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Telephonic Communication over the Power Circuit with an Electric Car

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TELEPHONIC COMMUNICATION
OVER
THE POWER CIRCUIT
WITH AN
ELECTRIC CAR

BY

FRANK WILBUR PADFIELD
WILBUR CLINTON MADDOX

THESIS

FOR THE

DEGREE OF BACHELOR OF SCIENCE

IN

ELECTRICAL ENGINEERING

COLLEGE OF ENGINEERING

UNIVERSITY OF ILLINOIS

PRESENTED JUNE, 1907

UNIVERSITY OF ILLINOIS

May 28, 1907

THIS IS TO CERTIFY THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

WILBUR CLINTON MADDOX and FRANK WILBUR PADFIELD

ENTITLED TELEPHONIC COMMUNICATION OVER THE POWER CIRCUIT TO AN ELECTRIC CAR

IS APPROVED BY ME AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE DEGREE

OF BACHELOR OF SCIENCE IN ELECTRICAL ENGINEERING

Morgan Brooks

HEAD OF DEPARTMENT OF ELECTRICAL ENGINEERING

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TELEPHONIC COMMUNICATION
OVER THE POWER CIRCUIT WITH AN ELECTRIC CAR

The general outline to be followed in the presentation of this thesis is as follows:-

1. Intrduction.
    - A. Object.
    - B. Previous Work on Subject.
    - C. General Method.
2. Discussion.
    - A. General Conditions.
    - B. Theory.
    - C. Mehtod of Procedure.
3. Conclusion.

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TELEPHONIC COMMUNICATION
OVER THE POWER CIRCUIT WITH AN ELECTRIC CAR

1. INTRODUCTION

A. OBJECT:- The object of this thesis has been to devise a set of telephone apparatus by means of which it would be possible for a dispatcher of electric trains to be in immediate communication, by talking or signaling over the trolley circuit, with cars and trains on the system.

B. PREVIOUS WORK ON SUBJECT:- Several experimenters have recognized the possibilities of such a system, and have devised a number of ingenious methods for talking to moving cars, none of which have been made a commercial success. Messers. Amrine and Carr, last year, succeeded in designing a telephone circuit by means of which they were able to talk over a twenty-two hundred volt alternating current transmission line. For their telephone they made use of only one side of an alternating current circuit with a ground return, while our problem was to talk over a five-hundred volt power circuit direct.

C. GENERAL METHOD:- While other experimenters have made use of auxillary wires and other devises, we proposed to use no extra wires or special types of cars, but to disign a telephone system, which could be installed at a small cost on any electric road operating on direct current, and by which it would be possible to talk or signal over the trolley wire with a ground return.

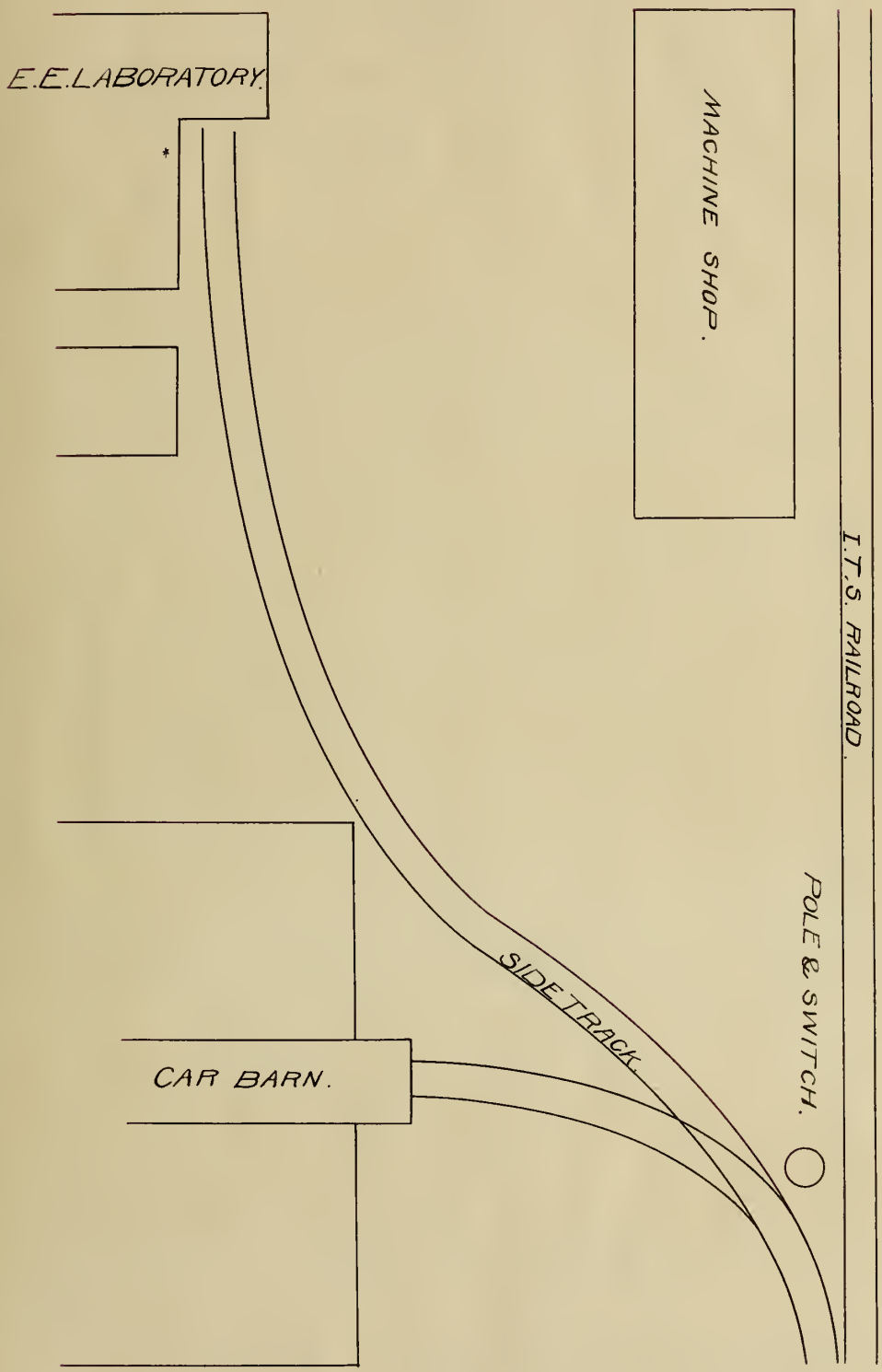

E.E.LABORATORY.
MACHINE SHOP.
I.T.S. RAILROAD.
POLE & SWITCH.
SIDE TRACK.
CAR BARN.

FIG. 1.

2. DISCUSSION

A. GENERAL CONDITIONS:- One set of apparatus was installed in the telephone laboratory of the Electircal Engineering Building, and the other set was placed in the Electrical Engineering Test Car. The connection from the telephone laboratory was made to the trolley on the spur of the Illinois Traction System as shown in Fig.1. Some difficulty was encountered in securing a good ground connection due to defective bonding of the rails.

B. THEORY:- The talking currents sent out from a local battery telephone set are alternating and of high frequency. By our systen these alternating currents must go over the same line on which there is the full direct current voltage, and in order that the direct current and high frequency currents should both reach their proper destinations, some means had to be devised for seperating the two. The flow of current through a capacity is proportional to the cycles per second,and direct current being of zero frequency will not flow through a condenser, or pure capacity. On the other hand in an inductance the flow of current is inversely proportional to the frequency, hence, an inductance offers a high impedance to an alternating current and a low impedance to a direct current.

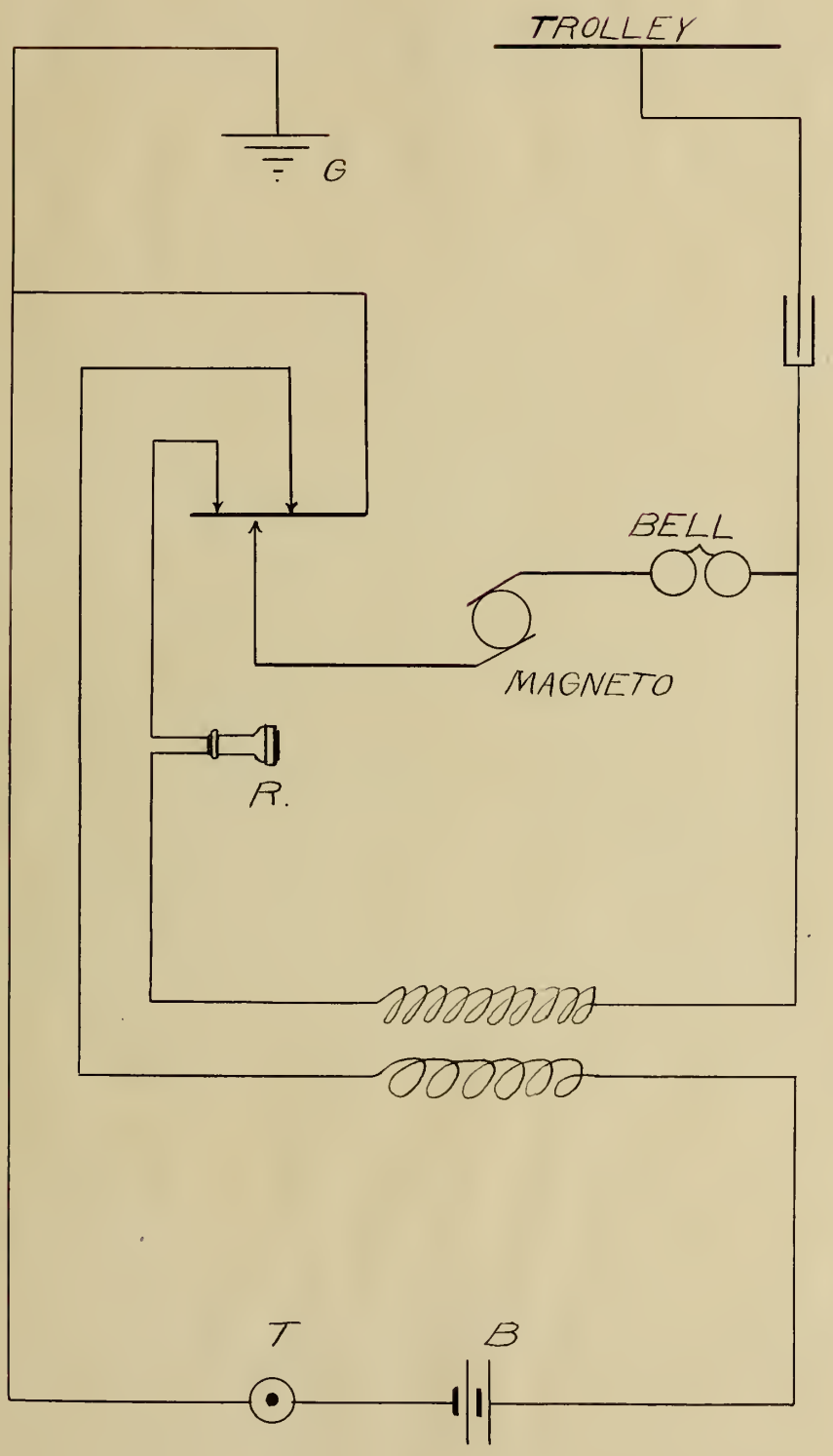


FIG. 2.

C. METHOD OF PROCEDURE:- The fundamental idea of connections was to place a local battery telephone set between the trolley and ground in series with a condenser. For safety the telephone set was placed between the condenser and ground.

With connections as shown in Fig.II. it was found impossible to talk over the trolley when the power was on. The talking currents as produced by this method of connection, were so weak that had they all gone through the receiving apparatus, their effect would have been drowned out by the noises from the line. With this connection the variation in the talking currents in the transmitter circuit were so slight, and the resistance of the receiver was so great in the secondary circuit that very low talking was produced.

In order to reduce the danger from shock in handling the telephone apparatus, one side of a repeating coil was placed in the main line in series with a condenser, and all of the telephone apparatus was connected to the other side of the coil. The efficiency of this coil was found to be high, it having no noticeable effect on the strength of the talking currents, although it was of high resistance. (Being about 500 ohms.)

The great difficulty encountered from the beginning of the work was the noises produced in the receiver due to commutation in the generators in the power station, and in the motors of the cars on the line. At this early stage of the experimental work it became very necessary to determine the

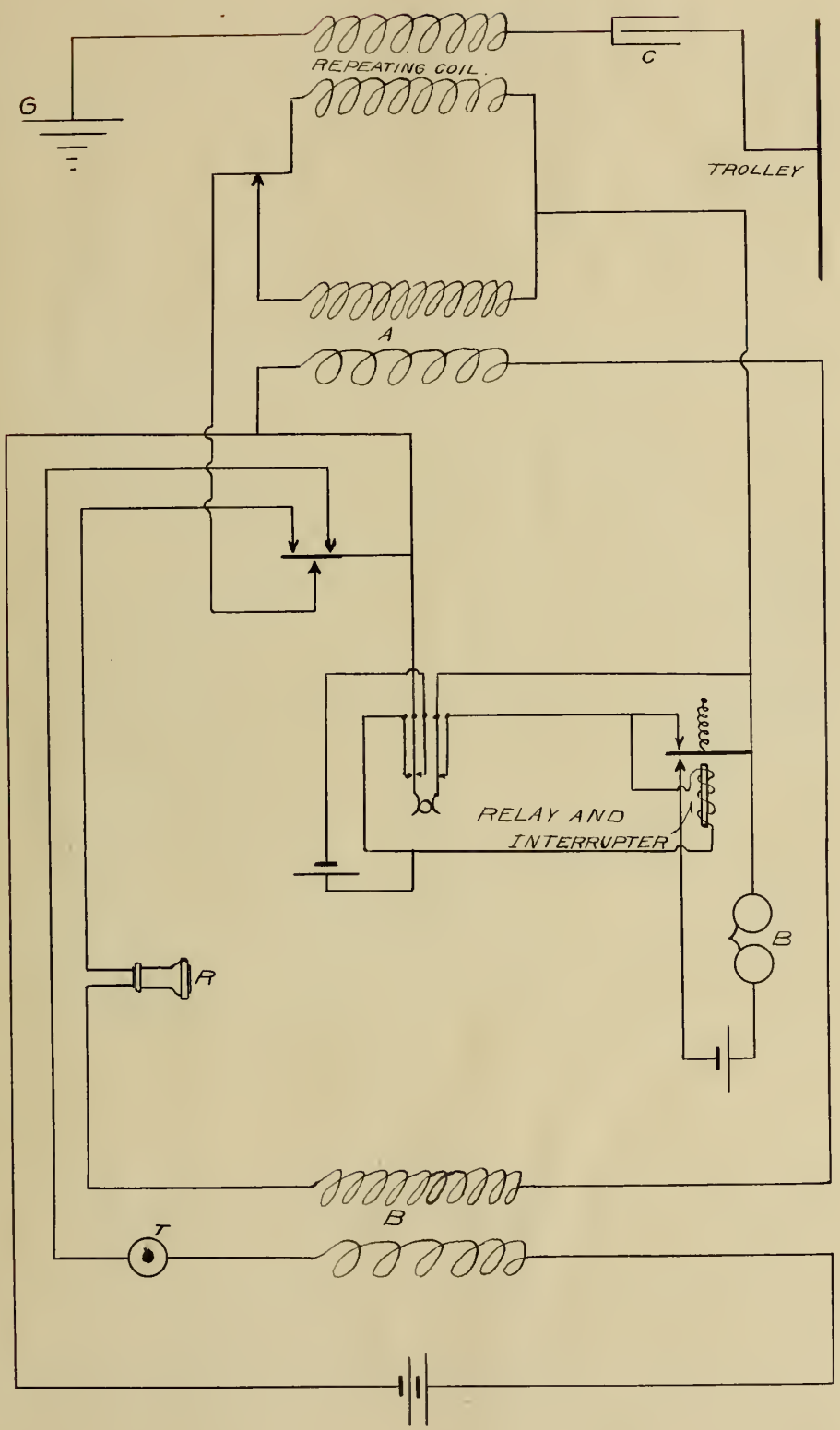


FIG. 3.

frequency of these noises. This was done by comparing the tone produced by the noises in one receiver, with that produce in another receiver by an alternating current of a known number of cycles per second. The highest attainable frequency was one-hundred and eighty cycles, and the frequency of the noises was determined to be considerable higher than this.

The frequency of the talking current was judged to be but slightly higher than the frequency of the noises, and for this reason it was found impossible to cut out these noises by means of a combination of inductance and capacity without also cutting out the telephone currents.

By means of a transformer arrangement as shown in Fig.III the noises were stepped down in volume, and since the telephone currents were stepped up at the sending station the same amount that they were stepped down at the receiving station, the effect was to decrease the noises without decreasing the talking currents. Thus it was conceived that the higher the ratio of the coils (A) the more pronounced the effect would be.

Fig. IV shows the transmitter and receiver in series. This was so arranged in order to make one induction coil take the place of two as shown in Fig.III. Two induction coils were made, having adjustable primaries and secondaries in order that the ratios of the coils might be varied. The coils were found to work best with eight layers of No 22 wire on the

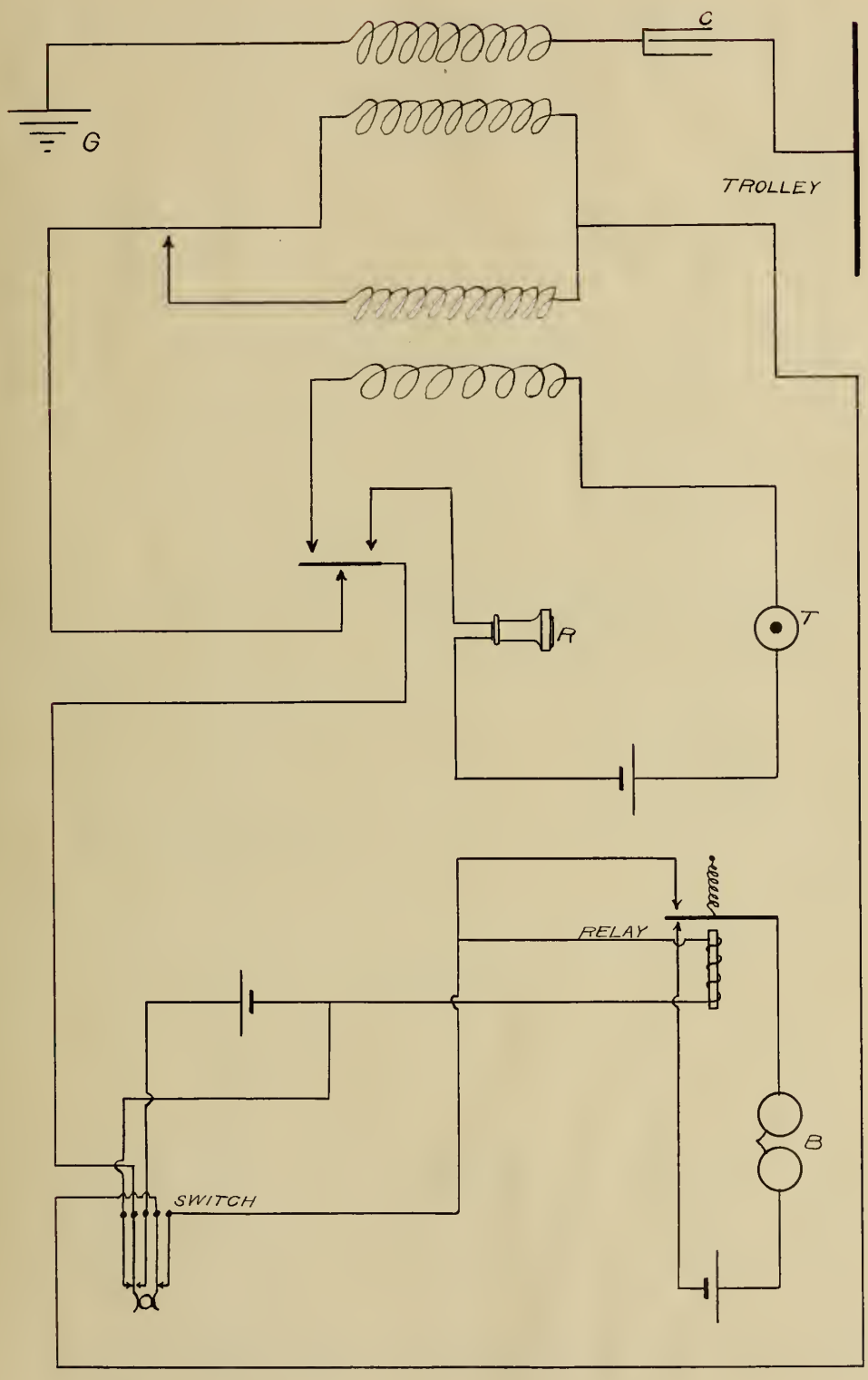


FIG. 4.

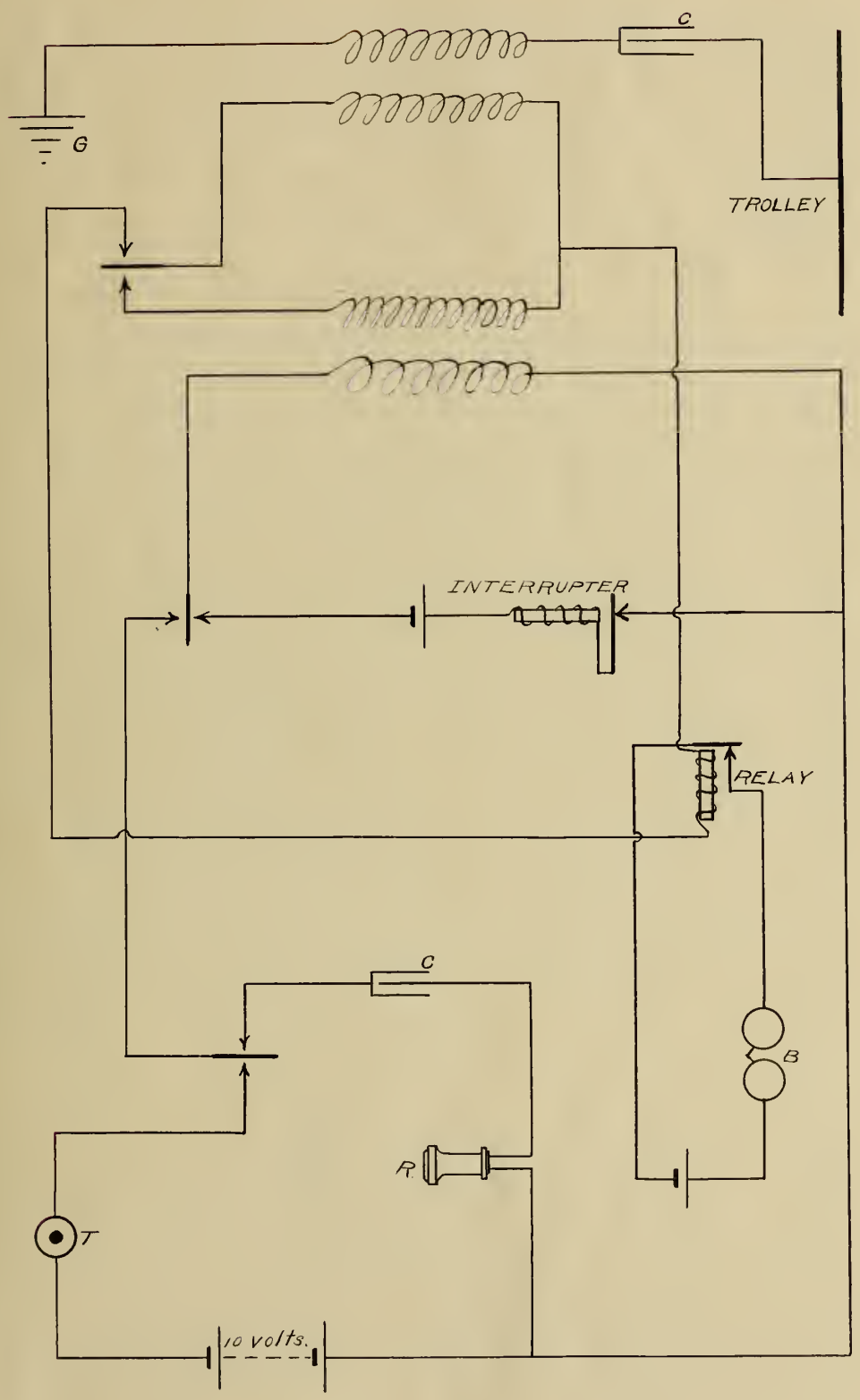


FIG. 5.

primaries and forty-two layers of No 36 wire on the secondaries. The coils were three and one half inches long. The placing of the transmitter and receiver in series reduced the efficiency of the transmitting circuit, hence the idea was abandoned.

Fig. V shows the transmitter and receiver in multiple; this gave the same results as those sought for in Fig. IV without reduceing the efficiency of the transmitter circuit. This connection gave very little resistance in the transmitter circuit. By using a Kellog transmitter it was found possible to use as high as ten volts from the battery in the transmitter circuit, which gave a variation in current from two to five amperes. Western Electric and Blake transmitters were also used, but it was found that they did not give as great a variation of the talking current as did the Kellog. While this gave an exceedingly loud speaking telephone when the trolley was dead, it was possible to hear conversation but faintly when the full voltage was on the trolley. This was due to the shunting of the telephone currents by the cars on the system.

The best results were obtained by having four condensers of two microfarads each placed in series multiple in the line, the noises being somewhat greater in volume, but not so shrill, and hence, not so annoying to the ear as they were with the smaller capacity, that was originally placed in the line. By placing a condenser in the receiver circuit, and varying its capacity, the best results were obtained with a capacity of from three-hundredths to two tenths microfarads, one tenth

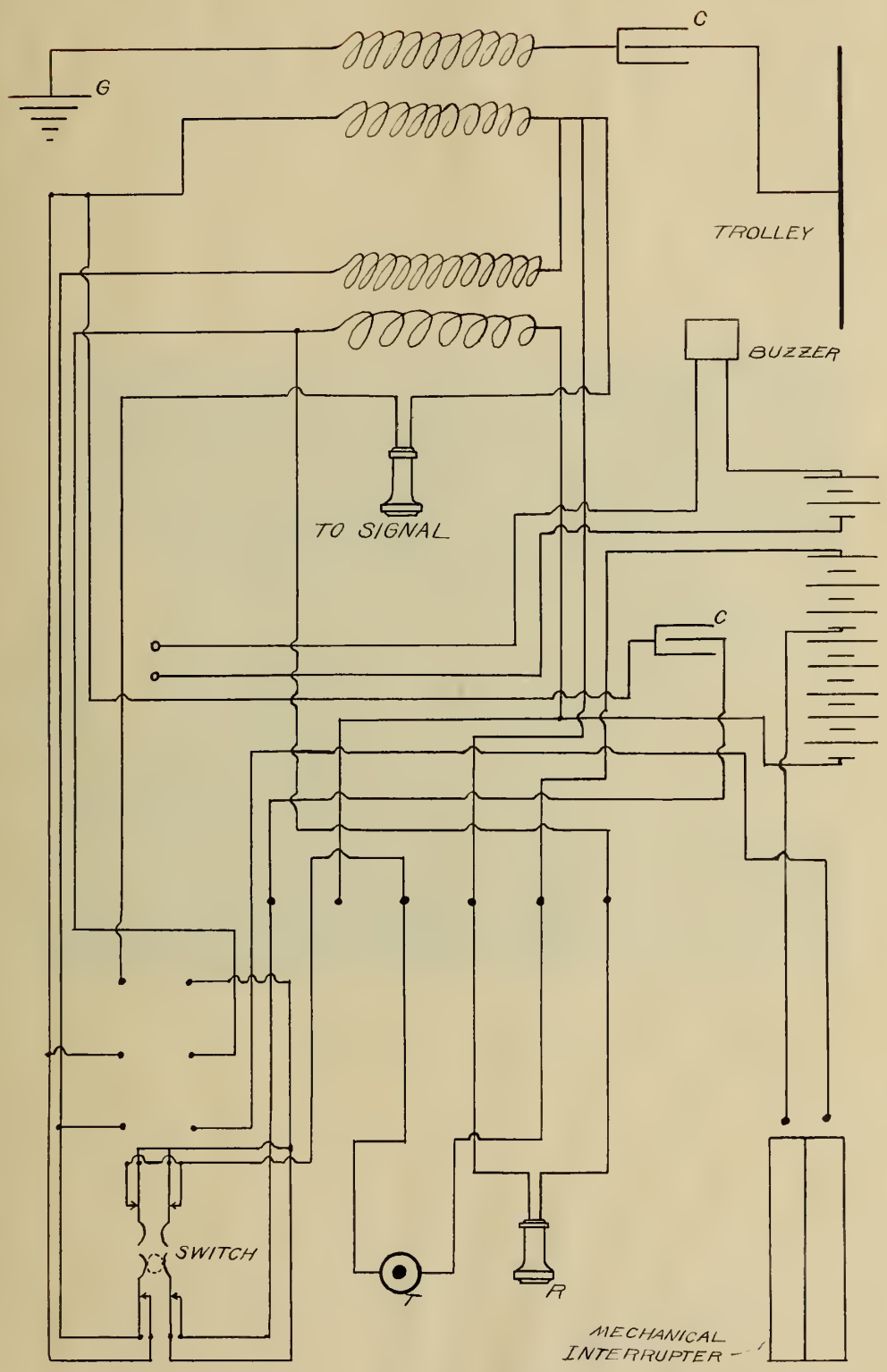
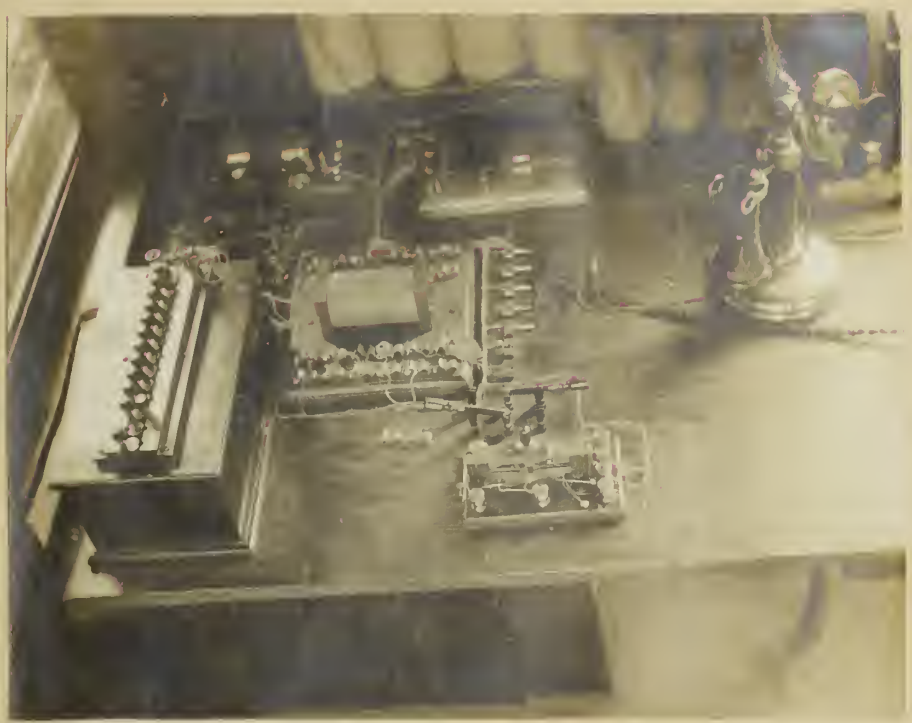

C
G
TROLLEY
BUZZER
TO SIGNAL
C
SWITCH
T
R
MECHANICAL
INTERRUPTER

FIG 6.



Apparatus in Test Car

giving practically the best results. By decreasing the capacity the trolley noises were almost entirely cut out, but at the same time the voice became less distinct. With one microfarad the noise became so loud as to drown out the voice almost entirely. While we were able to distinguish the tone of the voice and to catch occasional words and sentences, it was impossible to carry on a conversation with this system of connections.

With the other connections remaining the same as in Fig. V the receiver was connected directly across the repeating coil (Fig.VI). By this method of connection the noises were not stepped down, and hence were very loud, but at the same time the talking currents which went through the receiver were of such high voltage that the voice could be heard in spite of the noises. While this improved conditions, satisfactory conversation could not yet be carried on. By fixing a combination of switches such that when talking the receiver circuit was open, and when listening all the apparatus except the receiver was disconnected from the repeating coil, the efficiency of the apparatus was doubled.

In order to prevent the talking currents from being shunted through the motors and heaters of the cars on the system, the idea of putting an inductance in series with the motors and heaters of each car was thought of. While it was impossible to do this for all the cars on the line, the same result was obtained by putting the inductance in the trolley

line at the point where it branched off to the side track near the Engineering Laboratory. With this arrangement of inductances, and the telephone connections as shown in Fig.VI a very efficient talking current was maintained, and an entirely satisfactory conversation could be carriedon while the full voltage was on the trolley. The noises were quite loud, but the voice could be heard above these,in fact the sound of the voice could be heard in all parts of the room. The car was then allowed to coast, and the trolley contact was tested, and it was found that the talking was not interfered with by this. The car was next run, current being on the motors, and talking was again tried. It was found to be just as good as with the car standing still, except that the noises were slightly louder due to the motors on the car.

Along with the trials made at talking over the power circuit, efforts were made to perfect a signalling apparatus by means of which the operator in the car, and the operator in the office could call up each other. The ordinary ringer with connections as shown in Fig.I was first tried, but owing to the low frequency of the magneto ringer, ringing could not be accomplished when voltage was on the trolley.

The idea of a Wehnault Interrupter was soon thought of, but owing to the lack of proper voltage this idea was not made use of.

In Fig.III is shown a combined relay and interrupter. The object of this devise was to obtain a high frequency

pulsating current, which could be changed into a high frequency alternating current by means of an induction coil, and sent out onto the line. A similar instrument at the other station would then respond to this alternating current as a relay and close a bell circuit. This apparatus could not be made to work satisfactorily owing to the fact that the frequency obtained was not high enough, and the relay was not sensitive enough. Seperate relays and interrupters were next used with but slightly better results.

A mechanical interrupter was next designed and used. This consisted essentially of a wooden disc upon whose circumference were two-hundred seperate points to which contact could be made. A copper brush was so made as to touch one of these points upon the disc at one time. By revolving the disc at an ordinary rate of speed an interrupted current was sent through the primary of an induction coil, which produced in the secondary an alternating electromotive-force with a frequency of about one thousand. An ordinary receiver was placed across the repeating coil at the receiveing end of the line, in which a howling noise was produced sufficiently loud to be heard in an ordinary room.

Inductance Coil

3. CONCLUSION

From the foregoing discussion, it will be seen that the chief difficulity encountered, was to so confine the talkinf currents that they would reach their proper destination. When this was done the other matters would be of minor detail. To meet this condition a small inductance was so placed as to prevent the alternating voice currents from being shunted through all the cars on the system, and at the same time prevent the noises from the car motors on the line from becomming excessive in the telephone receiver. By designing an inductance and placing one on each car of an interurban line the main obstacle would be out of the way for talking to a moving car.

The commercial possibilities of this method of communication to electric cars are very evident. Telephonic communication might be established between the traveler and adjoining cities. By having the train dispatcher in constant touch with the operators on each car, an increased feeling of safety would be secured to the operators and passengers, and the danger to life and property greatly reduced.

F. W. Padfield.

H. C. Maddox