings of all kinds. They have had an experience in the above lines of trade extending over a period of 26 years.

The Bell Telephone Co., of Montreal and Toronto, had a fine exhibit, very tastily arranged, in the Main Building, showing, besides the usual full lines of every kind of electrical appliances, a new keyless fire alarm box and a fire alarm for hotels. The Company manufacture in their factory in Montreal all the various apparatus connected with telephone and electric work. They fitted up the police patrol system in Montreal.

William C. Wilson, of Toronto, had an attractive display in the Machinery Hall of all kinds of lubricating oils and grease, engine packing, belting, electric carbons, cotton waste, &c., also samples of ammonia oils—the latter being subjected to a very high cold test and being specially prepared for ice makers and brewers. Mr. Wilson's stand was well arranged and decorated with electric lights, which showed off his exhibit to advantage.

F. E. Dixon & Co., 70 King St. E., Toronto, showed samples of different kinds of belting—round belts, rubber belting, cotton and lace leather, belt studs, twisted raw hide belting, and their Goodyear welting. The firm supplied the 18-inch double belt which was driven by the 40 H. P. engine belonging to the Johnson Electric Co. to run part of their machinery, and during the time of the Exhibition it had been in use it had not stretched.

The Wm. Hamilton Manufacturing Co., Ltd., Peterborough, Ont., had on view the "Boss Turbine Water Wheel," which they claim gives the highest percentage of useful effect for every cubic foot of water used. It is made in dry sand, having smooth, even surfaces. The improved water wheel governor made by this Company is claimed to be the most simple, durable and efficient in correcting rapidly any disturbed motion of machinery driven by water power.

The Northey Manufacturing Co., Ltd., of Toronto, exhibited in the Machinery Hall several of their well known pumping engines. The one that attracted most attention from those practically interested, was their Underwriters' Fire Pump, the dimensions of which were 14 x 7 x 12, giving a capacity of 500 gallons of water per minute—equal to 2 1⅛ inch smooth nozzle streams—the engine, to produce this result, was driven at the rate of 70 revolutions per minute. The Company also showed an independent condenser, capable of supplying the wants of any steam engine of 200 H. P.; a brewer's air pump, with automatic regulator, as well as several small duplex feed pumps.

The town council of Millbrook has appointed a deputation to inspect the lighting plants of various towns prior to purchasing the necessary plant to light the town.

The street railway of St. Thomas, Ont., is said to have been purchased by Mr. Henry Everett, of Cleveland, Ohio, who is also interested in the Toronto and Montreal street railways. It is reported to be the intention to convert the railway into an electric line next spring.

Rumors have been abroad during the last few weeks pointing to the sale by the Royal Electric Company of their manufacturing business. The General Electric Co., the Montreal Gas Co., and the Stanley Electric Co., of Pittsfield, Mass., have all been mentioned as among the probable purchasers. Senator Thibeaudeau, President of the Royal Electric Co., has stated that there is no truth in these rumors.

At the annnual meeting of shareholders of the G. N. W. Telegraph Co., held in Toronto on the 26th of September, the following gentlemen were re-elected as the Board of Directors and Officers of the Company for the ensuing year: H. P. Dwight, Toronto, president and general manager; Adam Brown, Hamilton, vice-president; Hugh N. Baird, James Hedley, A. S. Irving, W. C. Matthews, Toronto; Richard Fuller, Hamilton; Hon. William McDougall, Ottawa; Charles A. Tinker, New York; secretary, and auditor, George D. Perry; treasurer, Arthur Cox.

SPARKS.

An incandescent lighting plant is being installed at Midland, Ont.

The construction of a new telegraph line from Rat Portage to Fort Francis, is talked of.

The Peterborough Electric Light Co. will, it is said, establish a lighting plant at Tweed, Ont.

The electric lighting plant at Kemptville, Ont., was recently purchased by Mr. J. J. Collins, of Ottawa.

An amalgamation has been consummated of the two electric lighting companies at Sydney, Cape Breton.

The Calgary Water Power Co. have lately installed and put in operation in that city, an arc lighting plant.

It is said to be the intention of the Bell Telephone Co., to extend their system throughout Southwestern Manitoba.

A joint stock company is said to be in process of formation at Windsor, Ont., to manufacture signals for electric railways.

The Waterloo Farmers' Alliance Telephone Co., after having been in business three years, have sold out to the Bell Telephone Co.

An electric railway is talked of to connect Galt via North Dumfries, New Dundee and Haysville, with New Hamburgh and Baden.

Mr. W. C. Harriston has purchased from Mr. H. G. Buck, the electric light plant and business at Norwood, Ont., and is erecting a new station.

The citizens of Summerside, P. E. I., have voted down the proposition that the council should purchase and operate an electric lighting plant.

Owing to some irregularity in the tenders submitted for an electric light plant for the town of Kincardine, the council decided to invite new tenders.

Messrs. F. H. Sleeper & Co., of Coaticook, Que., are endeavoring to form a company to supply electric light to the towns of Huntingdon and Ormstown.

Petitions are being circulated and signed at Ottawa, asking the council to request the Electric Railway Company to inaugurate a limited Sunday service.

Mr. T. S. Bell, Engineer, of Hamilton, has been employed to report on the possibilities of the water power at Chedoke Falls, for electric lighting purposes.

The Directors of the Hamilton & Dundas Railway Co. have decided to defer changing the line from steam to electricity, until July, 1896, when the Myles lease will have expired.

Mr. Gilbert Johnston, formerly chief engineer, and subsequently master of the steamer Hero, has recently been appointed chief engineer of the Richelieu & Ontario Navigation Co.

The Toronto Street Railway Co. carried 1,936,119 passengers during the recent Industrial Exhibition at Toronto, as compared with 1,797,877 during the same period of the preceding year.

The town of Trenton, Ont., has approved of a by-law to apportion $6,000 for the construction of a power house at the dam on the river north of the town, where it is proposed to generate electricity for lighting and manufacturing purposes.

The township council of York, at a meeting to be held on the 8th of October, will consider the advisability of passing a by-law to authorize the extension of the Toronto Suburban Railway Company's line to the village of Weston.

It is said to be the intention of the Montreal Park & Island Railway Co., to double track their line to Back River and to add six-hundred H. P. to their steam and electric plant. The Company have now under construction in the exhibition grounds, repair shops and car barns.

The ratepayers of the village of Weston have refused to sanction the proposed bonus of $5,000 to the Suburban Street Railway Co., to induce the company to extend their line to that village. Mr. Fraser, the Manager of the Company, states that unless the bonus is granted the extension will not be made.

Incorporation is being applied for by the Cataract Power Company, at Hamilton, for the purpose of conveying power to Hamilton from Niagara Falls. The promoters of the Company are, Messrs. W. H. Glassco, W. Southam, R. Fuller, W. A. Wood, J. W. Hendrie, W. W. Osborne, John Patterson.

After having sent a deputation to inspect the lighting stations of various towns and cities in Canada and the United States, the City Council of Stratford has instructed the fire and light committee of the Council to obtain plans and invite tenders for an electric light plant, to be owned and operated by the city.

The Yarmouth, N. S., Telephone Co. is reported to have earned a net profit on the past year's business of twenty-six per cent. Out of this a dividend of ten per cent. will be paid. The officers of the Company were re-elected as follows: President, H. B. Cann; secretary, E. K. Spinney, and treasurer, J. M. Lawson.

The Montmorency Electric Power Co., of Quebec, have commenced the construction of a new brick and stone building, 95 x 45 feet in size, on Prince Edward Street, in St. Roch's. This building is to be used as a distributing station and for office purposes. It is expected that the Company's new plant will be installed and in operation before the close of the present month.

A handsome new car has been constructed at the General Electric Company's works at Peterboro, for the Kingston Electric Railway Co. The car will be used for special occasions only. It is said that the company will make a new departure by placing this car at the disposal of those who wish to attend the opera, etc , in full dress, and who are willing to pay for extra accommodation.

The town of Magog, Que., has entered into a contract with Mr. LeMay to supply arc and incandescent lights for a period of five years. The price for arc lights is $55.00 per year; for sixteen candle power incandescent lamps, $5.00; and for 32 c. p. lamps, $10.00. A condition of the contract is that 16 c. p. lights are to be furnished to citizens requiring them at a price not to exceed $6.00 per lamp per year.

TRADE NOTES.

Messrs. F. H. Sleeper & Co., of Coaticooke, Que., are installing an electric light plant in the Dominion Snath Co.'s factory, at Waterville, Que.

The St. John Gas Light Co., St. John, N. B., have placed an order for a 2500 light alternating incandescent plant with Messrs. Ahearn & Soper, of Ottawa.

The 2500 light plant purchased from Messrs. Ahearn & Soper, of Ottawa, by the Windsor Electric Light & Power Co., of Windsor, N. S., has been put in operation. The lights are being taken up very rapidly.

The Chambers Electric Light & Power Co., Truro, N. S. are adding to their plant a 90 horse power Robb-Armstrong engine. This makes three of these engines purchased by them during the past two years.

The two electric light companies in Sydney, C. B. have amalgamated, and are increasing their plant by the addition of a 90 horse power Robb-Armstrong engine, and a 90 horse power Monarch Economic boiler.

Among recent shipments by the Robb Engineering Co., Amherst, N. S. are a 40 horse power Robb-Armstrong engine, a 40 horse-power Monarch boiler and a Perfection rotary saw mill to Messrs. John E. & G. Lake, Fortune Bay, Newfoundland.

The contract for the cars and electrical equipment of the St. John, N. B., Railway, has been placed with Messrs. Ahearn & Soper, of Ottawa, who will furnish twelve vestibuled cars with an outfit of two 30 h. p. motors each, of the Westinghouse type. The station equipment consists of two 250 h. p. generators of the Westinghouse multipolar type.

Messrs. Ahearn & Soper, of Ottawa, are very busy with orders for electric railway and electric light apparatus, and their Car Works are turning out large numbers of cars. The latest shipment consisted of twelve cars of various types to the Hamilton, Grimsby & Beamsville Electric Railway Co., and the factory is now at work on a number for Montreal and St. John, N. B.

SPARKS.

A twelve year old son of Mr. John F. Baker, of Kingston, is said to have prepared plans for an engine, and to have made the parts, put them together, and started the machine in successful operation. It is said to be the lad's intention to take a course in electrical engineering at Queen's University.

It is reported that the city of Hamilton will be asked to vote a bonus of $125,000 to aid the construction of the Hamilton, Waterdown and Guelph Electric Railway. The balance of the amount required to build the road is said to have already been subscribed. The total cost of the enterprise is placed at $300,000.

At a meeting of the City Council, of Hull, Que., held last week, an electric railway and lighting franchise was granted to Theophile Viau, and a company will be formed at once to construct and operate the works. The railway scheme will probably embrace branches to Aylmer, nine miles; Gatineau, four miles, and Ironside, five miles.

The Gas Company, of Galt, Ont., have ordered an electric light plant from the Canadian General Electric Co., of Toronto.

The Bell Telephone Co. has purchased property at the southwest corner of Notre Dame and St. John streets, Montreal, and will commence work at once on the erection of a new building suitable for their purposes.

MOONLIGHT SCHEDULE FOR OCTOBER.

Day of Month.	Light.	Extinguish.	No. of Hours.
	H.M.	H.M.	
1......	P. M. 6.20	A. M. 5.10	10.50
2......	" 6.20	" 5.10	10.50
3......	" 7.30	" 5.10	9.40
4......	" 8 20	" 5.20	9.00
5......	" 9.20	" 5.20	8.00
6......	" 10.10	" 5.20	7.10
7......	" 11.00	" 5.20	6.20
8	" 11.30	....	} 5.50
9......	....	" 5.20	
10......	A.M. 12.40	" 5.20	4.40
11......	" 1.50	" 5.30	3.40
12......	" 3.00	" 5.30	2.30
13......	No light.	No light.	....
14......	No light.	No light.	....
15......	No light.	No light.	....
16......	P. M. 6.00	P. M. 7.40	1.40
17......	" 6.00	" 8.20	2.20
18......	" 6.00	" 9.10	3.10
19......	" 6.00	" 10.10	4.10
20	" 6.00	" 11.00	5.00
21......	" 5.50	" 12.00	6.10
22......	" 5.50	A. M. 1.00	7.10
23......	" 5.50	" 1.10	7.20
24......	" 5.50	" 2.20	8.30
25......	" 5.50	" 3.20	9.30
26......	" 5.50	" 4.30	10.40
27......	" 5.50	" 5.50	12.00
28......	" 5.40	" 5.50	12.10
29......	" 5.40	" 5.50	12.10
30......	" 5.40	" 5.50	12.10
31......	" 5.40	" 5.50	12.10
		Total,	204.50

Incorporation is being applied for by the London Electric Co., London, Ont., to manufacture electricity for commercial purposes in that city. The proposed capital stock is $250,000. Among the applicants are Messrs. W. R. Brock, H. P. Dwight, Frederic Nicholls, Geo. A. Cox, Hugh Ryan, Robert Jaffray, and J. J. Kerr, all of Toronto, and M. J. Kent, C. B. Hunt, Edmund Meredith and C. R. Cameron, all of London.

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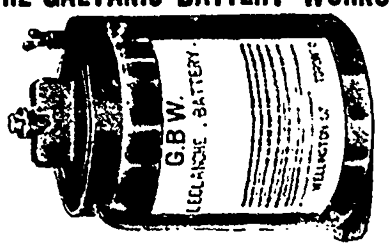

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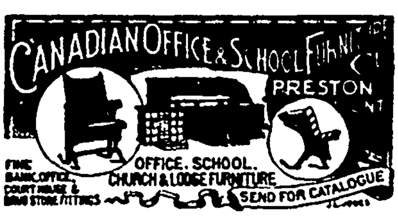

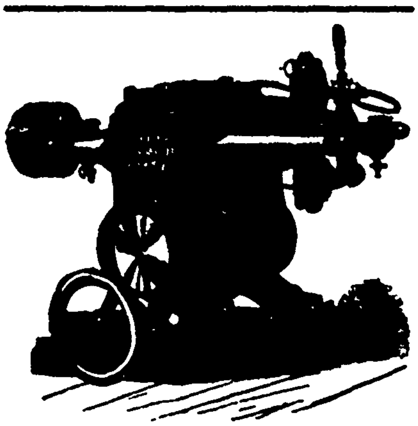

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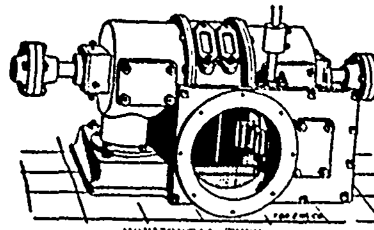

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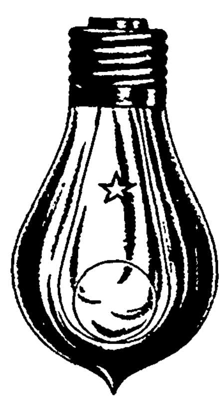

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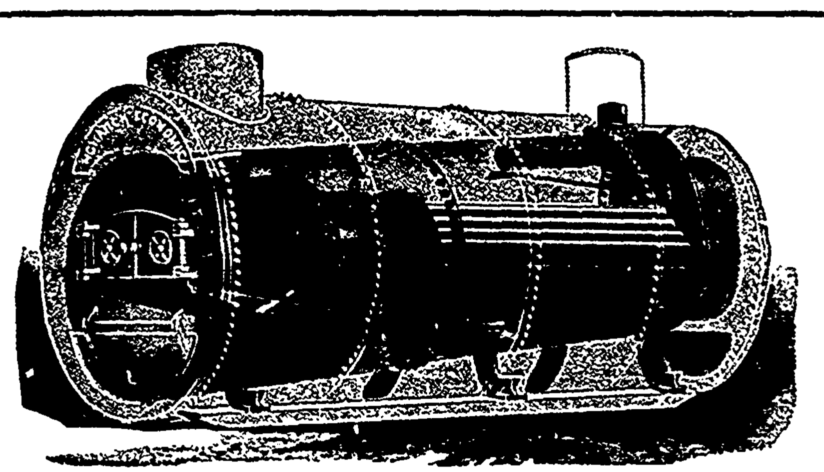

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