Dec. not rec'd Aug K/17/5

Vol. 9
No. 1 TORONTO, CANADA, JANUARY, 1915 $1.00 per year
15c. per copy

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President

C. L. WORTH,
Sec-Treas.

THE CENTRAL RAILWAY AND ENGINEERING CLUB OF CANADA

OFFICIAL PROCEEDINGS FOR JANUARY, 1915

CONTAINS:—

REPORT OF JANUARY MEETING

AND

PAPER ON "ELECTRIC LIGHTING OF RAILWAY CARS"

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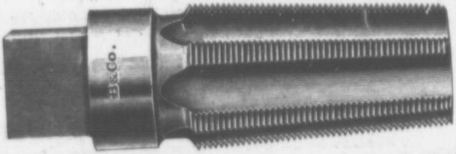

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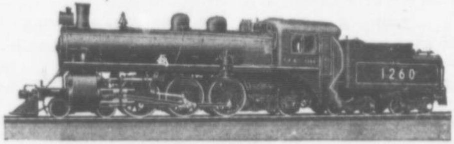

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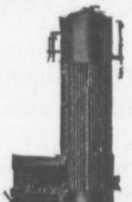

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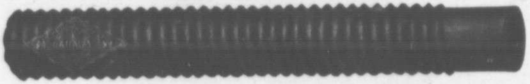

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OF CANADA

OFFICIAL PROCEEDINGS

Vol. 9
No. 1

TORONTO, CAN., Jan. 26th, 1915

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Published every month, except June, and July, August, by the Central Railway and Engineering Club of Canada.
C. L. WORTH, Sec-treas, Room 409, Union Station, Toronto.

Phones: Day, Main 4860.
Night, Hill. 5809.

MEETING OF THE CENTRAL RAILWAY AND ENGINEERING CLUB OF CANADA

COMMITTEE ROOM, HOTEL CARLS-RITE,

TORONTO, Tuesday, January 26th, 1915

The President, Mr. Jas. Wright, occupied the Chair.

Chairman,—

It is time to open our meeting. The first order of business is the reading of the minutes of the previous meeting. As you have all had a copy of these minutes, it will be in order for some one to move that they be adopted as read.

Moved by Mr. G. Baldwin, seconded by Mr. W. S. Cowan' that the minutes of the previous meeting be adopted. Carried.

Chairman,—

The next order of business is the remarks of the President. Gentlemen, I want to thank you one and all for your kindness in electing me to the office of President of this Club. I deem it an honor.

However, one thing I want to tell you is that no man, no matter what his executive ability may be, can achieve any measure of success in an office of this nature unless he has the hearty support of all the members, and I want to ask you to give me your hearty co-operation to make this Club a success during the year 1915.

At the next meeting, February 23rd, Mr. C. McNair, Representative Galena Signal Oil Company, Limited, will read a paper on "Lubrication."

I would like to announce that at the Executive Meeting held some few days ago, it was decided to hold a complimentary Smoker on the 18th of February, in the Odd Fellows' Hall on Bathurst Street. We hope to have a good attendance, and a right royal evening.

MEMBERS PRESENT

Wm. Hosking	G. Coker	G. Smith
J. Hawkins	Jas. Wright	J. Walker
E. Toy	F. Slade	T. B. Cole
S. L. Pearson	Edwin Watt	C. Radford
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J. Dodds	J. McLintock	E. Logan
W. Evans	J. Reid	F. Wickson

Chairman,—

Gentlemen, I have much pleasure in calling on Mr. MacNab who will read us his paper.

ELECTRIC LIGHTING OF RAILWAY PASSENGER CARS

BY E. S. MACNAB,

Car Lighting Inspector, Canadian Pacific Railway, Montreal.

The problem of lighting passenger equipment by electricity is comparatively new on this continent, although in Europe and the British Isles it has been the practice for about twenty-five years. However, the rapid increase in the number of equipments applied in North America, during the last few years, has to a great extent compensated for the relatively late start.

A perusal of Fig. 1 will show the number of electric-lighted cars in service in the United States and Canada in 1911 and 1914 respectively. It is noticeable that in 1911 the Canadian Pacific Railway had only sixty-eight electric lighted cars, whereas this figure has now been increased to three hundred and eighty, which includes one hundred per cent. of the compartment sleepers and observation cars, eighty-five

TABLE SHOWING INCREASE IN ELECTRICALLY LIGHTED CARS, 1911 TO 1914

Railway Company	Number of Cars equipped 1911	Number of Cars equipped 1914	Increase in cars Equipped
Pullman Company	2,400	5,800	3,400
Pennsylvania R. R., E.	902	1,924	1,022
Pennsylvania R. R., W.	516	714	198
N. Y. C. & H. R.	202	1,007	855
N. Y., N. H. & H.	350	410	50
Lehigh Valley	81	384	303
Great Northern	480	650	190
Total in United States	10,925	18,572	7,647
Canadian Pacific Ry.	68	359	291
Grand Trunk	34	164	130
Grand Trunk Pacific	..	72	72
Canadian Northern	14	226	212
Total in Canada	116	821	705

NOTE: Figures of other roads not included.

Fig. 1.

per cent. of the modern sleepers and sixty per cent. the total numbers of diners, the remaining gas lighted cars of these classes are being converted as the cars receive general repairs. The large increases on the Pennsylvania, New York Central and Hudson River, and N. Y., N. H. & H. Railways are probably due to the tunnels by which they enter New York City, gas or oil lighted cars not being permitted to enter either of these terminals. From the foregoing figures it is apparent that there is a strong demand for electric lighting in our passenger cars, and also that the railway companies are meeting it in a liberal spirit.

I will next endeavour to explain the methods adopted in lighting cars by electricity, and I will divide them in three main systems, namely, Straight Storage System, Head End System and Axle System, and a brief description of each may not be out of place. First, I will take the Straight Storage System which is the simplest. This equipment consists of a set of storage batteries contained in battery boxes under each car, the batteries being connected to the lamps by the usual wires and controlled by a single switch or switches. This is certain the simplest method of lighting, but when we investigate its methods of operation we begin to get into difficulties.

In the first instance, the batteries have to be charged at each terminal, or at least after every eighteen to twenty-four hours of lighting, which necessitates the car being held in the terminal yard for a period of from six to ten hours, depending on the condition of the batteries on arrival. It is, therefore, apparent that this system is out of the question for transcontinental services, as any road which has not a surplus of rolling stock cannot afford to hold its trains in the terminal yards for sufficient time to charge the batteries. The chief user of this system is the Pennsylvania Railway, which operates almost sixteen hundred cars on its local trains, also baggage and day coaches on most of its through services, the dining, sleeping and parlour cars, which have a heavy lamp load, being all lighted with the Axle System. Another disadvantage which this system entails is the heavy capital cost of installing the necessary batterycharging facilities at all terminals.

It is interesting to note that at one of the New York yards three hundred and fifty outlets have been installed, each outlet having a separate pair of wires back to the switchboard in the power house, number eight cable being the smallest size used. Power is obtained from three 250-k.w. motor-generator sets, giving one hundred and ten and two hundred and twenty volts. The switchboard arrangement is also considerably complicated due to the large number of individual circuits which have to be controlled.

It is interesting to note in passing that an attempt has been made to reduce the lengthy period of charge by increasing the charging rate by the use of the Wilson battery. This battery is so constructed that it can be charged at 1000 amp. rate for a short period, but as is apparent, this high rate involves specially heavy charging cables throughout the yards, and also special fittings on the cars. It has been adopted to a limited extent on the Erie Railroad on its suburban trains, but its non-adoption by any of the other roads indicates that its disadvantages overbalance its advantages. I will next touch lightly on the Head End System. This system as its name implies consists of a steam driven generator in the baggage car, located as close to the locomotive as possible. This system is in use on most of the roads running west of Chicago, and on "Limited" or solid trains, gives good service. The equipment consists of a 20 or 25 k.w. turbo-generator located in the baggage-car, driven by steam from the locomotive, a control switchboard is installed from which three main cables run overhead throughout the trains. As the turbine must necessarily be stopped during change of engines or while standing in a terminal before the locomotive is coupled up, it is therefore necessary to install a certain number of storage batteries on the train which will carry the lighting load during the above-mentioned periods.

It is the Northern Pacific practice to install 200 amp.-hour batteries on the postal car, dynamo car, standard sleepers, and observation car on each train. On most of the roads using this system the baggagemen are trained to operate the electrical equipment and after showing a certain proficiency by

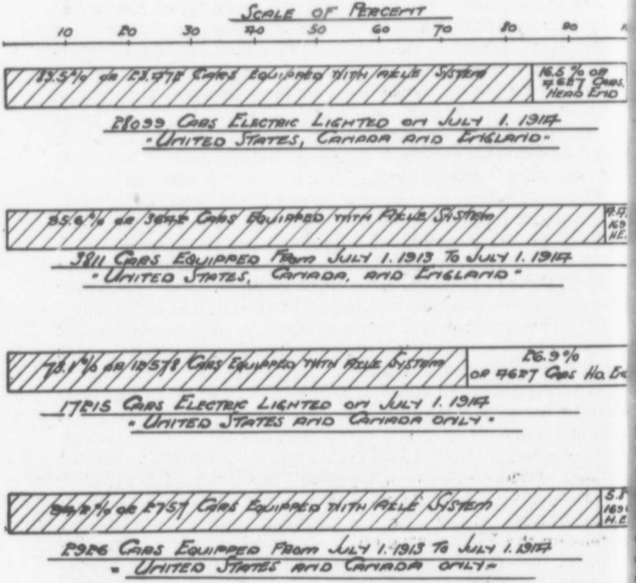


Fig. 2—Graphic Representation of Preference of Roads for Axle vs. Head End Systems, Jan. 7, 1915.

means of examinations, receive higher pay. I am advised by several of the electrical engineers that these men are giving satisfaction, some roads, however, still continue to employ train electricians.

The chief disadvantage of this system is the want of flexibility and this is felt where trains have to be remarshalled at junctions and cars switched off on branch lines, this leads to the necessity of equipping a large proportion of the cars on every train with batteries, increasing the capital and maintenance costs. Another disadvantage is the high steam consumption which the turbine accounts for, and our experience in Canada points to considerable difficulties from this source during the winter months should this system ever be tried. The next and most largely adopted is the Axle System. This comprises a generator driven by means of a belt from the axle and a set of storage batteries which supply current to the lamps when the train is at rest. As this equipment is applied to each car it follows that it is an individual unit and can be transferred to any line in any class of service without any adjustment of the apparatus being necessary. Fig. 2 shows graphically the number of cars fitted with each system in North America, from which the preference for the Axle System is apparent.

In describing the methods of operation of the various patent systems used, I will begin by pointing out that the design of an axle device involves the overcoming of five problems; (1) The reversal of polarity, due to the change in direction of rotation of the armature, when the car reverses the direction in which it runs; (2) The maintenance of a constant output in watts or horsepower, irrespective of the speed of the train, after the generator reaches its maximum, which is twenty-two to twenty-five miles per hour; (3) The lamp voltage must be held constant at the normal voltage which is thirty in the United States, and generally twenty-four in Canada, whilst the generator is running at a voltage of forty in the United States and thirty in Canada. (4) The batteries must receive a sufficient charge to replenish the loss of current consumed at terminal stops, but at the same time must not overcharge them; (5) An automatic arrangement must connect the generator to the batteries when the speed of the train is such that the generator voltage is equal to the battery voltage, and disconnect them when the speed falls below that point. To meet the foregoing conditions there are about a dozen patent systems in use in Europe, none of these have ever been adopted in this country, with the exception of the Stone System, which is extensively used in Canada. In the United States there are five principal systems, namely, the "Safety," "Gould," "Consolidated," United States," and the "E. S. B.". I will give a short description of the operation of each but I will refrain from making any criticisms as to their advantages or disadvantages, as it is not my intention to boost or criticise any of the systems, all of which have their good and weak points.

As the Stone System is more in evidence in Canada, I will begin with it.

1. Change of Polarity: This is effected by means of a rocking arm which is turned through an angle of about thirty degrees by a friction gear attached to the end of the armature shaft.

2. Constant output is maintained by means of suspending the generator out of centre and by means of a tension screw in the suspension, so that it is possible to vary the tension of the belt to give the desired watt output. This method of regulation appears at first sight to be rather crude, but it is surprising how well it acts in actual practice.

3. Lamp Voltage Control is obtained by the use of two batteries, one being charged while the other "floats" across the lamps. The floating battery and lamps are supplied with current from the generator through fixed resistances in multiple, which are connected so that when certain circuits are switched on, a resistance is also switched in multiple with the others, by this means it is possible to obtain close regulation with a varying lamp load.

4. Battery Overcharge: By means of specific gravity tests of the batteries, it is possible to regulate the tension of the belt so that the total output on the trip will take care of the lamp consumption and at the same time keep the batteries fully charged. A battery change-over switch is also used to reverse the charging and regulating battery at each stop.

5. Automatic Switch: This is operated by means of a governor attached to the end of the armature shaft, in conjunction with the friction gear and rocking arm mentioned above, operating a switch, which closes when the generator voltage equals that of the battery. The keynote of this system is simplicity, all the moving parts being contained in the dynamo, and can be readily changed if necessary. The switchboard contains only the main and circuit switches, also branch fuses. It is therefore impossible for the train crew to cause any damage to the equipment, through carelessness or otherwise.

I will treat the Safety and Gould equipments together, as they have many points in common.

1. Change of Polarity: This is effected in the Safety system by means of rocking the brush holder through an angle of ninety degrees by means of the friction between the brushes and the commutator. In the Gould system a double-throw switch is operated by means of a "dog" attached to the end of the armature shaft engaging a cam when the direction of the rotation is changed.

2. In both systems the voltage of the generator is held constant of a voltage coil connected across the brushes, this coil operating a solenoid which, by means of a lever, reduces the pressure in a carbon pile in series with the "field."

3. Lamp Voltage Control is obtained by inserting a carbon pile in the lamp circuit, the pressure of the discs being regulated by means of a solenoid connected across the lamp mains. As the voltage increases the solenoid operates and reduces the pressure on the pile, increasing the resistance in the circuit.

In the Gould system a pilot or small carbon pile is introduced to operate the large carbon pile with the object of giving finer adjustment in the system, the main pile is short-circuited when the car is at rest, and allows the battery to feed the lamps direct.

4. Battery Overcharge: In both systems the voltage of the generator being maintained constant, as the battery becomes charged, its voltage rises until it is practically equal to that of the generator when the charge is reduced to about three amperes. A series coil introduced in conjunction with the voltage coil of the generator regulator, operates the carbon pile in the field, preventing the output exceeding a predetermined amperage which would occur in the case of the generator becoming connected to a discharged battery.

5. Automatic Switch: Is electrically operated, a voltage coil being connected across the brushes which lifts a switch when the generator voltage reaches that of the battery.

Both systems have been applied to a large number of cars in the United States.

The United States lighting system provides for the change in polarity of the generator by rocking the brush holders through an angle of ninety degrees. The generator regulation is controlled by a carbon pile in series with the field, which is operated by means of a solenoid composed of a series and shut-winding. The lamp regulation is also taken care of by a carbon pile in series with the lamp circuit, which is operated by a shunt coil connected across the lamp mains.
which is operated by a shunt coil connected across the lamp mains.

The chief feature of interest in this system is the control of the battery charge by means of the ampere hour meter. The meter is located in series with the batteries and when they are being discharged the indicating hand travels over a circular dial in a clockwise direction and during charge in a reverse direction. The scale reading from 0 to 400, the position of the pointer indicates at any moment the amount of discharge, zero being the full-charge mark. When the hand of the meter travels back to zero, which shows full charge, it operates a small switch which, by means of a relay, reduces the generator voltage to the lamp voltage, from forty to thirty volts, cutting down the charge to the batteries. The meter is so constructed that it reads twenty per cent. slower on charge than discharge, which accounts for the necessary excess of charge over discharge required. The Pullman Co. have applied this arrangement to several hundred cars and I am advised that so far the results have been satisfactory.

The later Consolidated equipments have a similar arrangement embodying the use of the ampere hour meter, and with this equipment metal resistance grids are used in the field of the generator and lamp regulator instead of a carbon pile. A worm gear operated by the armature shaft in conjunction with a double-pole two-way switch effects the change in the polarity.

The E. S. B. system presents several features of interest, using the Rosenberg generator on which the main brushes are short-circuited, the armature current being collected from two main brushes at ninety degrees to the auxiliary short-circuited ones, the polarity of this generator always remaining the same. The generator voltage is maintained constant, irrespective of speed, by a wheatstone bridge connected across the field, and as this voltage is set to thirty-six, charging sixteen cells in series, it is claimed that it is impossible to overcharge the batteries. Owing to this low charging voltage, the lamp regulator used in other systems is dispensed with. It is necessary, however, to use thirty-four-volt lamps, which are not a standard. The principal claim of this system is that there are no moving parts on the generator regulator except the automatic switch, and that it gives the battery good treatment. The system has been applied to a number of cars on the Santa Fé Railway.

Batteries. I believe if a number of electricians who operate electric-lighting equipments were asked to name the details which causes the most trouble, I am sure ninety per cent. would reply, "The batteries." For the benefit of those who are not familiar with the construction and characteristics of the storage battery, I will give a brief description. It must be understood first that the battery is not a source of power, but simply retains electrical energy when charged from the axle generator or yard plant. It is composed of a number of positive and negative lead plates which are insulated from each other by means of hard rubber or wood separators, these plates being immersed in a solution of sulphuric acid, and the whole contained in a lead-lined crate. Each set of plates are burned on to a bridge to which lead lugs are attached for connecting to the next cell. The method of determining the state of charge is usually by means of the hydrometer, the fully charged density varying from 1.215 to 1.225; the density at discharge being from 1.125 to 1.150, suitable hydrometers with glasses and tubes being specially manufactured for the purpose. The voltage test is also used, a fully charged cell reading 2.2 volts on discharge and gradually dropping to 1.8 volts per cell on full discharge. The capacity depends on the area of these plates, and as a rule in car lighting service, varies from two hundred and fifty to three hundred and fifty ampere-hours at the eight-hour rate. The dimensions of the cells principally used in Canada are 13½" long, 7⅝" wide and 19" high, capacity, 315 ampere hours, weight, 163 pounds, so that a double battery of twenty-four cells will weigh 1.9 tons.

To maintain a storage battery in good working condition it should, as far as possible, receive about twenty per cent. more charge than discharge, but continuous overcharging will cause the plates to buckle, also create an excessive deposit of sediment, either of which will result in short-circuiting the plates, causing the cells to lose their charge and become "dead." Overcharge will also increase the evaporation of the electrolyte which, if not replaced by adding water, will also result in damage. The ill-effects of undercharge are also to be noted, as, owing to the action of the acid on the plates, in a discharged condition a sulphate of lead is formed which will have the effect of reducing the capacity of the cell which may be removed by a continuous slow charge. As the charge in a set of batteries gradually leaks out when left standing for a long period, electric lighted cars should not be taken out of service and stored in yards where charging facilities are not available. It is the Canadian Pacific Railway Company's practice to charge the batteries on all cars not in service at least once per month.

Another source of trouble is due to the current leaking to earth through the lead-lined tanks, which will take place if the bottoms of the cells are allowed to remain wet. At the point where the leakage takes place in the lining an electrolytic action follows, which eventually produces a hole in the lining, allowing the acid to leak away; this happening in one cell will probably start the rest in that battery box. To prevent this, care should be taken to keep the outside of the cells and floor of the battery boxes as dry as possible and well insulated from the iron work of the cars. My reason for dealing with the above troubles is to bring out the fact that, as the battery maintenance is the heaviest item in the lighting on most railways, that considerable saving may be effected by paying attention to the various points which tend toward good battery maintenance.

Before leaving the subject of batteries, I would refer to the Edison battery which has been in the market for several years and to date has given favorable results. The general construction of the battery contains many different details to that of the lead type. The positive plates consist of several perforated steel tubes filled with nickel hydrate and metallic nickel plate. The negative plates consist of flat pockets of perforated steel, nickel plated, which are filled with metallic iron. The electrolyte consists of potassium hydrate in solution, with a small quantity of lithium hydrate. The elements are sealed in the containers, the cell lids being welded to the sides so that it is impossible to open the cell, which is unnecessary, owing to the tube and pocket construction of the plates, preventing any deposit of sediment. For flushing the battery, distilled water is required, as any chemical impurities introduced into the batteries will be fatal to their life. The electrolyte will last for two years, so that the only work necessary to be done on the batteries during this period is to keep them flushed and clean. The renewal of electrolyte is effected by pouring out the old solution and replacing it with new solution, this can be carried out in any yard. Owing to the falling off in capacity due to cold temperature, it is advisable to keep the battery boxes as air tight as possible and if this is done, trouble should not be experienced from this source. One of the chief drawbacks to the use of this battery is its cost, as, owing to the voltage of each cell being 1.2 volts as against 2.0 volts in the case of the lead battery, it necessitates the use of thirty-eight cells to take the place of twenty-four cells of the lead type. This increases the cost to approximately twice that of the lead battery. One point which should not be overlooked is the saving in weight, a set of thirty-eight Edison batteries (type A. 8. H.) weighing 973 pounds, as against 3,360 pounds (the weight of twenty-four lead cells), making a saving of 2,387 pounds per car. This saving in weight renders this battery easier to handle, and also saves in haulage.

ORGANIZATION

The question of organization directly interests any railway which operates electric lighting equipments and it is only by having a proper system of inspection and records that efficiency in operation and cost will be obtained.

In the past it was usual for a railway company to install a number of equipments, the installation being made by the car builders without any check or inspection whatever, and when placed in service an electrician was employed in the terminal yard to maintain them. Generally speaking as long as the lights in the cars did not fail no particular attention was paid, and after a year or eighteen months, it was found that perhaps the batteries were worn out and required renewal and the generators were in a more or less damaged condition. The equipment was usually blamed and the next order given to a competitive firm. But since electric lighting has become more general systematic organization has been adopted with a study of the defects and their causes which arise from time to time. A few figures may serve to illustrate the effects of closely watching the performance of the equipments. Take, for example, a road with five hundred cars of all classes equipped and supposing by careful study and experiments we reduce the lamp consumption by one lamp per car per month, we effect a saving of $225 per month, or $2,700 per annum.

Again, taking the battery situation a conservative estimate will place the life of a set at five years. Assuming we have a twenty-four batteries per equipment, and we increase their life by one year, we have, taking cost of battery as $630, as follows:

Depreciation at 5 years....	$126 per annum
Depreciation at 6 years....	105 per annum
Saving, per car..........	$021 per annum

Multiply by five hundred cars, and we have $10,500 per annum saved.

Again, take the question of belt-life. A saving of one belt per car per annum will approximate $5 per annum per car, or $2,500 per annum on five hundred cars.

Summarizing, we have:

	SAVING
Saving of 1 lamp per car per month............	$2,700 per annum
Extending the life of batteries by 1 year.......	10,500 per annum
Saving 1 belt per annum per car...............	2,500 per annum
Total saving............	$15,700 per annum

The above reasoning can be applied to all the various details of the equipments which would considerably increase the total amount saved, but these figures in themselves show what may be accomplished by good management and organization.

I have looked into the various methods of organizing this work on the railroads in the United States, and find that there is a considerable difference in the systems of organization adopted. In some cases the forces are controlled directly by a chief electrician reporting to the master car builder, on some roads the chief electrician acts in an advising capacity to the master car builder, the forces being controlled by the car foremen; on others the electrical engineer through his assistants directly control the terminal electricians. On the Canadian Pacific Railway the electrical engineer acts in an advisory capacity, keeping all the records; the actual control of the forces coming under the general master car builder and assistant master car builder on eastern and western lines. This arrangement has the advantage of bringing the technical experience of the electrical engineer to bear on the subject and still preserving the organization of the car department.

Having decided on the organization, the chief electrician or electrical engineer should supervise the preparation of specifications and wiring diagrams for all new rolling stock and see that same are lived up to by the car builders. This is important, as all equipments, as far as possible, should be installed to certain standards, the various conduit runs should be inspected to see that they are installed so that new wires may be drawn in at any time without tearing down the interior finish of the car, the quality of the conduit and wires should also be closely watched, as these items will reflect on the cost of maintenance in later years.

The generator suspension should be closely checked up with the object of providing for sufficient belt clearance and it will well repay any railway company to give this point due consideration, as it is no idle statement that fully half the light failures and lost belts are due to insufficient clearance.

The American systems all favor a truck suspended generator and as they weigh approximately 650 pounds, the suspension members have to be heavy, causing additional weight on the truck. With the Stone system the generator is suspended on the body of car, and I would also add that the Safety Car Heating and Lighting Company have perfected a body suspended generator which operates in a similar manner to their truck-suspended type, but weighs 176 pounds less. The advantages of the body-suspended generator are (1) Lighter suspension; (2) Generator located higher from track, and less liable to injuries from loose stones, etc.; (3) Can be inspected or removed with greater facility; (4) Longer drive, giving better efficiency.

The type and location of fixtures should also receive attention, as far as possible, standard types should be used, involving the minimum number of classes of glassware and as a rule, clear, unshaded lamps should not be used, as they are liable to cause eye strain. It is also advisable to standardize one size of lamp, which, on a large system, must be carried in the stores at all terminals. The Canadian Pacific Railway have now standardized on a 15-watt G. 16½ clear-bulb lamp for all classes of cars, reducing the number of sizes from four to one.

From the foregoing it is obvious that a little consideration of the installation of the electrical equipment, in the drafting room, will result later in a saving in the maintenance account.

Maintenance of Equipments

To maintain the equipments in a proper state of efficiency periodical inspection and overhaul is necessary, and any neglect of either will result in a heavy expenditure for renewals.

Overhaul

Each equipment should receive a thorough overhaul once per year when the generator should be removed from the car, taken apart, cleaned; and worn parts renewed, and on being rebuilt, should be tested on a special test-frame. The batteries should also be taken to the battery house, where each cell should be opened up, the cell box washed out under a spray, all bent plates straightened, and damaged separators, etc., renewed. The battery should then be re-connected in the shop and properly charged, when a discharge test chould be taken and its capacity noted. After re-charging, the specific gravity of the electrolyte should be adjusted, and the cell and battery boxes painted. The set is then fit to be replaced on the car. If the car is fitted with lamp and generator regulators, they should be reset, the carbons being specially examined. A considerable difference of opinion exists as to whether this overhaul should be carried out at the terminal yards or at the shops of the Company. In favor of the former system it is claimed that, by changing the equipments at the terminals, the overhaul is not dependent on the shopping of the cars, which in some cases is not on the twelve months basis. Also that more interest is taken in the work by the yard staffs than by the shop men. The latter method has the advantage of concentrating the work and ensuring a more standard treatment of each equipment, and therefore lends itself to better organization.

INSPECTION

As regards the inspection of the equipments, a yard force under the supervision of a chief electrician or foreman should be located at each terminal at which trains originate, and each car arriving should be inspected to ascertain if the equipment is in good working order, before leaving on its next trip, and all necessary running repairs made. On the Canadian Pacific Railway we find it advisable to give each car in transcontinental service a thorough inspection at Montreal and Vancouver, local cars receiving a similar inspection once a fortnight, with a lighter inspection each trip. At each inspection the height of acid in the batteries should be noted and water must be added if necessary. Neglect of this will cause sulphating of the plates, decreasing the capacity and life of the batteries.

YARD FACILITIES

The extent of the facilities required at a given terminal will vary according to the number of equipments handled and also on the amount of work it is intended to carry out at that point, and hard and fast rules cannot be laid down on the subject. As regards shop room the first question to be decided will be as to whether batteries will be cleaned and overhauled; if so, a battery room will be necessary.

The modern battery room is equppied with a washing table on which the elements can be inspected and also a compressed air and water spray over which the cell box is cleaned. Benches should also be provided to hold at least six sets of batteries while they are being charged up prior to being applied to the cars. Acid tanks for mixing new electrolyte and for holding electrolyte removed from cells while same are being overhauled should be provided, together with a press for straightening plates, also steam-jacketed tanks for boiling the acid out of connections, etc. A still should also be installed if Edison batteries are used.

The proper equipment of the battery room is one of the most important features in maintaining the equipments in good condition, as, if they are not properly handled, they will give poor results in service and their life will be considerably reduced.

The generator repair room should be fitted with a bench on which a generator may be conveniently dismantled and re-built. A work-bench with vise is also necessary, together with lockers and cupboards. A lathe and drill press are advisable if the use of same is not possible in another shop.

Battery charging facilities should be provided in the battery room and throughout the yard, in order that the batteries on any car may be charged without switching the car to any special point. The Canadian Pacific Railway practice is to run a circuit between each alternate pair of tracks, the wires being carried overhead on poles, the receptacles being placed on the poles about five and a half feet from the ground, each circuit having five receptacles, connected in series, about eighty feet apart. These circuits run back to a receptacle panel on the switchboard and by means of short flexible jumpers are connected to a number of power receptacles which are connected to the buss-bars through a variable-resistance reverse and overload circuit-breaker and ammeter. Fig. 2-A shows the layout of the Canadian Pacific Railway Glen Yard, Montreal, switchboard. Power is obtained from two 25-k.w. motor-generator sets, the switchboard consists of two main direct current generator panels, each equipped with an ammeter showing the total load on each generator. Distribution panels embodying seven circuits, which are each equipped with 75 ampere overload and reverse-current circuit-breaker, a 100 ampere ammeter, and a 1.9 ohm variable resistance with a carrying capacity of sixty amperes. Each circuit is connected to two power receptacles in series on the receptacle panel. By this arrangement it is therefore possible to regulate the charging current to each set of batteries on a car in any location in the yard.

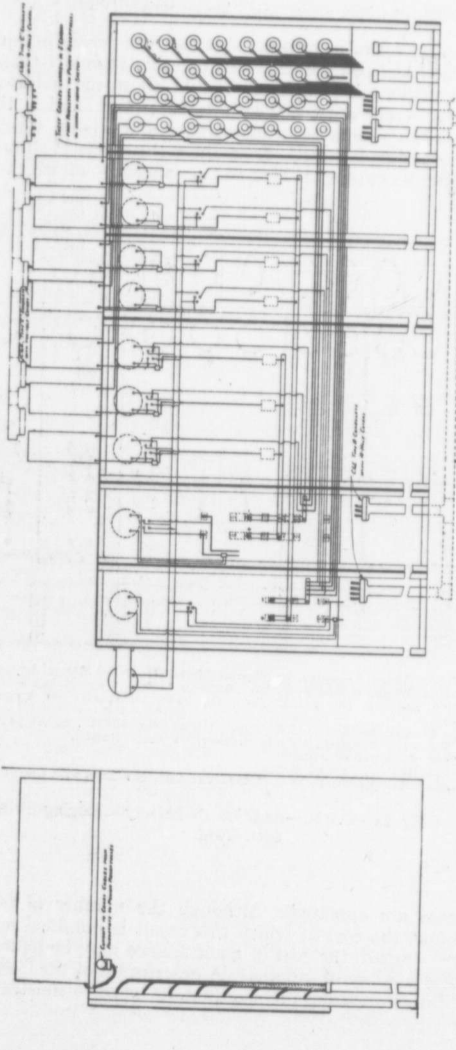
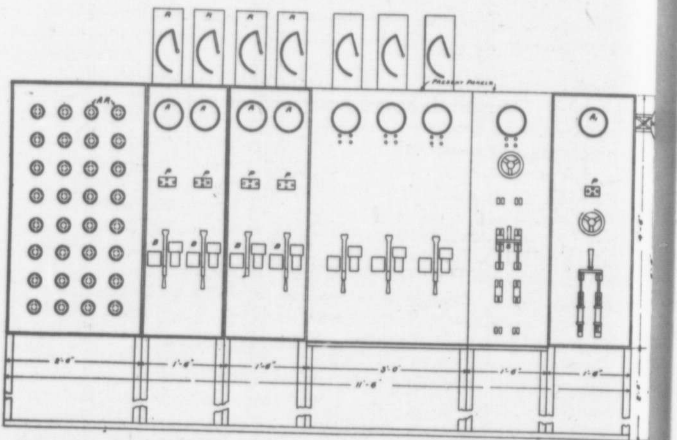


Fig. 2a—C.P.R.—End and Rear Views of New Charging Switchboard for Glen Yard

RECORDS AND ACCOUNTS

A complete set of records should show the details of equipment on each car, also the batteries, together with any changes or repairs made. A second set should show the failures of light during a given period with their causes, and a third should give the consumption of material and labour, together with the total cost per car. From these three sets of statistics it is possible to obtain an idea of the efficiency at which the



A—C.G.E. Type, 0-100 Range Ammeter, or Weston Model 24, 0-100 Range Ammeter.
A 1—Weston Model 24, Range 0-300, Type No. 06505 or C.G.E. Type Range 0-300 Ammet
R—C.G.E. Iron Grid Rheostat DL 174717 Form CR 9200. Capacity 60 Amps., 1·9 Oh
115 Volts.
B—Reverse Current Circuit Breaker, C.G.E. Type G, Cat. No. 107217, 50 Amps., 110 Volts,
I.T.E. Type EL Reversite Circuit Breaker, 60 Amp. Rating.
P—C.G.E. Four Point Potential Receptacle.
S—300 Amp., 250 Volt D.P.S.T. Fused Switch.
AR—Anderson Charging Receptacles Type E (Improved) Cat. No. 1598 with Lugs for No. 4 ca

Continuation of Fig. 2a—C.P.R.—Addition to Battery Charging Switchboard a Glen Yard.

equipments are operated. Although the number of failures may be low, the cost at which this result is obtained may be excessive. Again, the cost of maintenance may be light, with a resultant number of failures. A description of the Canadian Pacific Railway system of records may serve to illustrate the above:

RECORD OF CAR LIGHTING EQUIPMENT

Car, Name or Number............Initials......R.R. Class..........

Generator, Number...................Type....................

Voltage.............Special features................

Generator Pulley, Face......Diam.......Dwg.......Patt. No......

Axle, Diam. at pulley hub......Length turned......Dia. of Wheel.....

Distance from axle center to pulley center..........Dwg..........

Axle Pulley, Iron or Steel, Dia....Face....Bore....Length hub......

Dwg..................Patt. No..................

Belt, Kind...........Width........Length........Ply............

Fasteners..

....

Battery, Number cells........Type........No. of plates...........

Number of boxes.................Dwg..................

No. Lamps, 8 c.p.........12 c.p.........16 c.p.........Kind........

No. Fans........Size ....Make........Type ....

No. Fans........ " .... " .... " ....

Wiring, Diagram..

Wired By.........................Date......................

Equipment Installed By...........at...........Date..........

Equipment Tested By.........................Date..........

Dynamo Resistance...............Aux. Resistance No. 1..........

Switch, Type..

Fixtures, Type...................and Card No.................

Amperes to Lamps, 1-2 lights...............Full lights.............

Car Entered Service......................................

Miscellaneous Data..

Fig. 3

Equipment Card

When a car is equipped, a card (see Fig. 3) is filled out, showing the details of the equipment with all pattern and drawing numbers, on the back of these cards are marked the battery numbers, also any changes which may be made from time to time. These cards are filed in the electrical engineer's office on the card index system, and can be referred to at any time. At the same time when the car is equipped each set of twelve batteries receives a number, which is stencilled on them, and retain this number independent of the car to which they may be applied. A battery record card (Fig. 4) is filled out

BATTERY RECORD CARD

BATTERY No.......................TYPE..........................

NEW..........................

Date	Applied to Car	Repairs and Material	Cost

Fig. 4

for each set of batteries, on which is entered all repairs and changes from car to car, these cards being filed similar to the equipment cards. By means of these two records it is possible to determine all changes of equipment and batteries.

INSPECTION REPORTS

Each car is supplied with two report books, which always remain in the switch locker (see Figs. 5 and 6), one of which is

CANADIAN PACIFIC RAILWAY—CAR DEPARTMENT

Report of Electrical Equipment Examinations and Repairs at....Date..

Car	Class	Train	Battery Gravity		Material Used
			No 1	No. 2	

REMARKS:

Battery charged from............to............Rate................

Signed.....................

Fig. 5

(Original)

CANADIAN PACIFIC RAILWAY—CAR DEPT.

Car.............Train.............Date.................. 191..

From.............................To........................

Avg. Amperes generated..

(Ammeter to be read and recorded once in each Division with train at full speed.)

Condition of Lights ....

Was belt lost.....................About where..................

If Lights were unsteady, give explanation as to when and how, and action taken..

....

Remarks:..

....

Signed..

This Report to be made out by Sleeping and Dining Car Conductors. Original to be sent to Supt. S. D. & P. Car Dept.

Fig. 6

filled out in triplicate by the conductor, one copy remaining in the books, the other being sent to the superintendent of the S. D. & P. C. department, and electrical engineer. This report shows any defects which may be noticed by the crew and also the output of generators in amperes.

The other report is filled out by the terminal electrician in duplicate, showing condition of equipment on arrival, all repairs made, and if the batteries were charged. One copy remains in the book and the other is sent to the electrical engineer through the car foreman. By this means we have two permanent records of the operation of the equipments on each car, which can be traced by either an inspector or terminal electrician at any time. At the same time the forms are filed in the electrical engineer's office under the car names, and are retained for three months. From these two forms a monthly statement is prepared in the electrical engineer's office showing the number of failures and cause, also type of equipment and batteries. This statement also shows the number of car trips and the percentage of good to bad runs, which is shown in

EFFICIENCY REPORT OF ELECTRIC CAR LIGHTING

Month..............

Class	Runs Made	Lights Good	% Good	Lights Dim	% Dim	Lights Out	% Out	Equip-ment	Train No.	Failures
Observation..										
Sleepers......										
Diners........										
Compartment										
Parlor........										
First..........										
Private.......										
Total..........										

Fig. 7

Fig. 7. From the foregoing we have an accurate record of the efficiency of the equipments.

COST

To determine the cost of the equipments, a monthly statement is issued by the auditor of stores and mechanical accounts, showing the cost of labour and material at each inspection point, all material being handled by the stores department. On another statement this material is subdivided under the heads of generator, batteries, belts, lamps, etc., and divided

SUMMARY OF COST OF ELECTRIC LIGHTING PASSENGER CARS

Month.........................

	EASTERN LINES		WESTERN LINES		TOTAL	
	Cost	Cost per Car	Cost	Cost per Car	Cost	Cost per Car
Generators and Regulators						
Batteries........						
Lamps..........						
Belts...........						
Miscellaneous....						
Total Cost of Material						
Labour..........						
Cost of Charging Current						
Total...........						

Remarks:—

Fig. 8

by the number of cars equipped. We therefore can determine the total cost per car of each item and can follow up the causes of any increases. Fig. 8 shows the type of forms used for the summary.

CONSERVATION OF LIGHT

I would here ask all who are connected in any way with the operation of electric lighted equipment to assist in saving as much light as possible, while the cars are in the coach yards, terminals, etc. By all means give the passengers all the light they require, but save the waste. Probably gas lighting is more or less responsible for much of the waste which now prevails, as it is possible to use the gas in the tanks before a train arrives from the yard to receive its passengers, and replenish the tanks in a few minutes, whereas to recharge the batteries of an electric lighted car may take eight or ten hours. In conclusion I would draw attention to the work which has been accomplished by the Association of Railway Electrical Engineers, who, in conjunction with the train lighting committee of the Master Car Builders' Association and the various manufacturers, have worked out the various standards and specifications which assisted in raising the problem of electric lighting of passenger cars to its present state of practically universal adoption.

Chairman,—

We would like to hear from Mr. Treleaven.

Mr. T. Treleaven,—

I am sure I did not expect to be called upon to open the discussion on the paper read by Mr. MacNab, but I wish to thank you for the privilege of being here to-night, having received an invitation from Mr. Worth, your Secretary-Treasurer, together with an advance copy of Mr. MacNab's paper and I consider he deserves great credit for the way he has dealt with the subject. He has made everything so plain that there appears to be very little room for criticism or discussion, but the application of electric light in passenger cars is of great interest to all railway men, and considering this, I arranged to have a few of our men from London, Hamilton, and Toronto to listen to Mr. McNab, but as Mr. Kelly, our electrician, and a number of other gentlemen are more familiar with the subject than I am, I would prefer to hear them discuss the paper. Possibly later on I shall be glad to ask a few questions, thanking you.

Mr. G. D. Bly,—

I have listened with a great deal of interest to the paper, and am sure we all have. I do not know that there is very much I can say as I am not very well versed on the subject of "Electric Lighting of Railway Cars" except what I have learned this evening. What I do know of electric lighting is more in the stationary line. However, there are two thoughts that came to me: in connection with the axle system, the belts being under the cars I should imagine would give more or less trouble, especially in this northern country in the winter when there is ice and snow to contend with. Whether or not this is so, I do not know, but I would like to hear from Mr. MacNab on the subject. The other point was: has an attempt ever been made to use alternating current in lighting cars.

There are members here who have no doubt gone into the subject of "Lighting of Railway Cars" and it would be interesting to hear from them.

Mr. E. S. MacNab:

In reply to Mr. Bly I would like to say there certainly is a considerable amount of belt trouble experienced in the winter months. Our troubles in this respect begin in the middle of December and last until the end of March. Several experiments have been made with chain belting and it would appear that this is better than the ordinary belting, during the winter months. There was a Pullman running out of Toronto two years ago with a Morse silent chain which I understand gave splendid service, but in summer the cost of wear and tear is excessive.

Regarding the use of alternating current for lighting cars. This would be out of the question as storage batteries could not be charged with alternating current, and storage batteries must be carried to keep up the light while the train is not in motion.

Mr. L. K. Sillcox,—

I have been greatly interested in Mr. MacNab's paper, especially that part relating to Organization.

My opinion is that the most important accomplishment of electric lighting apparatus as applied to passenger equipment is the additional comfort rendered to the travelling public and minimizing the risk of fire. In order to meet this end, efficiency in operation must obtain. It is costing the railways of the continent a great deal to provide the luxury of electric light in railway cars. The problem of keeping batteries in a state of full charge is one which can only exist through persistent effort in careful and thorough inspection. On our Eastern lines we have just begun to go into the question of systematic maintenance for electric lighted cars.

Practically all of the difficulties on our road so far as electric train lighting equipment is concerned, centres on our ability to withdraw batteries from service long enough to have them thoroughly washed out and repaired. Electric train lighting units will do remarkable work, but yet to obtain such results without a proper system of maintenance is a costly proposition. I have one case in mind where a certain car was allowed to operate continuously for eighteen months without any effort being made on the part of the Operating Department to care for such equipment and the result was that the cells upon final examination required to be replaced at a cost of $600.00.

The mechanical defects which occur in the machines are most generally the result of insufficient lubrication. The charging of storage batteries should be carried out with some knowledge of the results to be obtained, for it is difficult at first hand to convince a person not versed in electrical matters of the fact that it is just as injurious to the battery to overcharge same as it is to allow it to operate with insufficient charge.

We have found a good instruction book to be a necessity as there is no other way in which a uniform system of maintenance can be carried out.

In my opinion, the point brought out in Mr. MacNab's paper regarding the proper installation of new equipment means a good deal. I was very glad to hear Mr. MacNab say something about the application of the conduit on the roof of the cars. For three years we have been trying the application of junction boxes on top of the roof. This year we have abandoned this scheme and are now testing out a design of box with only the cover exposed. This admits of easy inspection and repairs. The difficulty where conduit is exposed and allowed to enter junction boxes exposed to the elements, is that of securing a weatherproof connection. For obvious reasons it is necessary to use a slip joint with locknut on the outside and bushing on the inside of junction box to hold the conduit in place. Cinders collect, which diluted with rain and snow forms sulphuric acid and eats away the conduit where it enters the junction box, the result is that the installation has to be renewed in the course of several years.

We purchase all of our fixtures with threaded plugs. This is to enable a man to wire same without damage to the insulation. Prior to following this practice it was our experience to have practically all short circuits located at the fixture. Under the new scheme I do not know of more than five cases out of over 100 cars of a short circuit being found in the fixture wiring.

There is a great deal of difference in opinion regarding the various classes of belting which should be used for train lighting purposes and in view of the fact that we have not completed a test which we are running at the present time, I do not care to pass judgment on the subject.

Chairman,—

We would like to hear from Mr. Gray.

Mr. W. L. Gray,—

I did not expect to be called upon to-night, as I thought I had managed to slip in here without anyone seeing me; however, I think Mr. MacNab has covered the ground very thoroughly indeed.

He has explained how to wire cars, how to apply conduits, how to assemble batteries, has also explained how the various generators are applied to cars, and how to maintain the equipments in service, etc.; however, I might tell you of some little more or less amusing incidents which I have experienced in electric car lighting during my travels.

During some time I spent in Ireland—and with all due respect to Mr. MacNab—I observed a fellow attempting to recharge the batteries on a car, and for the purpose he had a large coil of wire lying there, the man in the meantime was eagerly gazing at the ammeter which apparently was not indicating. On asking him what was the matter, "Oh," he said, "the current has only been switched on five minutes it will take at least five more to get round that coil."

In another case, but this time on a countryman of my own, a competitive outfit was in trouble passing through Glasgow and when the yard electrician was asked what was wrong he replied, "Don't know; I took the cover off the dynamo and saw a bag o' hoops so put it back agin and let her go."

I do not think that I have anything more to add except that being connected with the company which has about 95 per cent. of the electric train lighting business in Canada has made the evening a very enjoyable one to me indeed.

Mr. E. Coker,—

Mr. President: I wish to thank you for asking me here tonight and I must say that I appreciate the privilege very much.

We have quite a number of cars which are illuminated with electricity and our main trouble is just what Mr. MacNab has mentioned. Mr. MacNab has covered the subject quite fully, and he has left little ground for discussion. The belting business is just what he has explained to you. As an instance; a car running from here to Chicago on a through train; if the belt were to break 25 or 30 miles out of Toronto you would be unable to have a new one applied until arrival at Chicago, necessitating having the lights on the batteries which would mean quite a loss.

Chairman,—

We would be glad to hear from Mr. Wood.

Mr. E. H. Wood,—

I am not a member of this organization, and I have to thank you for your kind invitation to be here to-night.

I am not an electrician, and I have not given this subject any great amount of study, Mr. MacNab brought out the point of the necessity for care in the maintenance of equipment. On the C.P.R. we have given this matter careful consideration in endeavoring to impress upon all parties concerned, the necessity of giving careful attention to this matter. We have got out a number of regulation cards which fully explain the requirements for proper care and maintenance of electric lighting equipment. I do not think there is anything more I can say.

Mr. T. B. Cole,—

I would move that a hearty vote of thanks be extended to Mr. MacNab for the time and trouble he has taken to prepare this paper.

Mr. T. J. Walsh,—

I second that.

Chairman,—

It has been regularly moved and seconded that a hearty vote of thanks be extended to Mr. MacNab for the time and trouble he has taken in preparing his paper. All in favor please signify in the usual manner: Carried.

Mr. E. S. MacNab,—

I am sure I feel greatly gratified for the vote of thanks and I can only say that the object of my paper has been to endeavor to help to bring about some advancement along the lines of "Electric Lighting of Railway Cars."

The subject electric lighting of railway cars is one of the latest being handled by railroads of the present day. Like all new subjects it is sometimes not quite understood by the managements, and when it comes to putting on the help required to do inspection work they often do not see the necessity of the expenditure.

Mr. Silcox gave you a very good example of neglect that is altogether too common—the case of a car in service eighteen months without inspection. He told you of the expense incurred because of lack of inspection of this one car, and you can see what it would be for a number. I could also tell you of numerous similar cases where a little foresight would have saved, money but, of course, people can only learn by experience.

I again thank you for the honor of reading a paper before you this evening, and also for the vote of thanks you have been so kind to accord me.

Chairman,—

I would like to ask Mr. Walsh to step up this way for a moment.

Mr. Walsh, on behalf of the Central Railway and Engineering Club of Canada Mr. Worth is going to present you with a medal, suitably inscribed, as a token of the Club's appreciation and gratitude for the able manner in which you filled the office of President for the year 1914. I can only say that I hope you will be spared long to wear it.

Mr. Worth,—

Mr. Walsh, it gaves me much pleasure to make this presentation.

Mr. T. J. Walsh,—

I am sure this is a surprise to me. I did not expect anything of this nature; especially this evening. I was unfortunately late getting down, as I did not leave the house until after nine o'clock, but I assure you had I known that this honor was to have been conferred upon me I would have made a special effort to get here earlier.

I regret that I was not able to achieve more for the Club during my term of office than I have, but I was, as most of you know taken seriously ill about the middle of the Fall Session and was unable to be with you at several of the meetings. If I have done any good, I am glad, and I hope to be able to take an active interest in the Club for some time to come.

I may say, however, that you have a President now who is, I feel sure, going to take things in hand and make this a banner year for the Club.

Again thanking you for your expression of good will.

Moved by Mr. J. S. Grassick, seconded by Mr. N. A. Davis, that the meeting adjourn.