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. THE CENTRAL . .

Railway and Engineering Club

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OFFICIAL PROCEEDINGS

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PROCEEDINGS OF THE CENTRAL RAILWAY AND ENGINEERING CLUB OF CANADA MEETING.

PRINCE GEORGE HOTEL, TORONTO, February 21, 1911.

The President, Mr. G. Baldwin, occupied the chair.

Chairman,—

I will now call the meeting to order.

As every member has received a copy of the minutes of the previous meeting, it will be in order for someone to move their adoption as read.

Moved by Mr. Herriot, seconded by Mr. Jefferis, that the minutes of the previous meeting be adopted as read. Carried.

Chairman,—

The next order of business is the remarks of the President.

I do not propose to take up much time under this head for several reasons. Mr. Prentice, who is with us to-night, and who is going to give us a paper on "Automatic Train Control," is in a hurry to get away.

I am very gratified to see such a good number here and also to note that there are so many strangers. Our Assistant Secretary informs me that there are quite a number of C.P.R. men here, and I sincerely hope that they will see fit to join this Club, as considerably over a hundred members are G.T.R. men and I would like to see a similar number from the C.P.R.

The next order of business is the announcement of new members.

NEW MEMBERS.

J. W. Blair, Manufacturer's Agent, Toronto.

W. Loach, General Foreman, Canada Foundry Co., Toronto.

T. F. Garrigan, Assistant Superintendent, Bridge Department, Canada Foundry Co., Toronto.

B. W. Pharis, Superintendent, Grey Iron Foundry, Canada Foundry Co., Toronto.

T. F. Maher, Foreman, Boring Mill and Lathes, Canada Foundry Co., Toronto.

J. E. Martin, Foreman Erector, Canada Foundry Co., Toronto.

L. H. Keller, Assistant Foreman, Structural Department, Canada Foundry Co., Toronto.

D. L. Lochrie, Brick Manufacturer, Toronto.

J. Burns, Burns Coal Co., Toronto.

V. Baker, Civil Engineer, Parker Russel Mining & Mfg. Co., St. Louis, Mo.

J. H. Fryer, Managing Director, Galt Malleable Iron Co., Galt, Ont.

E. E. Cummings, Factory Manager, S. F. Bowser Co., Toronto.

P. D. Saylor, Sales Manager, Mechanical Department, Goodyear Tire & Rubber Goods Co. of Canada, Toronto.

J. Hunt, Stationary Engineer, Consumers' Gas Co., Toronto.

W. Allen, Engineer, Consumers' Gas Co., Toronto.

G. S. Morris, Mechanic, Consumers' Gas Co., Toronto.

F. H. Hawkins, Mechanic, Consumers' Gas Co., Toronot.

J. G. Holfelder, Superintendent, Gurney Foundry Co., Limited, Toronto.

K. H. Cox, Engineer, Gurney Foundry Co., Limited, Toronto.

T. H. Jeffers, Foreman, Gurney Foundry Co., Limited, Toronto.

P. E. McClelland, Fitter, Gurney Foundry Co., Limited, Toronto.

A. Mitchell, Machinist, Gurney Foundry Co., Limited, Toronto.

J. Douglas, Foreman Moulder, Gurney Foundry Co., Limited, Toronto.

MEMBERS PRESENT.

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J. Wright
C. A. Jefferis
J. Herriot
H. G. Fletcher
F. D. Dewar
W. Keating
J. F. Campbell
J. Powell
W. Philpotts
W. E. David
W. Hetherington
W. Schadel
C. Kelso
H. L. Barnwall
J. W. McLintock
G. Richardson
R. S. Magee
W. R. McRae
W. R. Gardner
A. W. Carmichael
A. E. Till
J. T. Powers
H. Ellis
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J. Bannon
R. Pearson
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E. J. Friend
G. D. Bly
D. Campbell
W. A. Grocock
W. McGrath
M. A. Humber
P. McClelland
J. L. McLintock
F. Slade

C. Radford
N. D. McIntyre
J. McWater
J. B. Dunlop
E. G. Southam
F. Hardisty
T. B. Cole
E. E. Cummings
T. Craven
J. Barker
F. W. Prentice
C. DeGruchy
F. W. Somerville
H. O. Eddrup
C. L. Worth.
J. C. Donald
J. Morton
F. Saunders
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G. Baldwin
W. Evans
C. Parker
F. Wickson
L. S. Hyde

Chairman,—

I think you will all agree with me that this is a very creditable list for one night, and I might add that these names have been passed on by the Executive, and have been declared members of the Club. We do not wish you by any means to let up on the gathering in of new members, and we want you, one and all, to try and make this Club double the size it is.

Will pass on to the order of business, Reports of Special Committees, and I think Mr. Flecher has something to say under this head.

Mr. Fletcher,—

I am very pleased to report that everything is fine and rosy for our Social Evening next Monday. We have got an excellent programme together with only one or two more to hear from. Every arrangement that can be attended to has been done.

Chairman,—

In reference to what Mr. Fletcher has just told you, and for the benefit of those who may not know what he is referring to I would say that we are having a Social Evening next Monday night the 27th, at the St. Charles Restaurant. We will start the evening with Progressive Euchre, and I want you all to understand that Progressive Euchre starts sharp at 8.30 and those who are not there at that time will not stand much chance of winning a prize.

The next order of business is reading of papers or reports and discussion thereof.

The paper that Mr. Prentice has got up for to-night is on the "Automatic Control of Trains," and Mr. Prentice being here, I have much pleasure in introducing him to you.

WIRELESS TRAIN CONTROL.

F. W. PRENTICE, WIRELESS ENGINEER OF CANADIAN TRAIN CONTROL, LIMITED, TORONTO.

Twenty-two years of railroad service gives me a claim of fellowship among you: six months with the Grand Trunk at Merriton and five years with the Canadian Pacific in this city makes the tie closer.

All requests heretofore to give the story of wireless train control have been declined, because it is rather embarrassing to speak of one's own exploits and successes except to those whom one knows personally, or whose life work is such that their understanding enables them to appreciate it from a practical point of view.

It is admitted by all historians that the steam railroad has done more to advance civilization than any other factor in the past hundred years. It is the one salient feature around which all other inventions have centred or been dependent upon for assisting man to conquer the world. Little did Stephenson realize what he was doing for humanity when he conceived and built his first locomotive. As we gaze upon his plans, specifications and pictures of the "Rocket," in all its crudeness, we cannot fail to recognize and applaud his genius. It is true, the "Rocket" appears very tame, compared with the 400 ton giants that rush through space at 100 miles an hour, hauling behind them the modern hotels on wheels, or a 180 per cent. freight mogul, hauling a shipload of merchandise from ocean to ocean. The one mile of wooden stringers that the "Rocket" ran over has been replaced by the 106 pound rail, and these steel ribbons now aggregate over one million miles of civilizing influence, encircling our globe under every flag. The germaine idea of Stephenson has been fostered, developed and improved by thousands of inventive minds, until to-day we behold a perfect device in every respect.

With the improvement of the locomotive and the building of new lines came the realization that there must be a medium used to assist man in the handling of trains and the preventing of accidents.

By this time Morse had invented his telegraph. This seemed to be, in part, the solution of the problem. Only in the past two years has anything else been found adequate to take its place, and that is Bell's telephone. Even these great inventions are to a large extent dependent upon man for their proper working: his failure to live up to rules and orders transmitted through these media, causes, in one year, the loss of more lives than were sacrificed at the battle of Waterloo or Gettysburg, and damages amounting to millions of dollars yearly.

Again, with improvement of track and equipment came speed gradually increasing from two miles per hour to 1,000 miles in fourteen hours and considering this terriffic pace and the increase in travel, it is self-evident that there must be more perfect means of safeguarding the lives of the people.

About twenty years ago Professor Hall discovered that the steel rails by being bonded could be made to carry a low voltage of electric current without grounding, and as a result there was started a campaign of railway signalling. Taylor, Westinghouse, and hundreds of others have been working strenuously along this line. To-day it is possible to erect every 3,000 feet a semaphore post that will give an indication to an oncoming train as to whether the next 3,000 feet are safe. About fifteen per cent. of the 300,000 miles of track on the North American continent are equipped with what we term visual signals.

Sadly but truly it has been proven that these visual signals are still dependent upon man to obey their behest in order to stop the train. It is estimated that eighty per cent. of the collisions have been curtailed by visual signals, but our railway managers, and behind them the people who place their lives in their hands, demand that the other twenty per cent. be eliminated. To accomplish this, dependence upon human agency in the control of trains when danger exists must be done away with.

Every railroad man out of 5,000,000 in the world has had this problem brought forcibly to his attention daily for the past thirty years. Thousands of my fellow workers have endeavored to heed the call to solve the difficulty, as well as interlopers from other branches of industry who have come forward and tried to help, but all in vain.

Fourteen years ago, while working as night operator at Sudbury, I read of Marconi's first exploits with wireless telegraphy. Quite naturally, I became interested in the subject, and to pass away the long dreary winter nights entered zealously into a study of the art. The first book perused gave the history and fundamental principles as follows:

"The term, electric radiation, was first employed by Hertz to designate waves emitted by a Leyden jar or oscillator system of an induction coil, and since the discovery of these radiations by that brilliant young scientist of Karlsruhe, in 1888, they have been called almost universally, Hertzian waves.

"The same year Lodge investigated the theory of the lightning rod, and as a necessary part of his work he made a large number of experiments with disruptive discharges from small

Leyden jars and noted that the resultant manifestations were electric waves to neighboring wires.

"Professor Fitzgerald, of Dublin, had, several years prior to Hertz's discovery, theoretically demonstrated the existence of electric waves and attempted to produce them, but without practical results. Hertz, however, had no knowledge of the work of Lodge and Fitzgerald until after he had announced his own discoveries. One of the nearest approaches to the discovery of electric waves in space before Hertz, was made by Professor Joseph Henry, of Washington, when he succeeded, by means of a spark from a frictional machine on an upper floor of his house, in magnetizing needles in the cellar beneath at a distance of thirty feet, with two floors and ceilings intervening. Here were the elusive electric waves, but the knowledge of the electro-magnetic theory of light was yet to be elucidated by Faraday, and as Hertz pointed out, even though it had been enunciated by Maxwell, this special and surprising property of the electric spark could not have been foreseen by any theory.

"Silvanus Thompson, in 1876, produced electric radiations by an apparatus quite like the one Hertz employed twelve years later, but he failed to grasp the great underlying principle involved,—that the effects obtained were the evidence of electric waves traversing space in exactly the same manner as light waves. The cause of the electric waves as well as the effect produced by them must have come under the observation of experimentalists time and again, sometimes both together, as when Henry and Thompson noted them, but more often the effect was observed without the cause being suspected. As long ago as 1866, A. S. Varley, of England, applied for a patent on a lightning bridge based on the principle of the cohesion of carbon or metallic powder. Calzecchi-Onesta, of Italy, observed this 'coherer action' in 1885, but he attributed it to induction.

"It remained for Hertz to make known the real nature of the phenomenon, that others before him had merely speculated upon. Since his time the subject has been a favorite one with investigators and has received the attention of such eminent scientists as De la Rive, Lodge, Poyating, Bjerknes, Neaviside, Poincairé, J. J. Thomson, Lebedew, and Fleming, all of whom have contributed important results to the accumulation of facts.

"When the oscillations of a disruptive discharge occur, a displacement or strain in the ether in the form of a wave is produced similar to the strain in an elastic solid. The ether resists, by its elasticity, the emitted wave, and when the polarizations producing it cease, the ether resumes its normal state. To produce a wave there must be an expenditure energy, and the law governing the conservation of energy requires that the strained ether in being restored shall be supplied with some other form of energy to take its place. This law is fulfilled by the creation of magnetic flux or lines of force in a direction at right angles to the wave. When the magnetic lines of force disappear they give rise in their place to electric waves, and when the waves vanish they again produce magnetic flux, and so on. For this reason all ether waves are electromagnetic in character.

"An analogue of the electric wave and its accompanying magnetic action and reaction may be found in the sound wave. A bell, when struck, gives rise to an elastic strain, and the strain in disappearing creates velocity by setting the air particles into motion, and thus produces the strain energy in a kinetic form, by causing another strain in the opposite direction to the first."

To illustrate the above: Drop a ball into a tub of water, and there will radiate from the striking point ripples, or waves, the waves being larger at the striking point and gradually growing smaller the farther they recede. The static discharge between two electrodes or oscillators with proper inductance, or capacity, will produce waves similar to those in the tub of water, the only difference being that the electro-magnetic waves eminate in all directions.

"For receiving, or detecting, the waves, various forms of detectors have been devised, among the earliest of which Professor Branly brought out a filing detector made of two metal lugs inserted in a glass tube, the lugs being about one-fourth of an inch apart, and the aperture filled with metal filings of iron and German silver. A relay and battery were placed in circuit with the lugs. It was found that in a normal condition the current would not flow through the filings, but when waves were emitted in its zone the filings would become a conductor and the relay would be closed. It was supposed at first that these filings became magnetized and cohered together, hence the apparatus for detecting waves was styled a 'coherer.' Years later it was found that the filings were not magnetized, but that a high resistance was set up on the outsides of the particles of metal that resisted the flow of current through them; the emission of waves breaking down the resistance, allowing the current to flow and close the relay circuit."

A set of the above apparatus was built and worked very nicely at a distance of 1,000 feet.

Early in the spring of 1898 I returned to Toronto, when the owner of a business college at Yonge and Gerrard Streets, secured my services to build a wireless telegraph set for advertising durposes, the same being installed in May. A notable feature of this installation was the transmission of waves from the basement up through four floors to the top flat.

In June, the position of Chief Clerk to the Chief Train Despatcher of the B. & O. at Pittsburgh was accepted. The Penna. Co. had undertaken the reorganization of that much abused and maligned property. The numerous changes appeared to demoralize the operating force, so that for three months collisions, head-on and rear-end, were of daily, and I was about to say, hourly occurrence; the climax being reached on August 12th by a head-on of a passenger and freight on the Wheeling Division, resulting in a large number being killed and injured. An old friend despatcher was implicated in the unfortunate affair.

That night on retiring at one a.m. I fell into a light sleep. I dreamed that I was placing a wireless generator on the rear end of a van to prevent rear-end collisions. I awoke and slept no more that night. With drawing board on my knees, the first plan for train control by wireless was evolved and finished as the sun's first rays penetrated the cloud of smoke arising from Carnegie's numerous furnaces at Braddock, a suburb of Pittsburgh, on August 13th.

My superior officials became interested, as has every one else who has come in contact with "the wave." The lurid fascination of this mysterious agent that knows no barriers seems to be irresistable. Had I known the many years of toil, hardship and poverty this will-o'-the-wisp was to lead me through, I imagine my inclination would have been to seek to escape by plunging beneath the turbid waters of the Monongahela.

Two years and half were devoted to completing an installation of ten miles between Alkbridge and Relay on the Washington Division, just out of Baltimore. $15,000.00 were used experimenting, 3,000 different coherers were made and tested on the fliers and slow freight engines between Philadelphia and Pittsburgh before one was perfected which would stand up under the jar, oscillation, and vibration, of a hard-riding engine.

On the 13th of May all was complete for the official approval. A train of seven officials' cars left Baltimore early in the morning, passed into the installed zone at a speed of 100 miles per hour. In the second block, the gong on the engine and in each of the cars was sounded vigorously, and the train brought to a standstill. My hour of triumph seemed at hand. But lo, a pair of pliers in the hands of an engineer clipped the wave wire beside the track, and the sentence he uttered seemed my death knell: "Now ring your gong on the engine."

The General Manager, standing by my side, tried to comfort me, saying: "Cheer up, Prentice, you will win out, because precedent is in your favor." "How do you make that out?"

"On those poles the first message transmitted by telegraph was sent. 'What wonders God hath wrought.' On this roadbed where we now stand the first locomotive was successfully run by steam. Right here the Hertzian wave was first used for train control, and will win out, as the other two did."

I was in a predicament similar to that of George Westinghouse, (all honor to him for his great achievements) with his first application of the air brake, attempting to apply the air direct to the wheels. He reversed the principle, and has won a name that will go down through the ages as one of the world's greatest inventors.

For two years I wandered from position to position, all the time endeavoring to solve the problem, at last reaching Cincinnati, Ohio, financially hanging on by my teeth, as it were, but not disheartened. On the 13th of April (please note the 13 again) while passing a drug store at the corner of Walnut and Vine Streets, I noticed a small fountain inside a glass globe, throwing spray upward. Some one, for novelty, had placed a gas ball so the spray kept the ball up in the air by the force of the water.

This was the solution of the enigma. Use the "wave" to keep some object suspended in space. The cessation of the wave would allow it to fall by gravity, and the stoppage of the train could be effected.

Mr. Sidney R. Perry, of New York, secured a basic patent on this feature for me in February, 1907, the basic claim, No. 4, reading as follows:—"In a railway signal system a generator of Hertzian wave for each block, indicating safety, and the absence thereof danger," which in the opinion of the best experts absolutely gives a monopoly of wireless for train control.

Returning to Chicago in June, 1906, effort was made to secure permission to develop the idea on eighteen roads of that city, but without result.

During the months of October, November and December, 1906, a series of head-on and rear-end collisions caused the loss of 347 killed and over 4,000 injured, culminating in the rear-end collision at Terra Cotta, Md., on December 27th, in which sixty-three were killed and one hundred injured.

Becoming desperate, as inventors sometimes do, I wrote President Roosevelt a letter, telling him my difficulties. To my surprise he took the matter up and secured action by Congress as follows:—

"Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That the Interstate Commerce Commission be, and it is hereby, directed to investigate and report on the use of and necessity for block-signal systems and appliances for the automatic control of railway trains in the United States. For this purpose the Commission is authorized to employ persons who are familiar with the subject, and may use such of its own employees as are necessary to make a thorough examination into the matter.

"In transmitting its report to the Congress the Commission shall recommend such legislation as to the Commission seems advisable.

"To carry out and give effect to the provisions of this resolution the Commission shall have power to issue subpœnas, administer oaths, examine witnesses, require the production of books and papers, and receive depositions taken before any proper officer in any State or Territory of the United States.

"To enable the Interstate Commerce Commission to investigate in regard to the use and necessity for block-signal systems and applianees for the automatic control of railway trains including experimental tests, at the discretion of the Commission, of such of said signal systems and appliances only, as may be furnished in connection with such investigation free of cost to the Government, in accordance with the provisions of the joint resolution approved June 30th, 1906, $50,000.00."

The Block Signal and Train Control Board was appointed, and organized in July, as follows:—

Professor M. E. Cooley, Chairman, Ann Arbor University, Ann Arbor, Mich.

Capt. Azel Ames, jr., New York Central Signal Engineer, New York City.

B. B. Adams, Associate Editor *Railway Gazette*, New York City.

Frank G. Ewald, Consulting Engineer of the Illinois Railroad and Warehouse Commission, Chicago, Ill.

Wm. J. Borland, Railway Engineer, Washington, D.C.

At a meeting of the Board held in September, 1907, one of the first cases considered out of 345 was the Wireless Train Control. All the members of the Board, except the Chairman, expressed the opinion that wireless was too young to be given serious consideration. The Chairman stated that from his personal investigation of wireless, it would eventually be the solution of train control.

On the 13th of July, 1907, I made application to the General Manager of the Suburban Railroad, an electric line thirteen miles long, extending from 48th Avenue, Chicago, to La Grange, Ill., for permission to install and develop the system on his road. It was granted, and I was given a letter to the Superintendent at Harlem to this effect. Upon alighting from a Metropolian Elevated R.R. train at 48th Avenue, I found car 113 about ready to pull out. I boarded the car. Conductor No. 13 collected my fare and rang up the register, which recorded the thirteenth fare collected by him. On September 13th, the apparatus was finished and first tried out on car 113. In the apparatus on car 113 the antenna for picking up the wave was thirty-nine feet long. The pick-up under the car was thirteen feet long.

The first inspection of the Block Signal and Train Control Board took place on June 23rd, 1908. The final test of the Board took place on April 23rd, 1909, the report reading as follows:—

"The Prentice apparatus referred to in our last report has been further examined. In this the actuation of the stopping device (or the visual or audible signal) on a moving vehicle is affected by Hertzian waves, having their source in the currents in a line wire strung on poles at the side of the railroad and acting through the atmosphere without metallic connection from line wire to vehicle. This apparatus was tried on the line of the Suburban Railroad Company, an electric line between Chicago and La Grange, Ill. In the experiments witnessed the function of the Hertzian wave apparatus, which embodies a principle not before used in railroad signalling, was performed in a manner warranting the encouragement of further experiments whenever a more complete installation shall be made."

The Board also promulgated the following bulletin at the same time:—

"To obtain the greatest possible benefit from its use, and in order to be wholly desirable, the Board believes that any system of automatic train control should possess the following characteristics:—

"(1) The apparatus should be so constructed that the removal or failure of any essential part would cause the display of a stop signal and the application of the train brakes."

"If electric circuits are employed they should be so designed that the occurrence of a break, cross or ground, or a failure of the source of energy in any of the circuits would cause the display of the stop signal and the application of the train brakes."

"(2) The apparatus should be so designed that it may be used upon the open roadway, on bridges, or electric elevated structures, in tunnels or subways, and where either steam or electricity is used as a propelling power."

"(3) The apparatus should be so constructed as to conform to recognized standards of clearance for rolling equipment and structures, so that those portions of the apparatus, placed upon the roadway, will not be subjected to damage by rolling stock or engines, nor those portions placed upon the vehicles be damaged by any structure permitted to exist upon the roadway; and at the same time, all vehicle parts and roadway parts which may have to come into operative relation should be so designed that proper operative relation will be secured under all conditions of speed, weather, wear of track or vehicles, oscillation, and shock."

"(4) The system should operate under all weather conditions which permit the operation of trains."

"(5) The system should be capable of control by the ordinary means used for indicating the condition of the block about to be entered, such as electric track circuit."

"(6) The engine apparatus should be so constructed as to prevent release of brakes after an application has been made until the train has been brought to a stop, or the obstruction or other conditions which caused the application have been removed."

"(7) The system should be so designed that should operating conditions require it, speed control may be used; that is, provision should be made for a train to pass an automatic stop in tripping position without the application of the brakes, provided the speed is less than a pre-determined number of miles per hour."

"(8) The system should be so designed that when no cause for stopping a train exists, a definite and positive clear or proceed indication will be given at every point where a stop indication would be given or the brakes applied when adverse or dangerous conditions existed."

"(9) The system should provide, at least for use under congested traffic, for a continuous display of indications rather than for their intermittent display at certain definite points, as of course is necessary with fixed signals."

My system is so far the only system which meets this requirement, and is the only train control system in the world complying with the essential requirements stipulated by the Interstate Commerce Commission as noted above.

In May, 1909, realizing that it was impossible to secure permission to install the system on a railroad in the United States, and secure adequate assistance to meet the requirements of the Block Signal and Train Control Board, I decided to make an appeal to my former employer, General Manager J. W. Leonard, of the Canadian Pacific.

On May 23rd, in the City of Toronto, I met Mr. Leonard, who gladly delegated his Principal Assistant Engineer, Mr. Fairbairn, and Mr. Parker, Signal Inspector, to make an investigation of the electric line installation in Chicago, which was completed on July 6th, and the following September the track between Queen Street subway, Parkdale, and Royce Avenue, West Toronto, was assigned to me for development purposes.

Like all inventors, I was rich in theory and glorious prospects, but poor in purse, therefore, I appealed to my former co-workers on the C.P.R.—the engineers, firemen, conductors, and train despatchers, who came to my rescue, and with some of Toronto's staunch business men, saw in my invention sufficient merit to justify them in furnishing $15,000.00 for the installation and necessary expenses. Not only did they furnish the sinews of war, but have worked night and day assisting in the solving of the perplexing difficulties incident to a steam installation. This fidelity and loyalty has been augmented and strengthened by the continuous and never-ceasing assistance of Mr. James Oborne, General Superintendent, and his staff on the C.P.R. No appeal for help in a trying crisis has ever been refused. Many, many times, engines, material and men have been placed at my disposal at great personal sacrifice, as well as discommoding traffic operations.

On December 1st, 1909, the first hole for bonding the tracks was bored at Queen Street Subway. On September 14th, 1910, the work was completed.

To the average observer the distance from the air brake of a moving train to the roadway beneath is but a matter of feet and inches. To experimenters in the field of automatic train control, however, it is a formidable interval of space that cannot be measured in ordinary units of magnitude. Many are the inventors who have witnessed the inches in which they themselves first estimated this extent of space grow into miles, when they tried to span it with some form of energy, or sought to hurl across it some impulse which could be amplified and supplemented until there was power to stop a train. And, as one by one, their successive improvements on the almost inevitable first step, the mechanical trip, proved impracticable, and each new device in which they had embodied all the lessons and advantages of previous experience, succumbed to some unforseen action, of inertia, impact, or momentum, the miles stretched into infinity, and their hopes vanished. The results of this have been that knowledge of the conditions and requirements under which automatic control systems must operate is much more general than when interest in the subject was first aroused, and a more wholesome respect is entertained for the gap between the train pipe and rail.

A few inventors, however, have been fairly successful in securing an effective connection. They are the ones who have paid proper respect to the laws of mechanics, and have brought the light of scientific research and practice to bear upon the problem.

Even a fair degree of success with combinations of substance is a long step, for experience has demonstrated that things are liable to happen on and about a moving train which defy explanation, and are as little capable of being forecasted as a stroke of lightning. I have been accused of having this in mind in working out my system. Certain it is, at any rate, that in my system the uncertainties attached to matter and velocity and inertia are eliminated. The means here employed for this purpose are less tangible and more absolute in their operation. The scientific basis, as heretofore intimated, is the discovery by Hertz that electric oscillation produced in a circuit which possesses capacity and inductance creates in the surrounding ether a disturbance which is styled an "electric wave." This wave causes the metallic filing tube, commonly called a coherer, to become a conductor of current when it is brought into the radius of influence of the wave.

We now have before us three blocks of double track, being shown as equipped in the approved manner with the apparatus. The system is an adaptation of the main principles to certain conditions.

There are two parts to this system: First, that part which is on the track, and second, that part which is on the train.

The essential features of the track portion are the track circuit and the generator of the wave (Fig. 1). The manner of controlling the wave by the tract circuit relays will be evident from an inspection of the diagram. The generators, as a whole include the transformer T, the condenser C, and the discharge points PP, commonly known as oscillators. One of these generators is placed at the end of each block, and a wave wire is extended for a block length in the rear. This wave wire that is used is No. 12 aluminum, and is run in a trunking in the centre of the track, midway between the rails. The generator is controlled by the track circuits of the block in advance. As long as the flow of current through the track circuits is not broken or short circuited, the A.C. relays R, keeps the generator connected with the A.C. feed wires, stepping the 110 volts up in the ratio of 200 to 1, causing a static discharge to continuously take place between the oscillators, P.P. Connected to the oscillators will be noted the wave wire, W, and pick-up wire, U, extending along the track in the relative positions shown. All the track blocks are provided with the ordinary form of vane type relays and A.C. track circuits. It will be noticed that the wires W and U are charged with the wave producing current only when the block in advance is clear. This is in accordance with the closed circuit principle upon which the whole system is built, as will be more fully shown hereafter. The wave wire W, is insulated from the track, and its preferred position with reference to the track is along the middle of the ties as shown. On single track the wave wire is placed near the end of the ties. The maximum length of the wire which can be charged with one oscillator is measured by miles, so it is plain that the lengths of the blocks are governed, in actual operation, only by the requirements of traffic. The maximum distance for A.C. track circuits is 16,000 feet, while that of D.C. track

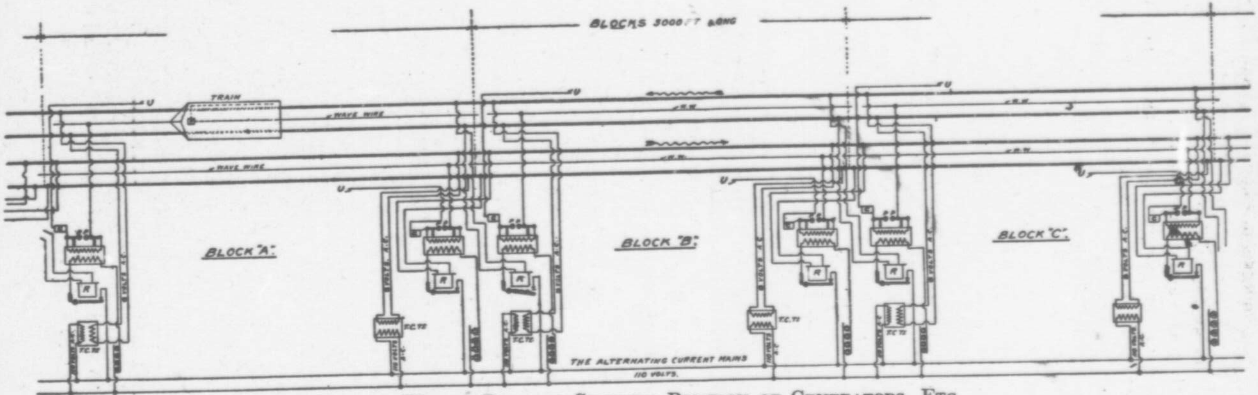

Fig. 1. Wiring Diagram Showing Position of Generators, Etc.

circuits is 3,000 feet. The installation on the C.P.R. is the first to use A.C. for track circuits on steam roads, its use heretofore being confined to electric lines. The distance in which the heaviest train going at the highest speed can stop is probably a safe minimum length for a block, 1,500 feet. The system thus is elastic enough for practically all conditions of present practice.

It will be understood that these oscillatory wave wires and generators may be applied to any forms of track circuits which are in general use, and moreover that they do not interfere with present forms of block signals. My system has no fixed signals on the ground. It may, however, be employed in conjunction with existing block and other signals.

The track installation on the C.P.R. consists of eight blocks, from 2,000 feet to 4,500 feet each, four blocks on the west bound and four on the east bound track, beginning at Queen Street Subway and ending at Royce Avenue, a distance of two miles, generators being located at Noble Street, Lansdowne, Golden, Wallace and Royce Avenues. These have been in constant service since March 25th, 1910, without interruption. The expense for current for this period has been two cents per

FIG. 2. TRACK SHOWING WAVE WIRE AND PICK-UP WIRE.

day per block,—about 90 per cent. less expensive than visual signal systems. There being no batteries in the track installation, the cost of maintenance is cut 50 per cent.

Having a wire which extends throughout a block (Fig. 2), and is charged with a wave producing current, which makes the wire the centre of a series of outwardly extending concentric impulses, having a constant radius of influence at any point along the wire, it remains only to run a train carried antenna, with its coherer, into the block, and at the instant this antenna enters the zone of the wave, it causes the coherer to become a conductor of electricity. This is the secret of the "wireless system."

The gap is bridged by Hertzian wave. Intangible, mysterious though the wave may be, it is nevertheless a fact that it furnishes an actual and positive connection between train and track. More than this, its field of influence can be definitely confined; the radius of the zone can be limited to one or two or five feet if desired, as easily as to a mile. This, of course, is accomplished in the generating apparatus. It is necessary to prevent the receiving by a train on one track of a wave intended for a train on the other track, and to make it impossible for a train going in one direction to be interfered with by a wave intended for a train in another direction.

The part of the system which is carried upon the engine comprises first of all the main antenna, nineteen feet long, suspended from the boiler braces by three hangers, the antenna consisting of aluminum plate four inches wide, and hanging directly over the wave wire, two inches above the level of the pilot or seven inches, from the indurated trunking.

Second: A pick-up antenna suspended in a like manner on the right hand side, suspended beneath the cylinder cocks,

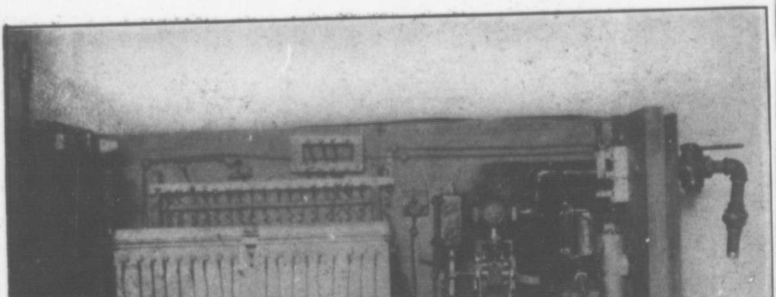

FIG. 3. LOCOMOTIVE EQUIPMENT FOR WIRELESS CONTROL.

thirteen inches outside of the rail and directly over the pick-up wave wire at the end of each block.

Third: A Pyle turbine generator giving six volts and twenty amperes of current for supplying the working force of the wave responsive apparatus.

Fourth: The train control mechanism (Fig. 3), the salient feature of which is the coherer, consisting of a wood fibre receptacle having a hole in the centre, and two lugs inserted in its bottom one-quarter of an inch apart. Placed in the coherer are the wave responsive filings, sufficient to fill in the aperture between the lugs. The coherer is rotated upon an axle through ninety degrees of space by a solenoid rack and pinion, being held in the upright position two seconds by means of two hold relays, the filings during that time resting between the lugs. Normally these filings are a non-conductor of current, but when the Hertzian wave is emanated in their zone the resistance on their outer surface is broken down and a current flows through them, closing the master relay, 15. Once these filings are cohered they will retain such cohesion until they are jarred to restore their non-resisting qualities, hence the rotating coherer to drop them out by gravity to perform this function. The coherer is in operation constantly as long as an engine is in service. The master relay opens and closes every three seconds when the wave is being received. Connected to the master relay is a series of ten hold relays, 3 to 12 inclusive. These relays will hold their magnetism one second each after the current is broken, and being in parallel series relay 12 releases its contact ten seconds after the master relay ceases to be operated by the wave controlling influence (Fig. 4).

Relay No. 7 through its contact energizes solenoid 13,

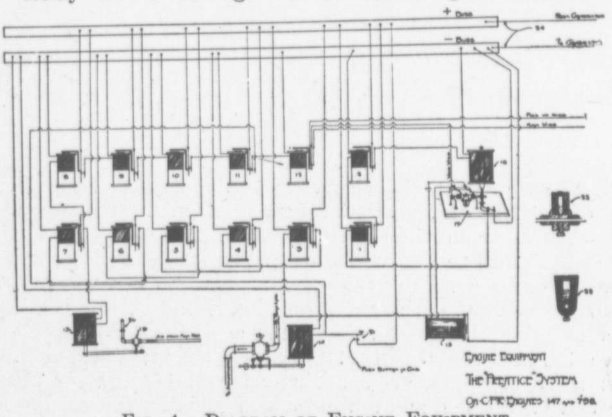

FIG. 4. DIAGRAM OF ENGINE EQUIPMENT.

whose plunger holds closed through a fulcrumed lever valve 19, which stops the air from the main reservoir blowing whistle, 20.

Relay 11 through its contacts energizes solenoid 14, which through its fulcrumed solenoid holds closed balanced valve 18, preventing the escape of air from train line through a one inch port.

Relay 12 has a front and back contact and a common connecting with coherer 17. When relay 12 is closed its common is in connection with the main wave wire antenna under the engine, and when disengaged is in connection with the pick-up antenna located under the steam chest.

Solenoid 14 is also subject to control by a push button, 21, located in cab of engine, by the engineer.

Engine No. 798, leaving John Street round house on its trip to West Toronto has its solenoid coherer, 16 and 17, in operation. There being no wave between Simcoe Street and Parkdale, master relay 15, hold relays 3 to 12, solenoids 13 and 14, are de-energized, whistle 20 is blowing train line valve is held closed by push button 21 to keep brakes released. Entering wave zone just west of Queen Street Subway, if the block is unoccupied, pick-up wave wire is unengaged and the wave jumps to the pick-up antenna, the wave reaching the coherer through its contact on relay 12, closing master relay 15, which closes relays 3 to 12. The coherer thus being automatically connected with main antenna under the engine, solenoid 13 stops the whistle from blowing, solenoid 14 closes valve 18 and the engineer can then remove his finger from push button 21. The engine is now under control of the wave, and as long as the wave is being received master relay 15 will be opened and closed every 3 seconds, 2½ seconds closed and ½ second open, consequently relay 3 and its trailing relays 4 to 12 will remain closed. The wave is being received from the generator at Lansdowne Avenue, the generator in turn being controlled by the A.C. track circuits being fed from Golden Avenue block station (Fig. 5).

Suppose there is a train standing in the block between Wallace Avenue and Golden Avenue. The wheels of the train shut off the current from A.C. relay at Golden Avenue stopping the wave between Golden Avenue and Lansdowne Avenue, the coherer fails to receive the wave, the master relay remains open, in one second relay 3 opens and relays 4, 5, 6, and 7 open successively, each one second later, and in five seconds after entering the block at Lansdowne solenoid 13 drops its valve 19, and the whistle, 20, starts blowing; four seconds later relay 11 opens, de-energizing solenoid 14, and the train line valve is opened, and ten seconds after entering Lansdowne Avenue block the brakes are being applied to engine 798,

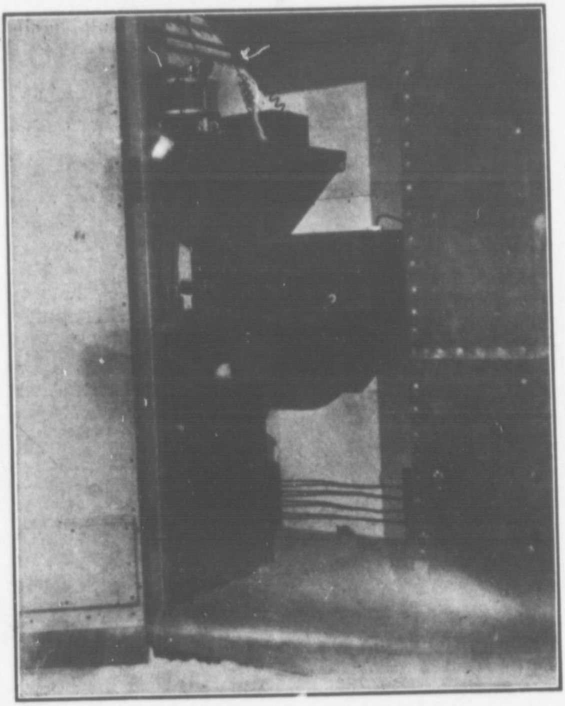

FIG. 5. INTERIOR GENERATION BOX, SHOWING TRANSFORMER AND OSCILLATORS.

which will be brought to a stop without closing the throttle, as the power of the air brake is three times greater than the steam.

Relay 12 has opened and the coherer is now connected with the pick-up antenna under the steam chest, which is 3 feet 5 inches from the main wave wire in the centre of the track. The engine is brought to a stop unless the engineer when the whistle starts to blow closes push button 21, holding solenoid 14 closed, thus preventing the application of the brakes. If the engineer is incapacitated or dead it is obvious that the train will be brought to a stop. Suppose that before 798 reaches Golden Avenue, the train in block A has cleared, when 798 gets over pick-up wire at Golden Avenue, the engine is again placed under control of the wave.

However, suppose that block A is still occupied, the pick-up wire at Golden Avenue is, not energized and engine 798 enters the block with its coherer still connected with the outside antenna, and as the waves from the main wave will not jump over twelve inches the apparatus on engine 798 is irresponsive and the train runs in and through block A under the whistle signal of caution.

The hold relays are immersed in oil in a metal box and the oil will stand 50 degrees below zero.

Engine 147 has covered 5,000 miles with the apparatus intact, 104 hours continuous run of the equipment has been made on engine 798 without stopping. Engine 798 is in service from 6 a.m. Monday until 8 p.m. Sunday, handling from twenty to sixty cars per trip. Stops are made daily with wide open throttle.

The train line valve is set for 25 pounds reduction, and it requires this reduction to make stop with light engine. With twelve cars at fifty miles per hour a reduction of 17 pounds is made in the train line. With thirty cars the valve only makes 13 pounds reduction; with forty cars 8 to 10 pounds, and with sixty cars 5 pounds, the valve simply mechanically making the amount of reduction necessary to make the stop —no more, no less.

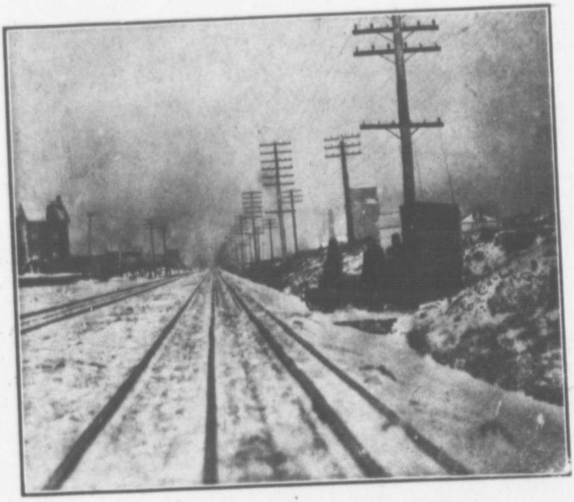

FIG. 6. PICK-UP AND MAIN WAVE WIRE.

The basic features of the invention are set forth as follows: First, among them is the fact that all track devices and all train devices are on the closed circuit principle. It is evident that the train pipe is kept closed by a balanced valve, and the moment the wave ceases it drops open by gravity. It is not pulled open, and the only chance of its failure is when the apple fails to fall from the tree to the ground, and when that occurs we will none of us have any occasion for train control.

The coherer always working is the watchman of the apparatus. It delivers a report that all is well every two seconds to the master relay. It ceases reporting when all is not well, the coherer is perpetually being up-drawn to keep it in prime condition for the wave influence (Fig. 6), which is received by the engine carried antenna. The whistle valve and the train line valve are being forcibly retained in the presence of the wave, and opened and dropped by the gravity principle in case of its cessation exactly in the predetermined order. A failure anywhere means a stop, except the engineer is in possession of his senses and faculties and uses the push button to keep the train line closed; but under any conditions in case of the cessation of the wave the air whistle is a constant reminder of the necessity for caution and of danger ahead.

A train entering a block when the next block is occupied is brought to a stop unless the engineer intervenes. After this the train may proceed under a caution signal. The caution signal forces attention either until a clear block is reached, or until the mechanism on the engine has renewed operations because of the wave on the unlock wire.

It will be understood with reference to the wave that its influence may be confined to a definite zone, and that its ability to affect the coherer is in no way affected by the presence of masses of metal, as on the line between West Toronto and Parkdale we run parallel to and have crossing the line the Ontario Development Co.'s and the Hydro-Electric Co.'s high tension wires of 80,000 volts; two metal bridges are crossed over, carrying our wave wires, and also the metal overhead bridge at Dundas Street is passed under.

The seeming complexity of detail must be understood as being confined to the train stopping apparatus; the simplicity of the wireless action of the wave wire on the track and the receiving antenna on the engine may be appreciated at a glance. Given this connection, and any form of application of the impulses of the automatic stopping of the train which will satisfy local requirements is possible.

The device that you see to-night has taken its present form as the result of a process of elimination by its designers of less suitable forms. The experimental installation of the system has now been working on the C.P.R. for the last four months, and the results on the engine and beside the track with the Hertzian wave are absolutely perfect and satisfactory in every degree.

This system is the first one so far as is known to utilize the principle of the wireless telegraph for signalling. The wireless telegraph as expounded by Marconi, Fessenden and many other eminent practical scientists has demonstrated its practicability as a means of communication and a commercial success, and I have no fear that the wireless train control will take its place in its own particular field and do it as successfully as the others. Of course there will be changes made in some of the devices which we use, just the same as there are changes made in any invention when it is fitted to a variety of actual conditions, but the changes are more likely to be alterations of detail than of method.

Chairman,—

I am sure you have all listened with a great deal of pleasure to the very interesting paper given by Mr. Prentice.

As Mr. Prentice is going at ten o'clock, and it is now nine-thirty I shall be pleased if anyone desiring to ask Mr. Prentice any questions will do so.

We have several gentlemen with us to-night who we are very pleased to see. Amongst them is Mr. Somerville, who most of you know is the late Resident Engineer of the G.T.R., and I am sure we should all like to hear from Mr. Somerville.

Mr. Somerville,—

I came here to-night to listen to Mr. Prentice, and not to talk about this subject. However Mr. Prentice got me interested very shortly after he came to Canada about fifteen months ago. I examined his device, as he had it then, very thoroughly. You are probably aware that while I was on the Grand Trunk I had all sorts of devices for the control of trains to report on, and unconsciously I made tests which I see are called for by the requirements of the American Inter-State Commission.

In all the appliances that were put before me I found one weak point, and that was, that they all relied to a greater or lesser extent to the man on the engine. I have the utmost confidence in the man on the engine—always had. I believe that nine hundred and ninety-nine out of every thousand of the men on the engines try and succeed in doing their duty to the utmost of their ability. But we are all liable to accidents, all liable to sickness, all liable to troubles—mental and personal then no matter how hard we try to do our work these various things interfere with us, and I think every engineer will agree with me that occasionally he does not see all that he ought to see. The thing that has always struck me in connection with safety appliances is that we should guard against those unfortunate, unintentional violations of the rules by the man on the engine failing to see the signals placed before him, and of all the appliances that were put before me, with the exception of Mr. Prentice's, I saw none that got over that difficulty.

I do not think I am saying anything that will hurt Mr. Prentice when I tell you right here that when I first saw Mr. Prentice's invention I saw that it was all right, but his appliances were very crude. I think I have been, to some extent, for the last fifteen months what is called in the Church of Rome when they want to make a saint of some good person who is dead, the "Devil's Advocate," who has to find out the faults of the person they want to sanctify. I think I have spent most of my time finding fault with Mr. Prentice's appliances. I appreciated that with the invention he had he would be making the greatest mistake he could make to put that appliance before the big railroad companies as long as there was any liability of failure. He told you of one failure he had when demonstrating before the B. & O. This failure was the greatest thing that could have happened to him, it was his salvation, and therefore I have been pointing out to Mr. Prentice, time and time again, things that did not appeal to me from my experience on railroads, things that appeared to me would not satisfy the transportation people, and one after another these difficulties have been eliminated.

I can speak confidently to you to-night, and say that I believe Mr. Prentice's appliance as it stands at the present time is an absolute success, and will do all that it is intended to do.

I thank you all for listening to me, and I have had great pleasure in being here. This is the first time I have ever attended one of your meetings, and I hope it will not be the last.

Chairman,—

I will now call on Mr. Parker, of the C.P.R.

Mr. Parker,—

I am sure it gives me a great deal of pleasure to be present this evening and hear what Mr. Prentice has to say for himself. He is very much better able to speak for himself than I am able to speak for myself. With so many duties crowding in upon me I have been unable to make any preparation for saying anything to-night, and it is rather unfair of the Chairman to call on me.

You probably have heard something to-night for the first time, and I am not the least bit surprised that you have not got much to say, when I first saw it I was the same.

I first saw this invention on an electrical line just outside Chicago, but in a rather different form from what it is to-day. To-day it is applied to steam locomotives; there it was applied to an electric line.

I have followed this thing pretty closely since its inception and I do not think that there is any one able to speak of the details better than myself. During the last five or six months I have not been in such close touch with it as I was previously.

There are a great many details to work out and a great many have been solved, but there are still some to solve and I have no doubt when it is stretched over a considerable mileage there will be many more difficulties to solve. It is like starting to walk or drive down a crowded street, you do not see the way clear ahead at the commencement, but as you go along you are able to thread your way through the difficulties which present themselves. All these things have to have a commencement, and when you commence you do not see all the obstacles in the way, but the way opens out as you go along, and that is how it will be with this system when it is applied.

There is no doubt that all over the world, in connection with steam lines and electric lines, with the fast traffic we now have there is a strong sentiment for some method of controlling trains outside the manual operation of the engine driver. I saw an account the other day where the State lines of Prussia are making tests every day with a view to making it possible to control trains by some other means than the engine driver seeing signals beside the track. They have, for a great number of years, been experimenting with signals operated in the cab. In some parts of England, owing to the track signals sometimes being obscured by fog, experiments along these lines have been made, but they have not yet been able to arrive at any satisfactory solution to the difficulties met with in inventing an absolute cab signal. There is the difficulty of making contact with the moving vehicle automatically.

There is a device in the New York Subway—a mechanical trip,—which would be absolutely useless where the line is exposed to the elements and there is always the danger that some part of the apparatus may be broken and carried away thus rendering the device useless, and that is the reason why the specifications for automatic safety devices drawn up by the Railway Board states that clear indication shall be received at all times in the cab. Mr. Prentice's device is the only one I know of which gives a clear indication at all times to the engineer that the track is clear or not to run on, and he is not dependent on reaching any particular portion of the road before he can receive a clear signal.

I was dumbfounded when I first saw this apparatus working in Chicago. I thought it a mysterious sort of thing, there is nothing you can put your finger on, I might almost say it is elusive.

When I saw the apparatus being tested in Chicago, I traveled on a car following a regular car. The motorman started the car, came inside, put his feet up on the seat in front of him and settled himself down to rest. I was amazed and said to the motorman, "Suppose the car in front stops, how are we going to stop?" The motorman told me that just as soon as the car entered the block occupied by the car ahead, the car would stop. After a while we entered the block of the previous car, something went bang and the car stopped and we investigated to see if we could see what had stopped the car, but there was nothing to be seen. I might say that Mr. Prentice's apparatus had not only stopped the car but shut off the current to the motor. He, of course, does not attempt to cut off the steam of a locomotive, but is content to apply the brakes which are sufficiently strong to overcome the action of the steam.

I want to say while Mr. Prentice is here, that, while we have not yet made an official test on the C.P.R., we hope to do so in a very short time. I am sure Mr. Prentice has been most kind and generous in all his dealings in connection with this matter, and has always been prepared to submit any changes for our approval, and it has been a great pleasure to deal with him. There has been nothing covered up, and you do not have to find the faults out for yourself.

I am sure there is no gentleman in this room to-night, who, if he will thoroughly investigate this matter, will not only derive a great deal of pleasure but also a great deal of knowledge, and I would commend the question to your earnest consideration. With these few words I will close.

Mr. Prentice,—

I wish to say that now that you have seen a drawing of the apparatus on the screen, I shall be pleased for any of the members of the Club to call at the office, 320 Confederation Life Building, where we have in operation the apparatus which was used on engine 147, and make a thorough investigation of same, and cut as many wires as you please, and investigate it at your leisure, and we will entertain you and show you exactly how it will operate on the engine.

I wish to thank you very kindly, and I hope in the near future to be a member of your Club.

Mr. McRae,—

Mr. Chairman, I cannot let this occasion pass without making a few remarks. I am sure you will all agree with me that the Club is to be congratulated for the honor which Mr. Prentice has done us in giving us the benefit of the first lecture on this wonderful invention to-night, and I have much pleasure in moving a hearty vote of thanks to Mr. Prentice.

Mr. Jefferis,—

I have much pleasure in seconding that.

Chairman,—

You have all heard the vote of thanks proposed by Mr. McRae, seconded by Mr. Jefferis, what is your pleasure? Carried.

Chairman,—

Mr. Prentice, I take the greatest pleasure in extending to you the hearty vote of thanks of this Club for the very interesting paper which you have given us to-night.

Mr. Prentice,—

I thank you.

Chairman,—

The Secretary has asked me to remind the members who have not paid their dues that now is a good opportunity to do so.

Chairman,—

I am very pleased to see such a good crowd here to-night, and I do not see why we do not get a crowd like this every night considering the excellent papers which we get from time to time.

The Executive and Reception Committee are asked to wait after the close of this meeting.

Moved by Mr. Fletcher, seconded by Mr. Carmichael, that the meeting be adjourned. Carried.