TOLL SYSTEMS

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INTRODUCTION

It is the purpose of this course to familiarize members of this organization with some of the early toll developements, and to outline in a general way the types of equipment and the methods used for handling toll traffic. For information concerning telegraph equipment, transmission practices, vacuum tubes, repeater equipment and carrier equipment, the reader may refer to other readily available material on these subjects.

The material for this course has been obtained largely from similar courses given by other organizations and from various publications of the Bell System.

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SECTION 1

OPEN WIRE PLANT

Local subscribers' telephones are connected by means of wires to a central office in which equipment is located to connect two local subscribers together. Facilities are also provided in these offices to connect local subscribers to a toll central office which may be located in the same building as the local office or in a separate building used for handling toll traffic from a number of offices in a local area. These toll central offices are connected together by means of wires which are called toll or long distance lines. The term toll arising from the fact that an additional charge is made to talk over these lines in addition to the local rental charges usually made on a yearly basis. The wires used for connecting two toll central offices together in nearby local areas are termed "toll lines". The wires connecting toll central offices together that are in the order of fifty miles or more apart, are termed "long distance lines".

These wires, with their associated outside plant equipment, that connect the local subscriber to the local central office, the local office to the toll office, and two toll offices together may be divided into two general classes, namely the open wire plant and the cable plant. This first section will deal with the former as all of the early forms of telephone communication used open wire circuits to link one subscriber to another. Even to this day open wire circuits are used for the major part of the distance on our three transcontinental lines.

The use of a single wire with ground return for toll purposes has never been extensive. This is due to the excessive noise and crosstalk which occurs between circuits of this type. "Crosstalk" is a term that has been applied to the transmission received on one talking circuit due to voice currents in another circuit. This crosstalk is usually due to capacity effects and leakages between wires of several circuits. The use of a ground return for a toll line circuit would be satisfactory if there were no power systems and if only one telephone circuit were involved, but when two or more circuits are used for telephonic communication, the ground return becomes a common return for all of these circuits as shown in figure 1.

In figure 1 four local subscribers' lines are shown connected to a central office in which line L1 is connected to L2 and L3 to L4. These are single wire lines and in order to complete the circuit from the subscribers' stations A, B, C and D, it is necessary for the voice currents to go through the common return. This may be the ground or a single wire which is connected to one terminal of all these subscribers' telephone sets. Each of the single wire lines will have a certain resistance depending upon the length, size and kind of wire used. The ground return may also have a considerable resistance, depending upon the physical character of the earth at the point where the line is grounded. If the ground return is not of zero resistance and if subscribers C and D are talking, voice currents will flow in both of the single wires L1 and L2, because the return circuit is a parallel circuit consisting of the common return and the single wire lines L1 and L2. If the current flowing in the circuits L1 and L2 is of sufficient magnitude, the conversation between the subscribers C and D can be heard by the subscribers A and B. This is termed "crosstalk" and for this particular condition, the magnitude or extent of the crosstalk depends upon the resistance of the common return circuit.

Up to about the year 1900 there were many ground return systems in use and they may still be found in use to some extent in rural districts where these circuits are not exposed to severe electrical interference. During the early stage of the development of the telephone, electric street railways and electric light systems were also coming

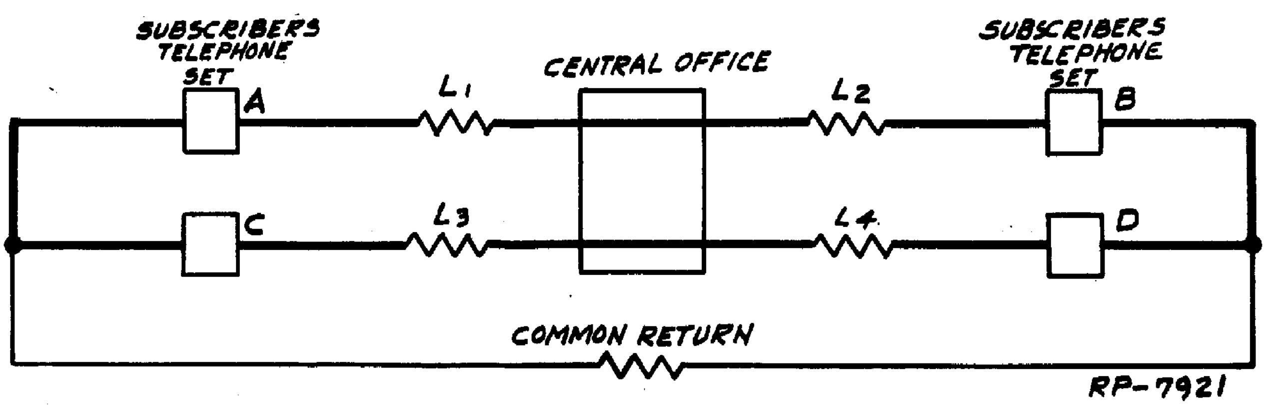

Fig.1 Schematic of a Ground Return System

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rapidly into use in the larger cities. These systems also utilized a ground return and considerable noise from these sources was experienced in ground return telephone systems.

The single wire ground return telephone circuit was first used for connecting two telephone subscribers together as shown in figure 2-A. As the number of these private lines increased, a demand arose for some method which would provide for telephonic communication between the so-called private lines. In order to provide for this class of service, it was necessary to terminate private lines at a central point where they could be switched or connected together as desired. The first local central office actually consisted of several private lines which were terminated in a telephone set, (one for each line, as shown in figure 2-C) mounted on the wall in a central office. Each telephone was equipped with a jack which had a terminal connected to the line. Calls were answered by the central office attendant talking over the telephone set which was connected to that particular line. The attendant completed the connection between subscribers' lines by means of long cords which were equipped with plugs at each end. The plug on one end of the cord was inserted into the jack of the calling subscriber's line and the plug on the other end of the same cord was inserted into the jack of the called subscriber's line. This completed the connection between subscribers who desired to communicate with each other.

Grounded telegraph circuits were in commercial operation for some time prior to the invention of the telephone and as it became desirable in the use of different telegraph circuits to be able to connect them together to meet various service conditions, a telegraph switchboard as shown in figure 3 was developed for interchanging and testing telegraph circuits. The line conditions of grounded telephone and telegraph circuits are the same, therefore, it was logical to use this early telegraph switchboard for connecting grounded telephone circuits together for communication between two telephone subscribers.

In this switchboard the subscribers' lines were connected to long bars of brass with curved slots cut in them at regular intervals. Brass posts with curved slots cut in them were placed directly opposite the slots in the long bar and spaced so that the curved slot cut in the long bar and the post would form a circular hole for the inser-

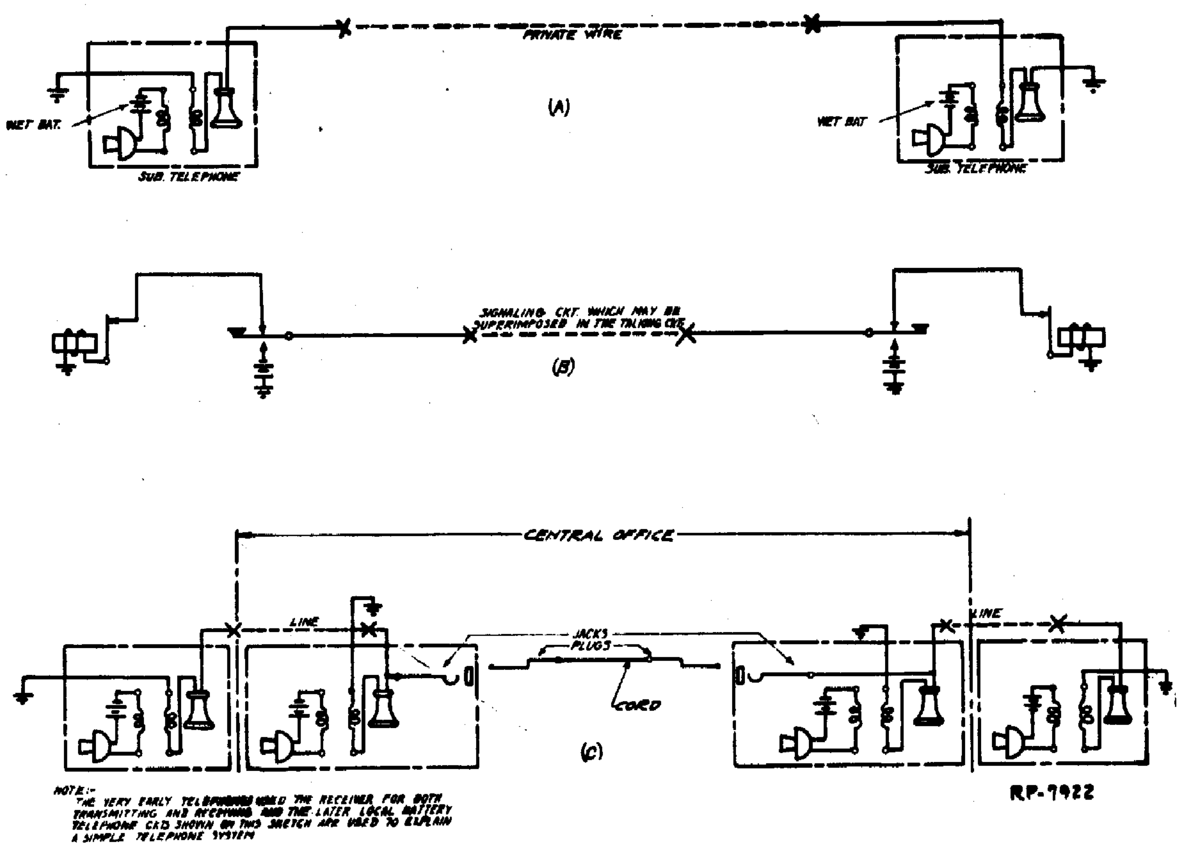

Fig. 2 Early Telephone and Telegraph Systems

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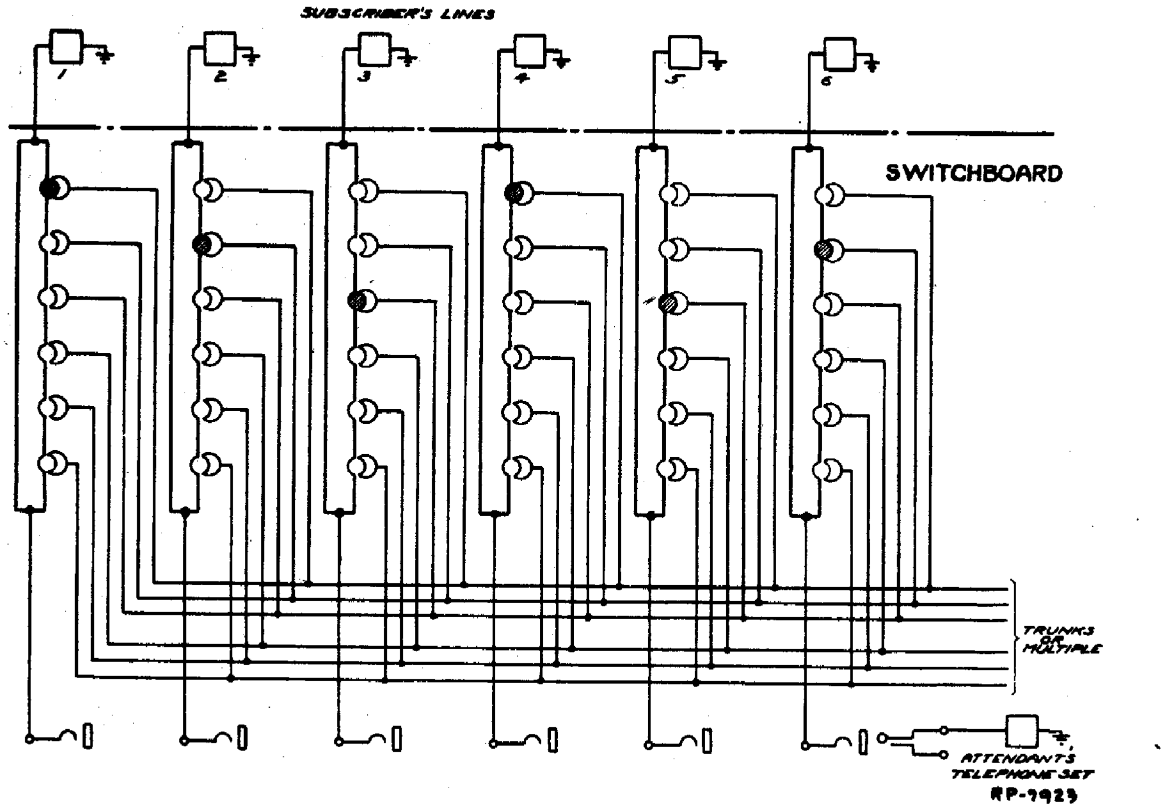

Fig.3 An Early Switchboard

tion of a tapered brass plug. A long bar was connected to each subscriber's line and the corresponding contact posts for each bar were connected together as shown in figure 3. The top row of contact posts are connected together and so on for each row shown. In figure 3, subscribers' lines 1 and 4, 2 and 6, and 3 and 5 are shown connected together by the insertion of brass plugs. The attendant answers a call by inserting a plug which is connected to a common telephone set in the central office, into jacks which are connected to each long bar and the subscriber's line.

Signalling between subscribers and the central office was done by means of an elementary circuit consisting of a wet battery, push button and buzzer, which was operated over the same single wire ground return circuit used for talking, as shown in figure 2. The telephones mounted on the wall in the early central office and the telegraph switchboard represent what is today called the central office switchboard, and the attendant performed the functions of our modern telephone operator.

The use of a single wire and ground return for a toll line circuit, was abandoned in the early stages of the development of the toll system and was replaced by the present day two-wire or metallic toll line circuits. The metallic circuit is the same as the grounded circuit, except that an additional wire is provided for each circuit in place of the ground or common return wire. That is, each telephone or toll line has its own individual circuit which is not physically connected in any way to any other circuit. This eliminated the crosstalk between circuits due to the resistance of the ground connections in the common return wire. These circuits are still subject to interference by induction between two or more toll line circuits and between toll line and power circuits, but as will be described later, a method has been provided to eliminate to a great extent trouble from this source.

The improvement obtained by using two wires instead of one was the beginning of the toll line development which involved new problems to be solved, such as those listed below:

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(1) Kind and size of wire to be used to obtain satisfactory transmission of the voice currents.

(2) Insulation.

(3) Crosstalk between pairs of adjacent circuits.

(4) Interference from power circuits.

There were also a great many problems to solve in line construction, etc., which will not be discussed. The insulation of a toll line circuit becomes an important factor from a transmission standpoint. It is necessary to provide insulation at approximately 40 poles per mile, which gives 40 parallel leakage paths between the two wires of a pair and between the wires and the ground, per mile. Therefore, in order to reduce to a minimum the transmission loss due to leakage, it is essential that the insulation resistance shall be as high as possible.

Iron wire was used to a considerable extent for short toll lines but due to its high resistance compared to that of copper wire, it was replaced with copper wire for toll and long distance circuits. The copper wire used ranges in size from #14 B & S to #8 BWG gauge wire, depending upon the length and importance of the open wire circuit. Very little use has been made in the Bell System of copper wire smaller than #12 NBS gauge for these circuits.

Toll line circuits, until recently, have been of the open wire type strung on cross arms attached to poles. The demand for toll service between some of the larger toll centers has become so great that it has been necessary in a great many cases to overload the pole line by stringing additional wires to provide for the increase in traffic. This traffic, of course, is increasing all the time and the most recent development is to provide aerial or underground cable between cities where the traffic is sufficient to warrant the expense.

The length of open wire line over which we may satisfactorily transmit "commercial speech", (i.e. 200 cycles to 2000 cycles approx.) depends upon the cross sectional area of the wire and the mutual and grounded capacity and leakage between the wires of a pair. It is considered that good transmission will be obtained from subscriber to subscriber over thirty miles of #19 B & S gauge cable which has a capacity per mile of 0.054 microfarads.

#19 B & S gauge cable having a capacity of .054 MF and a resistance of 88 ohms per loop-mile was the standard of comparison in determining the transmission equivalents of different types of toll line circuits. For example, the transmission loss incurred over a circuit consisting of #12 NBS gauge copper wire was expressed in the number of miles of standard #19 B & S gauge cable over which the same transmission loss will be incurred. The expression "Ten mile equivalent of a circuit" meant that the transmission of the circuit under question was equivalent to the transmission of ten miles of standard #19 B & S gauge cable. This transmission unit is dependent upon an arbitrary factor, the standard cable with currents at 800 cycles, and is apt to be confusing when currents at other frequencies are being considered. For this reason another unit called "TU" has been adopted which is based upon the ratio of energies. It is about 5% larger than the standard miles. This unit will be explained later.

While 30 miles of standard cable or about 28.5 TU is considered to give good transmission for frequencies within the voice range, it is not satisfactory for high grade toll line service because the terminal losses must be added to the toll line losses to obtain the transmission equivalent between two telephone stations. The high grade lines of the Bell system give transmission equivalents of approximately 10 TU between the terminals of the toll line circuit and very few toll lines, if any, have an equivalent of 28.5 TU. The terminal losses may be as high as 7 miles depending upon the size of the town or city and the equipment used for completing connection in the local central offices.

The diameter in mils, weight in pounds per mile of wire, resistance per mile of circuit and the transmission equivalent in terms of that received over thirty miles of standard #19 B & S gauge cable for different sizes and kinds of wire are given below:

IRON WIRE:

Equivalent to 28.5 TU's		Dia. in Mils.	Weight per mile of wire in lbs.	Resistance per mile of cct.
#6 BWG	170 Miles	203	590	16 ohms
#8 BWG	135 "	165	390	24.2 "
#10 BWG	120 "	134	258	36.4 "
#12 BWG	90 "	109	170	55.4 "

COPPER WIRE:

#8 BWG	850 Miles	165	435	3.9484
#12 NBS	400 "	104	173	9.9402
#10 B&S	400 "	101.9	166	10.3330
#14 NBS	250 "	80	102	16.8010
#12 B&S	250 "	80.81	105	16.3892

It is obvious from these equivalents that iron wire is not satisfactory for long distance toll lines, but it is not so obvious what size of copper wire should be used for a universal system in which the smaller gauge wires may be connected to large gauge circuits for long haul service, that is, a

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#8 gauge circuit might be used between New York and Chicago, and a #14 gauge circuit between New York and Philadelphia. The transmission received over each of these circuits individually would be fairly satisfactory, but unsatisfactory transmission would be obtained over these circuits between Philadelphia and Chicago via New Yo This illustration is used only to point ou that a real problem exists in determining the size of wires to be used for toll and long distance lines and it is not intended to give the impression that no small gauge wires are used in the plant as a great many of the short haul toll lines are of #12 NBS wire.

As the demend for toll service increased, it was desirable from an economical standpoint to place several pairs of wires on one pole line, in which case the wires of different circuits might parallel each other for long distances. It was found under these conditions that objectionable crosstalk was received from one pair to another, due to mutual leakage, induction and capacity. Currents are also induced from nearby power circuits which cause noise to be produced in each individual toll circuit. For example, assume that a power circuit parallels a toll line circuit in the same horizontal plane, and quite close to it. One wire of the toll line circuit will be located closer to the power circuit than the other wire, and the voltage induced in the nearer wire will be slightly higher than that induced in the other wire. The current in both wires is flowing in the same direction and if the line had perfect insulation the current caused to flow through the telephone circuit would be the effect of the difference between the potentials induced in the two wires.

To reduce these effects, a method of transposing the wires has been worked out and the standard method used for transposing a pole are given in handbooks. To explain in a simple way the results obtained by transposing a toll line circuit, assume that a toll line as shown in figure 4 is 500 feet long, and parallel to a power circuit. If this pair of wires is transposed every 100 feet, there will be four transpositions which will give a difference of potential in the circuit due to 100 feet of the circuit as the voltage induced in the other four sections of the circuit will be the same in each wire. Therefore, if the circuit is transposed three times (every 166+ feet) instead of four, no difference of potential should exist in the two wires of a pair if the same voltage is induced in each wire per unit of length. This, of course, is ideal and is not practical to obtain, as it is impossible to build a pole line so that the distance between the interfering circuit and the toll line circuit is the same at all points throughout the entire length of the circuit.

A standard method of transposing a group of circuits on a pole line has been adopted by the Bell system, and is in general use on the A. T. & T. Co.'s and Associate Companies' toll lines. Private lines, such as telephone circuits on power lines, long subscribers' lines and low grade toll circuits may be close and parallel to power circuits. In general not more than two or three circuits of this kind will be placed on one pole line. In such cases, the lines are transposed to best meet the conditions

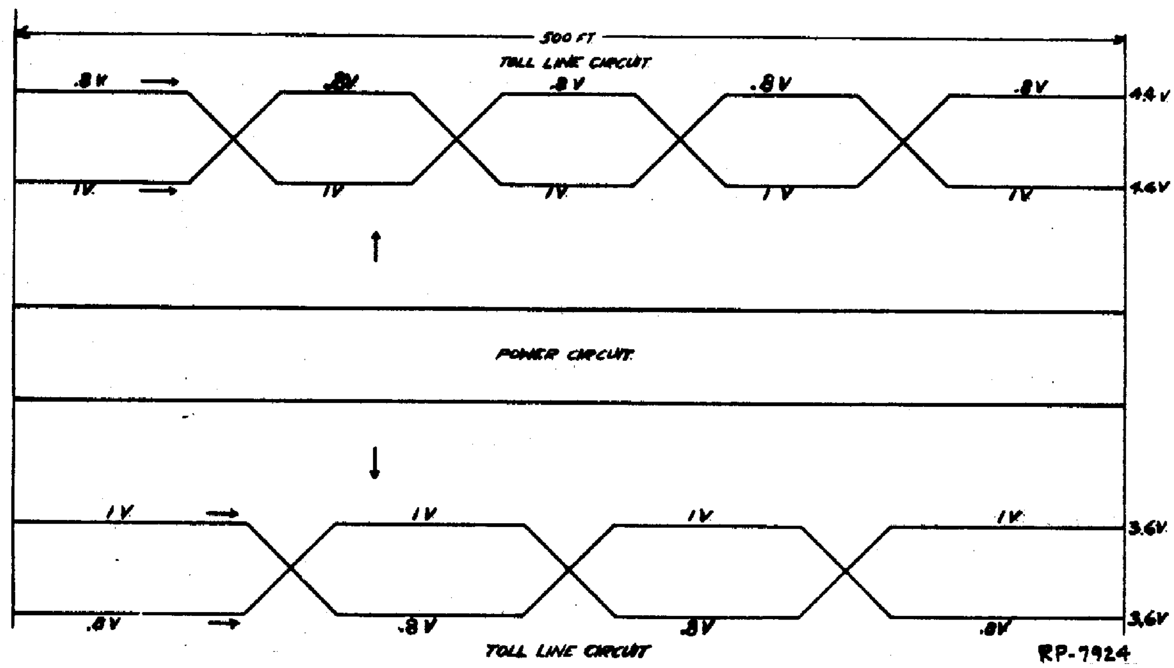

Fig.4 Diagram Showing how Crosstalk is reduced by Transposing Conductors of a Line

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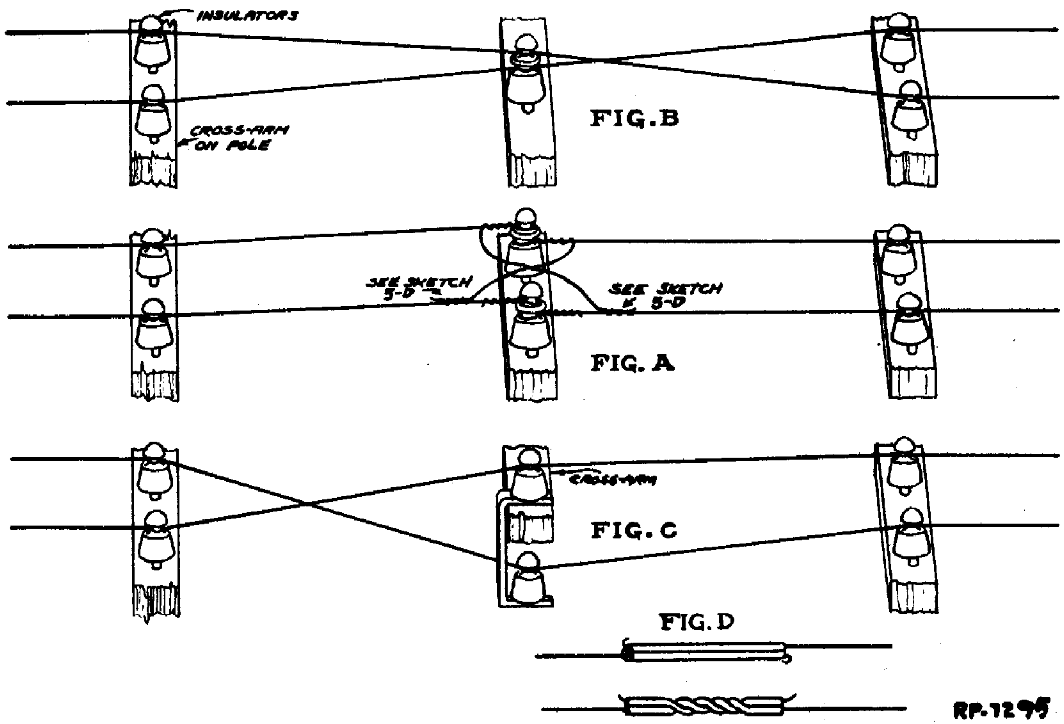

Fig. 5 Diagram Showing the Method of Making Transpositions

under which they are working. If it is only necessary to make a few transpositions in a circuit to eliminate interference and crosstalk, some advantage might be obtained by making an odd number of transpositions, but where the standard method is used, an odd number of transpositions would not have any appreciable effect in reducing interference because of the irregular spacing between the toll line circuit and the power circuit. The transpositions per circuit are also spaced equal distances apart and are made at least once per mile, depending upon the location of the circuit in the pole line.

The transposing of individual pairs to reduce interference from induced current on the line is not so difficult, as this pair of wires can be transposed as often

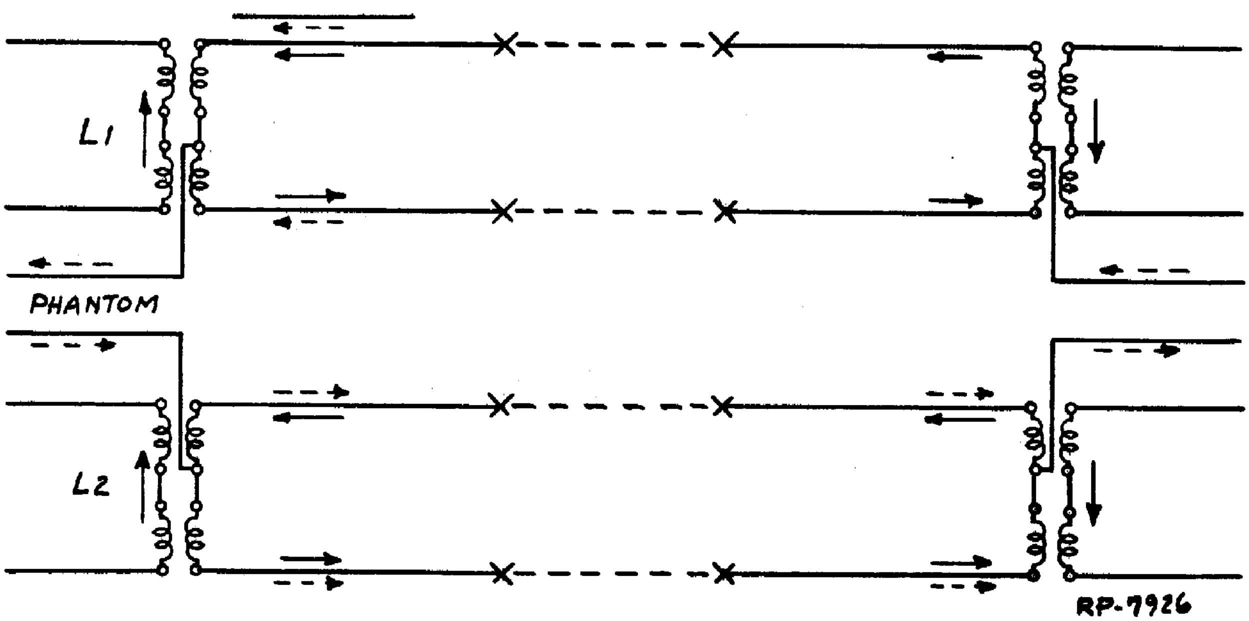

Fig. 6 Simple Schematic of a Phantom Ckt

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as it is necessary to reduce interference to a point where it is not objectionable, but where there are several pairs of wires on one pole line, it becomes a real problem, as crosstalk or interference will occur between any of the pairs of wires on the line.

Different methods of transposing two wires are shown in figures 5A, B and C. The transposition shown in figure 5A in which the wire from both directions was one of the first methods used were terminated on double groove glass insulators. The wires from one direction were terminated with sufficient length to make the cross over and connection to the wires in the opposite direction by means of a copper sleeve about 3 inches long, shown in figure 5D. A copper sleeve connection is made by passing the wires through the sleeve in opposite directions and bending the ends at right angles to the sleeve. One end of the sleeve is then clamped in one position and the other end is twisted around about three times.

The method shown in figure 5A is expensive and in view of this, the method shown in figure 5B was adopted. This transposition is made by giving two wires one half turn and tying them to separate grooves on a glass insulator. This method is slightly less costly than the straight away stringing of wires, and it is not necessary to make connections at each transposition. However, the wires are brough close together on the insulator and considerable trouble has been experienced due to the wires swinging together at the cross-over point.

The present method of making transpositions is shown in figure 5C. This method is slightly more costly than the method shown in figure 5B, but it is considerably cheaper than the method shown in figure 5A. The trouble experienced with method 5B has been practically eliminated by using two insulators mounted as shown.

In the ground return circuit only a single wire per circuit is strung on the pole line. It is, therefore, impossible to transpose a circuit of this kind to obtain the same difference of induced potential on each side of the circuit, with respect, to the telephone set connected between the single wire and the common return. Consequently, all of the current flowing in the circuit, due to the induced voltage, will flow through the telephone set. The voltages induced into the circuit may be due to neighboring power circuits or to voice currents flowing in adjacent wires. If the induced voltage is of sufficent magnitude, objectionable noise or crosstalk will be experienced.

From an economic standpoint it is desirable to obtain all of the facilities possible from the open wire plant. As the toll plant developed and more circuits were required to handle the service, a scheme was devised to obtain three circuits from two pairs of wires. This circuit arrangement is shown in figure 6 and the circuit derived from the two pairs of wires is called the Phantom Circuit. The circuits obtained from each individual pair of wires and the phantom circuit are called a Phantom Group. The two pairs of wires from which the phantom circuit is derived are called Physical Circuits. These wires are generally called a Pair in the plant when they are not phantomed, and are seldom, if ever, referred to as a physical circuit. The physical circuits of a phantom group are often called Side Circuits in the plant.

The phantom circuit is obtained by connecting into the terminals of each physical circuit, a repeating coil, which is commonly called "phantom repeating coil". This is a repeating coil designed for use in this particular type of circuit, so that one half shall have, as nearly as possible. the same characteristics as the other half of the line winding. One side of the phantom circuit is brough out from the middle point of the line winding of the phantom repeating coil, and the other side of the phantom circuit is brought out from the middle point of the repeating coil in the other physical circuit. Two wires of one physical circuit are used for one side of the phantom and the two wires of the other physical circuit are used for the other side of the phantom circuit. The phantom repeating coil is connected into the physical circuit to repeat currents in the physical circuit only, and the line windings, as well as the windings connected to the subscriber's line, are connected inductively into the physical circuit. If the line windings are connected inductively to the physical circuit, and the phantom circuit is connected to the middle point of the line windings of this repeating coil, the current in the phantom circuit will flow through the two line windings of the repeating coil in opposite directions. These two line windings of the repeating coil, having approximately the same characteristics, namely resistance, inductance, and capacity, no current will be induced in the secondary winding, as the current in one winding will neutralize the magnetic effects of the current in the other winding. The current path for the phantom circuit is shown by a dotted line arrow in figure 6 and the current path for the physical circuit is shown by a full line arrow.

In figure 7 the line wires have been omitted and the conventional form for showing a Wheatstone Bridge circuit is used to show clearly how the phantom circuit is obtained by means of two repeating coils in each physical circuit.

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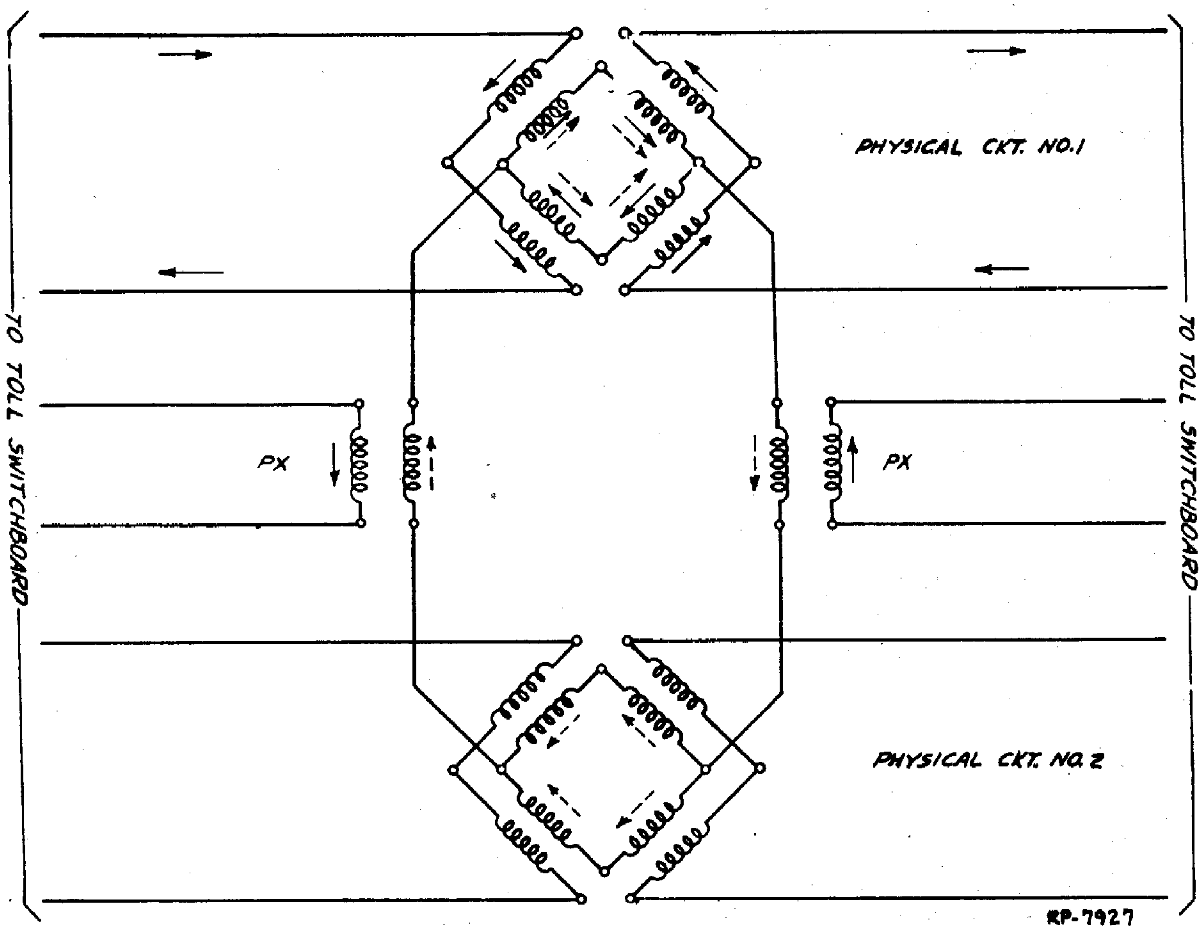

Fig. 7 Phantom Circuit Shown in Form of Wheatstone Bridge—Line Wires Omitted

If the Wheatstone Bridge circuit were balanced no current would flow in the phantom circuit due to current flowing in the physical circuit or vice versa. It is practically impossible to obtain an exact balance of the bridge with repeating coils only and as the line wires are a part of the bridge circuit , the characteristics of each wire of the pair shall be the same, as near as possible, in order to reduce to a minimum the current flowing due to the bridge being unbalanced. Some of the problems in repeating coil design are discussed briefly below:

If we take two wires and lay them side by side for winding the repeating coil in parallel, there will be a certain amount of distributed capacity between the two wires for the entire length of the winding. When these two wires are wound on a spool or into a coil, there will be a certain amount of capacity between the layers of turns. If these capacity effects are not distributed uniformly throughout the entire winding, there will be an appreciable capacity unbalance to the phantom circuit, which will cause crosstalk between the phantom and the physical circuit.

The distributed capacity of parallel wires, twisted pair, and between layers of turns in a coil, is shown diagrammatically in figure 8. The crosstalk current flow, due to unbalanced capacity between the windings of C, D and E are also shown in this figure. The distributed capacity between two parallel wires or between two wires twisted together should be approximately the same if the size of the wire, insulation, space between the wires and length, is approximately the same. The capacity between layers of parallel wires and layers of twisted pairs, will change since the space between the wires of different layers is changing constantly.

Referring to the phantom repeating coil circuit, shown in figure 8, the capacity has been considered as lumped on each side of the phantom tap. If the capacitites A and B are equal, the impedance of the windings C and D and the leakage per each wire of the pair are the same. No current will flow through the resistance F because the same voltage and polarity is impressed upon the condensers A and B. If the capacity A is different from that of B, or the line leakage of one wire of a pair is different

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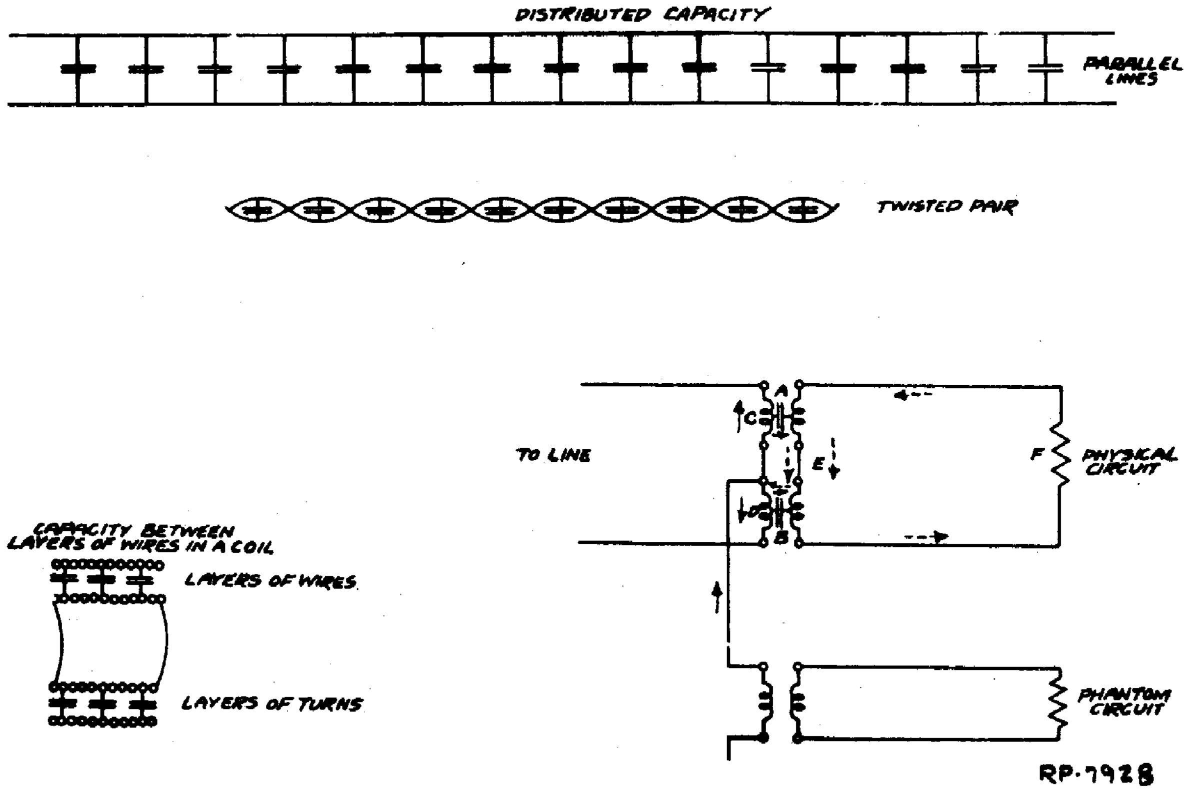

Fig.8 Examples of Distributed Capacity in Phantom Circuits

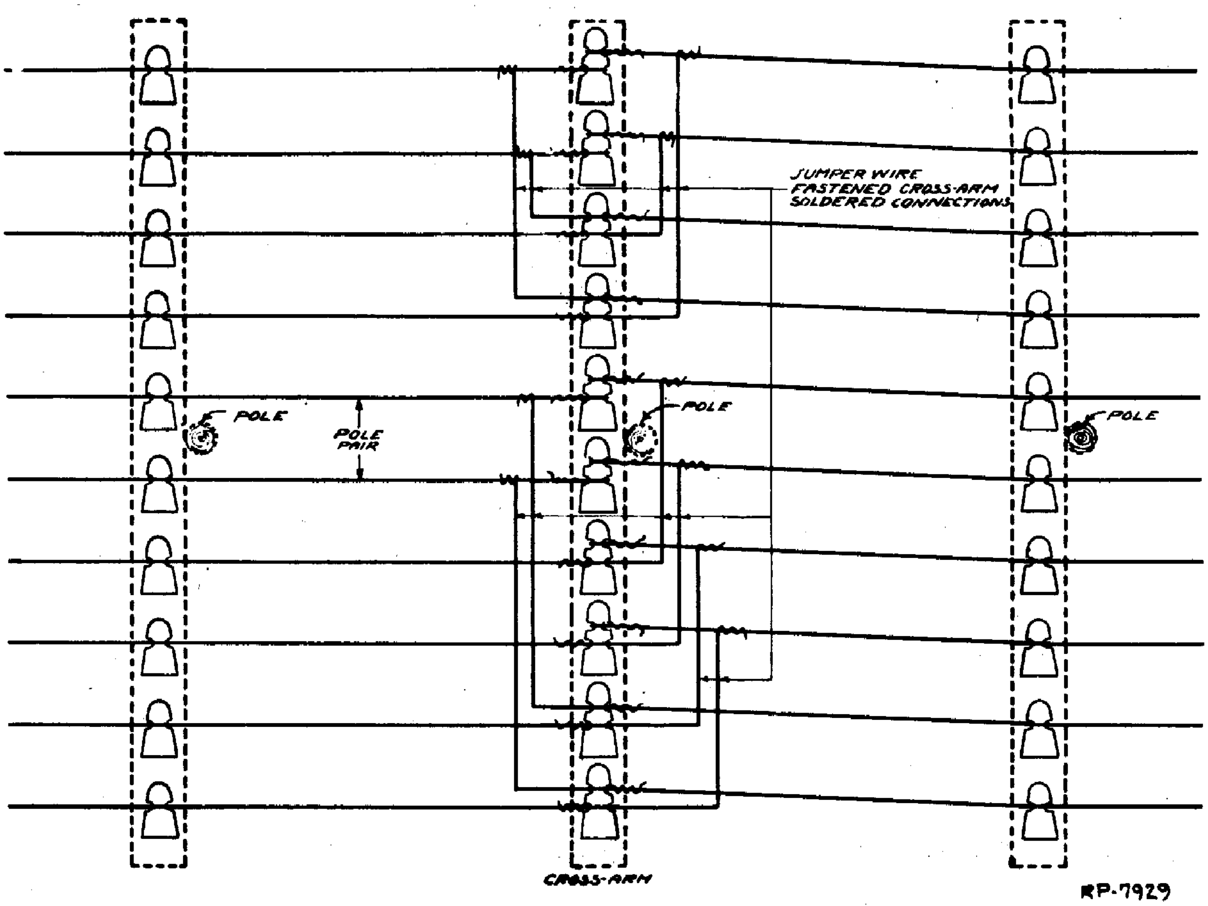

Fig.9 Diagram Showing one Method of Transposing a Phantom Circuit

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from that of another wire of a pair, the voltage impressed upon the condensers A and B will not be the same, and a current will flow through the resistance F, because the phantom currents flowing in the winding C and D are unequal, thereby causing a current to flow in the winding E. The magnitude of this current is not sufficient to be objectionable, which enables the phantom circuit to be used for commercial service.

The introduction of the phantom circuit brought up a new problem in regard to crosstalk between phantom circuits and other circuits on the same pole line. The transposing of individual pairs of wires has been discussed and it is apparent that this method will not be effective for phantom circuits, because each side of the phantom circuit is derived from the two wires of a physical circuit. From the example referred to, it is evident that a difference of potential exists between the wires forming the two sides of the phantom circuit and in order to reduce interference to a minimum, it is necessary at some of the transposition points to transpose the whole phantom group or two physical circuits together. It is also necessary to transpose the individual pairs of the phantom group as well as the complete group. Standard methods for transposing a pole line which carries phantom circuits are given in handbooks. A transposition of this kind is shown in figure 9. The two pairs of wires next to the pole pair have been selected for the phantom group and the pole pair is transposed with the wires of the phantom group. The pole pair in this case is the equal of a half pole pair because it is the pole pair for half of the distance. One of the early methods used for transposing a phantom group and an adjacent pair of wires is shown in figure 9. The wires are terminated in both directions on double groove glass insulators and the transposition is made by connecting the wires together by means of jumper wires which are fastened to the cross arm.

This method is not entirely satisfactory from electrical standpoint because the leakage between the wires of a pair is increased appreciably, particularly during wet weather, and it is also expensive. In order to improve the characteristics of the circuit and reduce costs, this method has been replaced by the method shown in figure 10 which is similar to the arrangement used for transposing non-phantomed circuits.

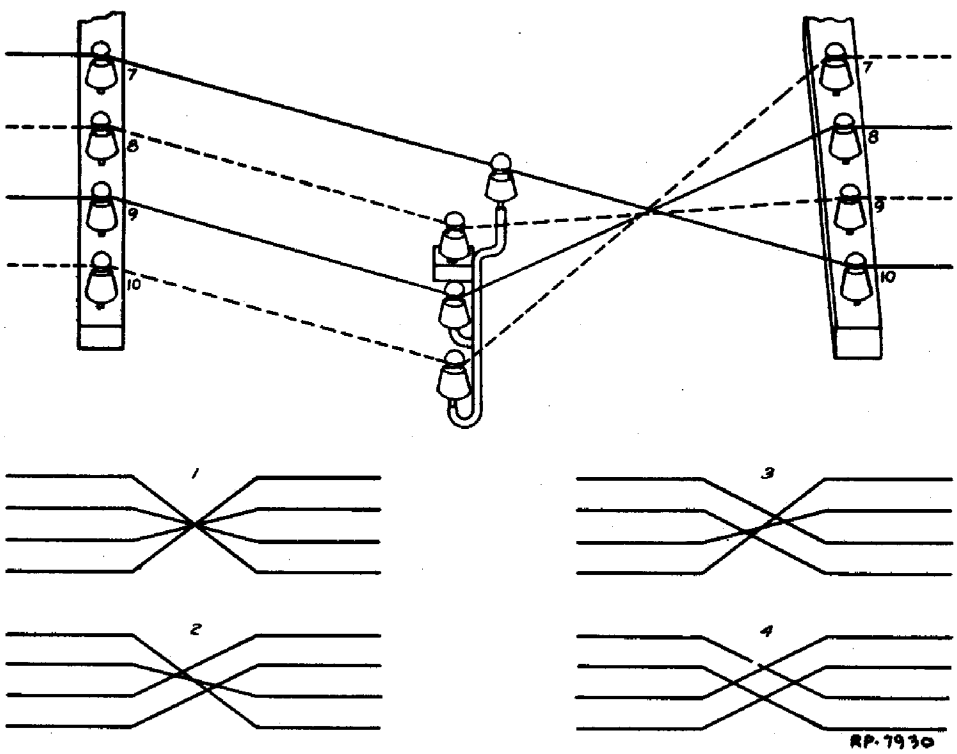

Fig.10 Diagrams Showing Various Types of Phantom Circuit Transpositions

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The wires of a pole pair are spaced farther apart than wires of other pairs on the pole line. Consequently, the characteristics of the pole pair are different from those of other pairs. This makes it necessary to provide special equipment in some cases for use with the pole pair and half pole pair. This will be explained in greater detail later in the course.

One of the questions that might be asked after a study of the phantom circuit shown in figure 6 is this: Can the phantom circuit be phantomed and thus obtain seven circuits for each four pairs of wires, as shown in figure 11? Circuits of this kind have been shown in various books on telephony, but they have never been used to any extent for commercial service. We hear of circuits of this kind being operated satisfactorily from time to time and they are generally found to be in sections of the country where they are not subjected to inductive disturbances from power or other telephone circuits. When satisfactory results are obtained, the circuits of this group are probably the only circuits on the pole line. This circuit is called a ghost and while it is no doubt feasible to obtain an additional circuit in this manner that will operate satisfactorily, it is not practical for general use.

The present open wire toll plant of the Bell system consists of the following types of circuits:

1. Two wire or metallic telephone circuits which are called physical circuits.

2. Phantom circuits which are obtained from two metallic or physical circuits.

3. Physical and phantom circuits may be equipped for carrier telephone in addition to the regular telephone circuit.

4. Physical and phantom circuits may be equipped for composited, metallic and carrier telegraph in addition to the regular telephone circuit. Carrier telephone and carrier telegraph may be obtained on these circuits by reducing the number of channels of each.

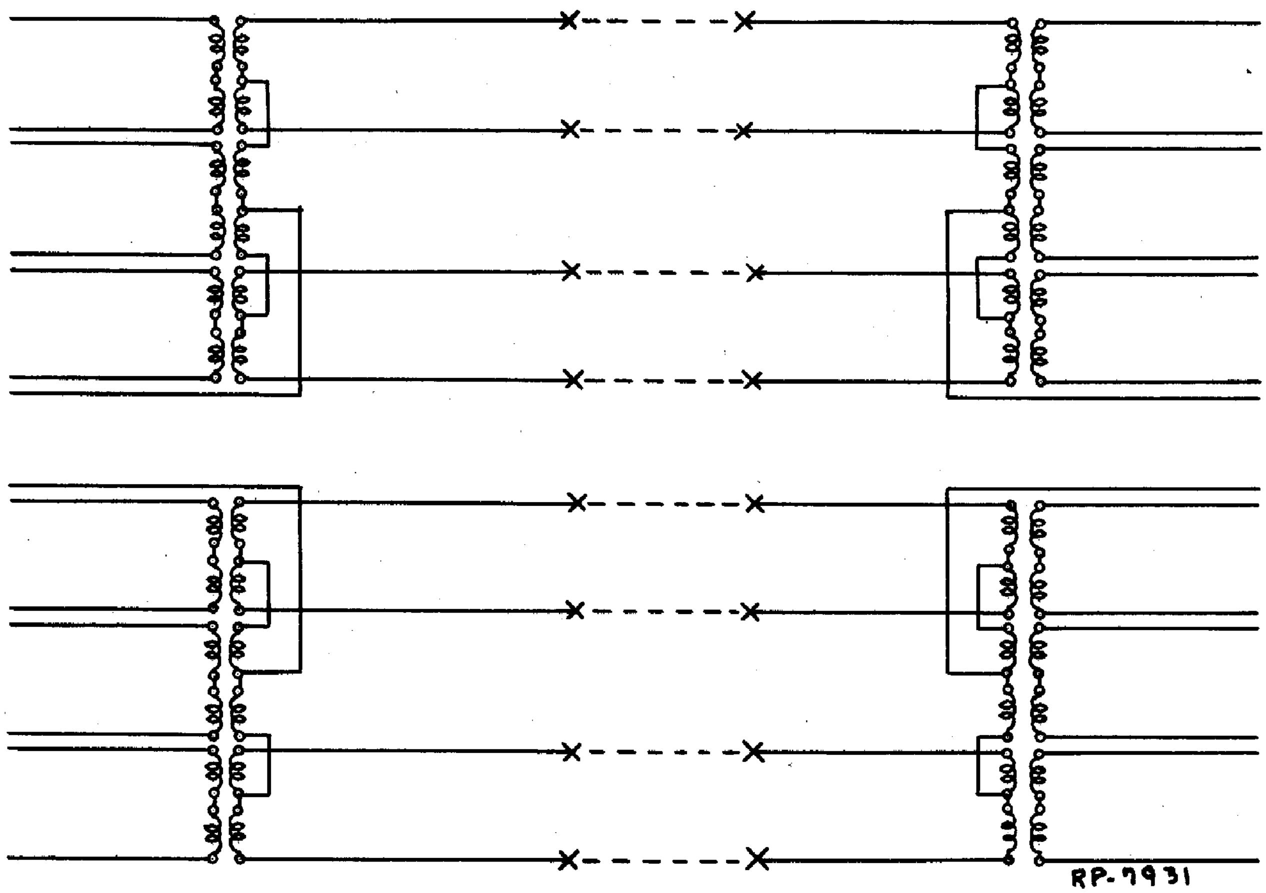

Fig.11 Schematic of a Ghost Circuit

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QUESTIONS

1. Why are ground return systems not used in the toll plant?

2. What were some of the new problems brought up by the introduction of metallic circuits?

3. What was the early standard of comparison for determining the transmission equivalent of different types of toll line circuits?

4. What were the values of the resistance and capacity and the size of wire comprising this standard?

5. What is meant by a line having a ten mile equivalent?

6. What is considered the maximum loss over which conversation may take place?

7. What is the transmission equivalent of a high grade toll line between terminals?

8. What kind of wire is used for long haul toll lines?

9. What causes crosstalk between adjacent circuits of a toll line? How is this crosstalk reduced?

10. Why are phantom circuits used?

11. What is a phantom group? What is a side circuit?

12. Why are special repeating coils used in phantom circuits? What are the special features of these coils?

13. What are the advantages of the method of transposing phantom circuits shown in figure 10 over the method shown in figure 9?

14. What is a ghost circuit? Why is it not commonly used?

15. What are the four types of open wire circuits used commonly in the toll plant of the Bell System?

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SECTION 2

CABLE PLANT FOR VOICE TRANSMISSION

Open wire toll lines are brought into the central office in aerial or underground lead covered cable. The transmission loss to voice currents in thirty miles of standard #19 B & S gauge cable is approximately the same as the loss incurred to these currents in a 250 mile open wire circuit of #12 NBS copper. Due to this excessive loss in the cable circuit, it is desirable to terminate the open wire lines as close to the central office as is practicable.

The toll cable plant of the Bell system has, until recently consisted of entrance cables and a few long distance cables, the most prominent of which is the toll cable between Boston and Washington. Toll cables have recently been developed which will provide satisfactory transmission of the voice currents for much greater lengths of cable circuits. Cable circuits have recently been put into operation between New York and St. Louis via Chicago, a distance of approximately 1300 miles. The satisfactory transmission over long cable circuits is largely dependent upon the telephone repeater, which will later be discussed in detail.

The local cables are used to provide facilities for bringing into the central office, several subscribers' lines within a small space. The maximum number of pairs that can be assembled in a cable is dependent to a great extent upon being able to handle the cable economically in the prosesses of manufacture, and its installation in the plant. The number of paired conductors in local cables varies from five to twelve hundred. #22 B&S gauge wire is used in cables having six hundred pairs or less, and #24 B&S gauge wire is used in the twelve hundred pair cable. In general, the number of conductors in aerial cables will not exceed three hundred pair and the larger sizes are used for underground construction only.

The first step in making of cable is the insulating of the copper wires with paper. This is done by insulating machines which wrap the paper tape around the wire in the form of a continuous helix, overlapping at the edges. These machines put on about 2400 "wraps" or turns in a minute. Various colored papers are used in order to identify the two wires of each pair and certain groups of pairs in the finished cable. These papers are approximately 0.004" thick and 0.625" in width.

The insulated wires are then twisted into pairs. After the wires are paired they are formed into a cable by the stranding machine. This machine consists of a number of revolving drums, on the outer part of which are arranged the reels containing the pairs of wires. The center pair or pairs of wires are drawn straight into the machine. The successive drums, rotating in opposite directions, apply the remaining pairs in reverse layers over this center. In the same operation the assembled pairs are covered with a double wrapping of heavy paper as an additional insulation between the wires and the sheath, which is later applied as an outside protection. The finished core as the unsheathed cable is called, is wound upon large take up drums. This stranding together of pairs is necessary to provide flexibility, for if the pairs were all run straight through, the cable could not be bent without stretching some of the wires or kinking others.

The core is then dried in vacuum ovens heated to about 250 degrees F, until the moisture in the paper insulation has been driven out. After the cable has been thoroughly dried, the lead sheath is applied as the core is drawn from the ovens.

The sheath is composed of an alloy of lead with approximately 1% antimony and it is applied by a lead press or sheathing machine, which is essentially a machine for making lead pipe. A hydraulic press working at enormous pressure forces the sheath metal between the tapered end of a hollow core tube and die ring, thus forming the pipe. The sheath metal temperature is about 450 degrees F, at which it is in a plastic state but it is not hot enough to damage the paper on the core in the short time during which the paper may be exposed to that temperature. The end of the cable core to be covered is passed through the hollow core tube and into the pipe. The pipe fits the core snugly, and draws it through the lead press as additional pipe or sheath is extended. The core is thus protected by a continuous tube of sheath metal, which must be free from cracks or other imperfections. The complete cable as it comes from the lead press is wound upon the familiar wooden reels.

Toll entrance cable is made in a similar manner to the local cable and the smallest wire used for this purpose is #19 B&S gauge copper. Twisted pairs provide satisfactory transposition on the physical circuits but it is not sufficient to prevent interference between the physical and phantom circuits or between phantom groups which consist of two physical circuits. Therefore, entrance cables which are made of twisted pairs only, are not satisfactory for bringing the phantom circuit into the central office before separating it from the physical circuits. Phantom circuits are, however, brought into the central office in short entrance cables having only twisted pairs when the interference received between the circuits is not sufficient to be objectionable for the class of service handled over these circuits.

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In order to obtain a satisfactory phantom circuit in a long toll entrance cable, the physical circuit and the phantom groups are transposed for the same reason that it was necessary to transpose the open wire toll lines. The capacity between wires and pairs of wires is much greater in cable than open wire because the wires are placed closer together. Interference from power circuits is practically eliminated as the wires in a cable are shielded by a lead sheath which is connected to ground at frequent intervals. It is therefore necessary only to transpose the wires in a cable to reduce interference between physical circuits and phantom groups.

In order to reduce to a minimum the possibility of objectionable interference between the physical and the phantom circuits of a quad, the capacity between each of the wires of the physical circuits should be the same, as nearly as possible. The mutual capacity between the wires of the same circuit is not considered in this case. These capacities are measured at regular intervals and the quads having capacity unbalances, that will tend to neutralize each other, are spliced together.

In local and short entrance cable the wires of each pair are twisted together and each pair in the cable has the same length of twist. The phantom circuit is obtained in the cable by twisting two pairs of wires together to make a quad. Two different types of quadded circuits are used in cables. Each pair or physical circuit forming quad #1 has different lengths of twist; each pair of quad #2 has twists different in length from each other and also from those of the two pairs forming quad #1. The pairs of wires used for quad #1 are twisted together and the pairs of quad #2 are twisted together with a different length of twist from that used in quad #1.

Quads are wound in layers around the core of the cable similarly to twisted pairs and quads 1 and 2 are placed adjacent to each other in the layer which insures that two quads of the same type will not be placed adjacent to each other.

Long cable circuits equipped with telephone repeaters are operated over four wires between terminals. One pair of a four wire circuit is used for talking in one direction and the other pair is used for talking in the opposite direction. The phantom circuit is obtained in the same manner as explained above. The four wire circuits are terminated at the central office in repeating coils which are arranged to change the four wire circuit to two wire circuit between the four wire terminal equipment, and the toll switchboard. It is necessary to terminate all circuits entering a switchboard on a two wire basis, so that the same general type of cord circuit can be used for completing all connections between subscriber's lines and the toll line.

Telephone repeaters are connected at regular intervals into the four wire circuit to amplify the voice currents, and the difference between the input and the output currents may be as great as the attenuation of thirty-five miles of #19 B&S gauge cable. Therefore, it is desirable to separate or shield the input from the output line circuits because the output current is of a much greater magnitude,which is likely to cause induced currents to flow into the input circuit. The induced currents will flow into the input circuit of the telephone repeater without being attenuated to any great extent, and the most interference will be obtained near the repeaters where the difference in the voice current levels is the greatest. The induced currents will be amplified in the repeaters and attenuated in the line sections to the telephone station where they will be received as noise or cross-talk.

Each pair of wires of a four wire circuit is not different from a two wire circuit,in reference to interference between adjacent circuits. The two pairs of a quad, therefore, may be used for different four wire circuits which will provide a means for separating the in and the out circuits which are generally designated as "East" and "West". The lay-up of the pairs of wires and the quads in a cable varies considerably because the size of wire and number of conductors in a cable, vary according to the requirements of the plant. The following typical layout of quads will be used to explain how the East and West circuits are separated in the cable:

Core		5	Quads	#19	B&S	Gauge	Wire	East
Layer	1	7	"	#16	"	"	"	
"	2	12	"	#16	"	"	"	
"	3	25	"	#19	"	"	"	East
"	4	30	"	#19	"	"	"	"
"	5	28	"	#19	"	"	"	West
"	6	32	"	#19	"	"	"	"
Lead Sheath								

East quads in core and layer #3 are shielded from the West quads in layer #5 by the East quads in layer #4. Quads in layer #5 are also shielded from the cable sheath by the West quads in layer #6. Therefore, the East quads in the core and layer #3, and the West quads in layer #5 are shielded and separated sufficiently to make them satisfactory for long haul high grade cable circuits, which require several four wire repeaters operating in tandem to obtain satisfactory transmission of the voice currents. The East quads in layer #3 and the West quads in layer #5 would also be satisfactory for long haul service. The other East and West quads in the different layers are used for short four wire circuits which have only a few four wire repeaters operating in tandem.These quads and the #16 B&Sgauge

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quads may be used for straight two wire or phantom group circuits. The layers and parts of layers may be interchanged at a splice between sections, in such a way that the East and West quads will not be exposed to each other or the cable sheath for more than approximately one-half the overall length of the cable.

Up to a few years ago cables were not considered a success on account of their high mutual capacity and variable unbalances. The improvements in design and manufacture as previously described in this section together with the use of loading coils have made it possible to use cables successfully in connection with comparatively long lines.

The development of the loading coil more than any of the preceding improvements has made long distance telephony possible over open wire and cable circuits. In experimenting with cables it was soon found that telephone transmission was reduced very much more thru the cable than thru a similar length of open wire employing the same gauge conductors. It was early recognized that since the cable had a very much larger mutual capacity than open wire lines, telephone transmission must be poorer.

It was not realized for many years that a "corrective element", namely self inductance was present to a considerable degree in open wire circuits. In the case of cables, however, where the two conductors are very close to each other, this inductive effect is nearly neutralized. Use is made of this effect in our non-inductive resistances and in the non-inductive windings on some of our relays. Some idea of the benefit of this inductive effect that is present in a #8 B.W.G. open wire line having its conductors spaced 12" apart, may be obtained from the following. The commercial range of such a circuit is approximately 1000 miles. However if we could conceive of a line where the conductors were spaced 12" apart, but in some mysterious manner self-inductance was eliminated, the commercial range of the transmission over this line would be only 350 miles. This inductance, it may be seen, offsets the effect of capacity between conductors. However, if the capacity were not present, we would prefer not to have inductance since the combination acts as a low pass filter thus reducing the frequency band which may be transmitted over the line. On the highest grade lines, such as those used for broadcasting purposes, extra light loading spaced at relatively frequent intervals is provided.

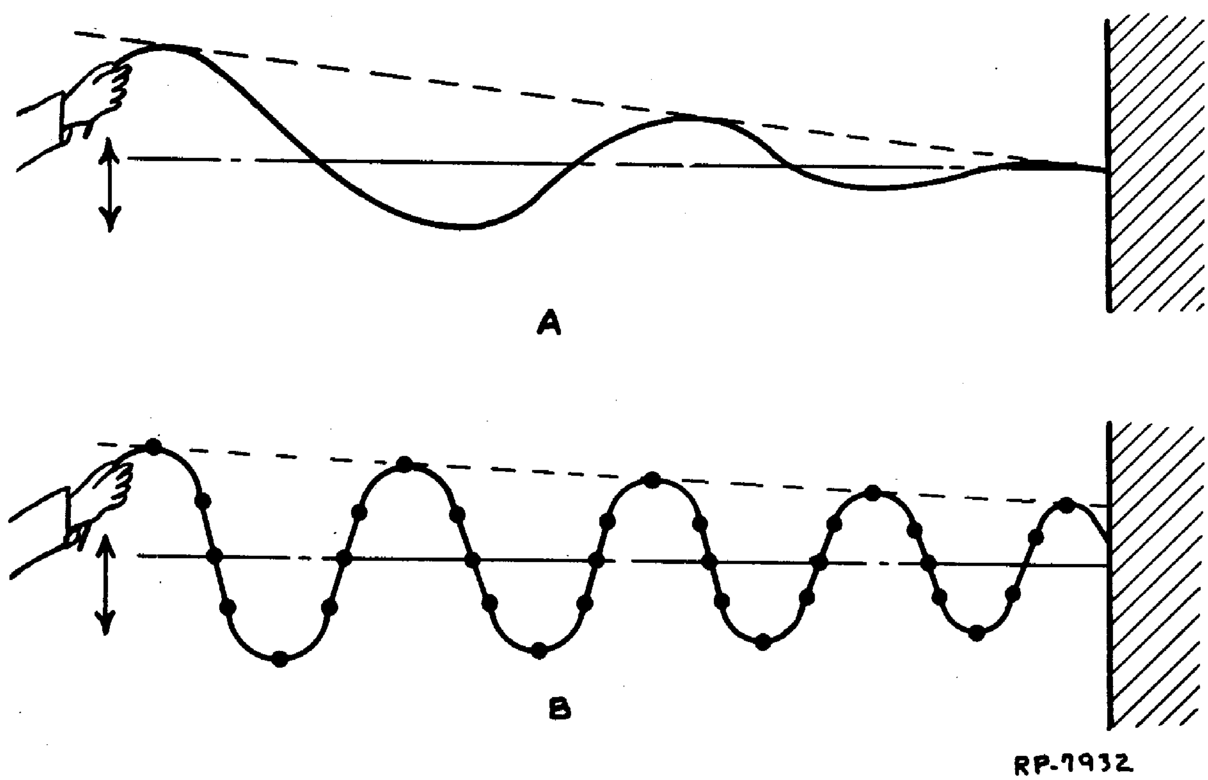

Fig.1 Analogy Between a Loaded and Non-Loaded Vibrating String and a Loaded and Non-Loaded Telephone Line

As seen from the foregoing it is necessary to increase the inductance in open wires and to add still more inductance to cable circuits to increase their useful range for telephony. It remained for Professor Michael Pupin in 1900 to furnish the telephone engineer with information, backed by mathematical investigation and checked by experiment, for applying "loading coils" to telephone circuits.

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The effect of loading in telephony is analogous to the loading of a vibrating string with equal weights uniformly spaced along its length. If we vibrate the free end of a string as shown in figure 1-A, waves are set up by this motion and will travel the entire distance to the other end, but will rapidly become smaller as they travel along the string. However, if the string is uniformly loaded with equal weights, as shown in figure 1-B, the vibrations will travel the entire length of the string and will reach the far end almost as large as when they left the originating end. In the case of the telephone line, loading is accomplished by connecting induction coils at regular intervals as shown in figure 2, thus increasing the electrical mass of the line. This increased mass reduces the friction (resistance) loss and reacting with the elasticity (capacitance) of the circuit also reduces distortion. From this it may be seen that speech can be transmitted with much less attenuation and distortion over a line having a sufficient amount of inductance.

In a cable, for example, loading coils are spaced approximately 1.15 miles and 1.66 miles apart depending upon the amount of loading required. Since the capacity of an open wire circuit is much less than that of a cable circuit, and the self inductance is higher, it is not necessary to place the loading coils as close together on open wire circuits as on cable circuits.

The usual form of a loading coil consists of a toroidal or ring core made from compressed powdered iron, with copper windings applied over it. As many as 200 of these coils are placed in a cast iron pot and covered with an insulating compound to prevent them becoming short circuited and to keep them free from moisture. At present loading coils are being placed in the telephone plant at the rate of approximately 700,000 a year. There are nearly 900 of these coils in one cable circuit between New York and Chicago. The use of these loading coils during the period between 1900 and 1927 has made possible a saving of nearly $200,000,000.

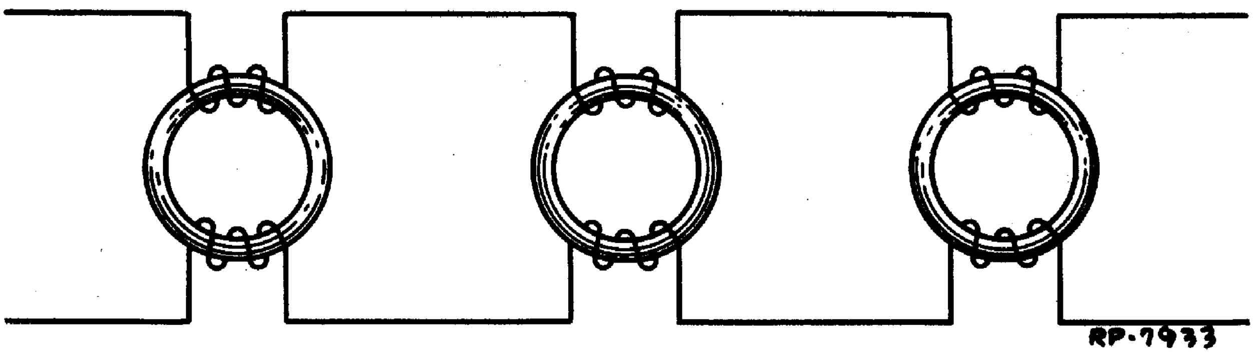

Fig. 2 Diagram Showing the Introduction of Loading Coils in a Telephone Line

RECOMMENDED REFERENCES

Fifty Years' Progress in Electrical Communications, M.I. Pupin, Journal of the A.I.E.E., Jan.& Feb. 1927.

Telephony, McMeen & Miller, pages 46 to 49.

A New Era in Loading, W. Fondiller, Bell Laboratories Record, September 1927.

Telephone Communication, Wright & Puchstein, Pages 203 to 226.

QUESTIONS

1. What development stimulated the extensive use of the toll cable?

2. What material is used for insulating the conductors of cables used in the outside plant?

3. Why are the conductors of a cable stranded instead of running straight?

4. Why are the cores of a cable heated before the lead sheath is applied?

5. What is a quad? Why are quads used?

6. Why do the twists of two adjacent quads differ?

7. Why is the input pair of a four wire circuit shielded from the output pair? How is this shielding arranged for in a toll cable?

8. Why is loading used in cable circuits and on open wire circuits?

9. Why is it necessary to provide more frequent loading in cable circuits than in open wire circuits?

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SECTION 3

TOLL SWITCHBOARDS — NO. 1 TYPE

Until comparatively recently the No. 1 toll switchboard was the standard for large toll centers and as this switchboard is still a very important factor in our present toll system, some of its important details will be discussed in this section. The No. 1-D, No. 9 and No. 10 toll switchboards are used in smaller centers but in general perform similar functions to the No. 1 toll switchboard. The circuits, however, are modified somewhat to meet the requirements of the particular type of switchboard and of the smaller toll center. These latter switchboards will not be described in this course in detail as it is believed that if the fundamentals of the larger switchboards are grasped, no difficulty will be experienced with these smaller boards. The new No. 3 toll switchboard will be taken up in a separate section.

RECORDING TRUNK CIRCUIT

When a call is passed from an "A" operator in the manual office to a toll operator, the call is received in the toll office over a recording trunk, a schematic of which is shown in figure 1. Battery and ground from the calling cord in the manual office causes a lamp to light in front of the recording operator. When the operator sees this light she plugs her answering cord into the jack associated with the lamp, thereby extinguishing it. The supervisory lamp in the cord circuit in the manual office is also extinguished because the 12,000 ohm winding of the L relay in the recording trunk is short-circuited, thus allowing sufficient current to flow over the trunk to operate the manual cord supervisory relay.

With the recording cord connected to the trunk, the recording operator obtains the details of the call and requests the subscriber to hang up as he will be called when the connection is established. Should the local operator wish to recall the recording operator before she has disconnected, the withdrawal and reinsertion of the manual operators cord will cause the supervisory lamp of the recording cord to light due to the fact that the RC relay applies battery and ground across the tip and ring of the toll side of the trunk thereby lighting the supervisory lamp of the recording cord.

If the toll operator wishes to recall the local operator, the repeated withdrawal and reinsertion of the recording cord will cause a change in resistance in the trunk circuit thus causing the local supervisory relay to flash the associated supervisory lamp.

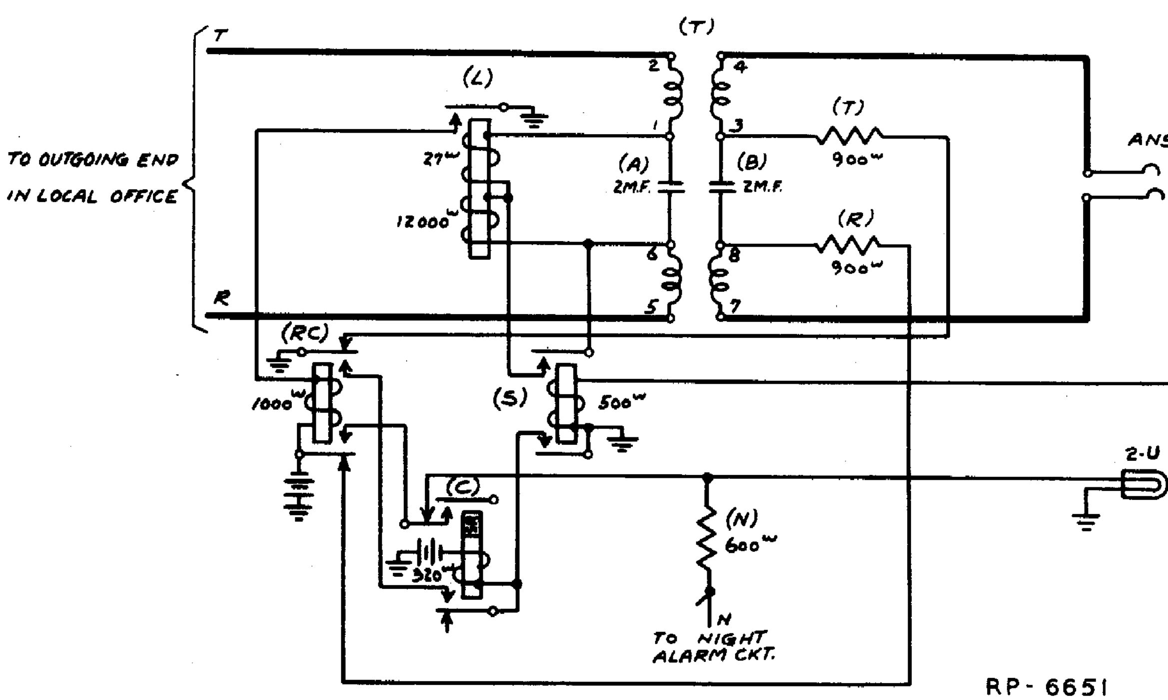

Fig. 1 Recording Trunk Circuit

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When the recording operator disconnects her cord the local operator will be advised of the fact by the steady supervisory lamp associated with the calling cord associated with the trunk to the toll office.

RECORDING CORD CIRCUIT

When the recording operator sees a light appear in front of her, she inserts the back or answering cord of a pair into the jack associated with the light, thus extinguishing the lamp, bridging a high impedance relay across the tip and ring, and connecting her telephone set to the calling party as shown in figure 2. The recording operator then obtains the necessary details of the call and if necessary connects the subscriber to a toll operating room desk or to

If the local manual operator wishes to recall the recording operator she will withdraw and reinsert her calling cord in the trunk as described under recording trunk circuits thus causing the LU relay to operate and lock thereby lighting the back supervisory lamp of the recording cord.

When the plug of the cord at the calling position is withdrawn the front supervisory lamp again lights as a signal that the called operator has disconnected. The withdrawal of the "A" operator's cord from the outgoing end of the recording trunk lights the answering supervisory lamp as a disconnect signal. The recording operator then releases her HOLD key and withdraws both plugs returning the circuit to normal.

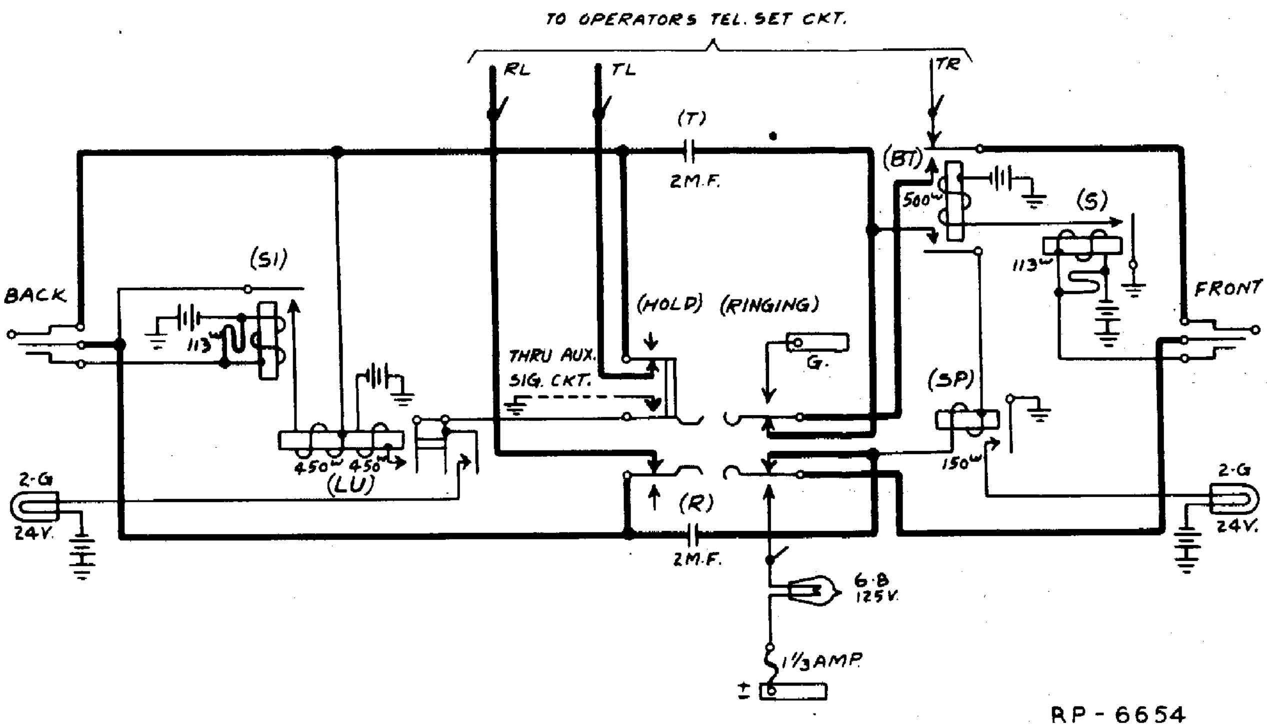

Fig. 2 Recording Cord Circuit

another position. Before completing this connection the operator makes a busy test with the tip of the fromt cord and after selecting an idle trunk to the desired point, inserts the plug. This operation causes the front supervisory lamp to light from the battery and ground across the interposition trunk. If the trunk is of the ring down type, the RINGING key is operated to signal the desired operator. When the desired operator answeres the call, the battery and ground is removed from the trunk thus extinguishing the supervisory lamp. This is a signal to the recording operator that the call has been completed and she operates her HOLD key to remove her telephone set from the connection.

The two condensers, T and R in the tip and ring leads, are placed in the circuit to separate the DC supervision of the answering and calling ends of the cord.

TOLL CORD CIRCUIT

After the recording operator has obtained directions concerning a desired toll call the ticket used to record this information is sent to a directory desk where routing details, and, in the case of a person to person call, the desired number and other necessary information are added to the ticket. From here the ticket is sent to a line or outward operator having access to trunks to the desired point. This line

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operator then picks up the "toll" plug of the cord and inserts it into a jack of the line going to the desired point and operates a RINGING key that places ringing current out on the toll line to signal the distant operator. From figure 3 it may be seen that when the "toll" plug of the cord is inserted into the jack that the S-1 relay operates which in turn causes the RL relay to operate, thus preventing the Supervisory lamp from lighting. After the distant operator has been signalled, the line operator will operate the TALKING key so that she may pass the desired number when the distant operator answers.

on the hook. When the distant operator has established a connection to the desired party she will call the line operator by ringing back over the toll line. This ringing current, applied to the line approximately two seconds causes the RU relay to operate thus causing the RL relay to release and light the supervisory lamp associated with the "toll" cord. The release of the RL relay also causes the LU relay to lock under control of the TALKING key and keep the lamp lighted after ringing is discontinued. When the line operator operates her TALKING key, the LU relay releases and causes the light to be extinguished. The line operator

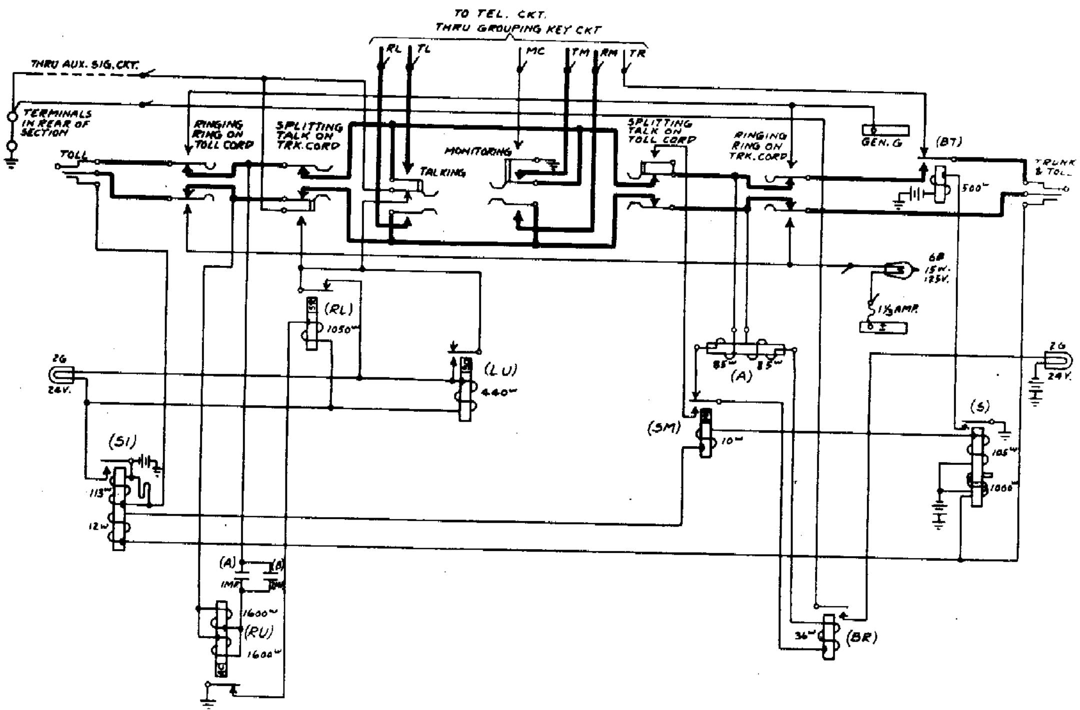

Fig. 3 Toll Cord Circuit

The line operator will then establish a connection to the calling party by plugging the "trunk and toll" end of the same cord into the jack of a toll switching trunk to the local office after previously having received a trunk assignment over a call wire from the local "B" operator. The "B" operator is instructed to connect the trunk to the calling subscribers line but no ringing is applied at this time. When the "trunk and toll" end of the cord is inserted into the switching trunk the S relay operates. The SM relay is marginal and does not operate over the high resistance sleeve circuit of the toll switching trunk. The operation of the S relay operates the BT relay cutting off the busy test and connecting the tip of the circuit thru. The supervisory lamp associated with the trunk and toll cord will operate as an indication that the calling party has their receiver

operates the "trunk and toll" SPLITTING key and then the RINGING on trunk key to call the originating subscriber. After ringing, the line operator will operate the TALKING key and when the calling subscriber answers the line, the operator will release the SPLITTING key thus completing the connection between the two subscribers.

To guard against the possibility of lighting the toll supervisory lamp as a false signal due to telegraph interference or surges of current over the line, the RL relay is made slow releasing and the LU slow operating. Should the RU relay operate momentarily on telegraph pulses it will not usually remain operated long enough to cause the release of the RL relay. If however, the RL relay has released momentarily, the slow operation of the LU relay will give the RL relay sufficient time to reoperate before the LU relay operates and locks, lighting the supervisory lamp.

It was not thought necessary to show a sketch of the toll switching trunk used with this cord in the toll office as it is very simple and is nothing more than the customary outgoing trunk circuit found in a manual office but having a 500 ohm instead of a 37 ohm sleeve.

A new operating practice is now being put into effect known as the combined line and recording method, often called the CLR method. With this new system the line operator acts as a recording operator and if possible completes the connection immediately instead of requesting the originating subscriber to hang up. When using this method traffic is speeded up considerably. Another comparatively recent development is the introduction of straightforward trunking. When the straightforward trunking

TOLL LINE CIRCUIT

When the line operator plugs the "toll" cord into the line jack the S relay operates thus removing the ring up relay, RU, from the line and supplying battery for the operation of the busy signals. A similar circuit is used at the inward board at the distant toll office to receive the ringing signal from the originating toll operator. See figure 4. When ringing current is received the RU relay operates causing a light to appear at an inward position. The inward operator inserts a cord into the jack associated with this light thus causing the light to be extinguished and the busy signal to operate. Should the operator wish to transfer the call to a thru position she may operate the TRANS key. The operation of this key will cause the lamp to light at the thru position. When the thru operator has taken up the call the inward operator may restore her cord to normal.

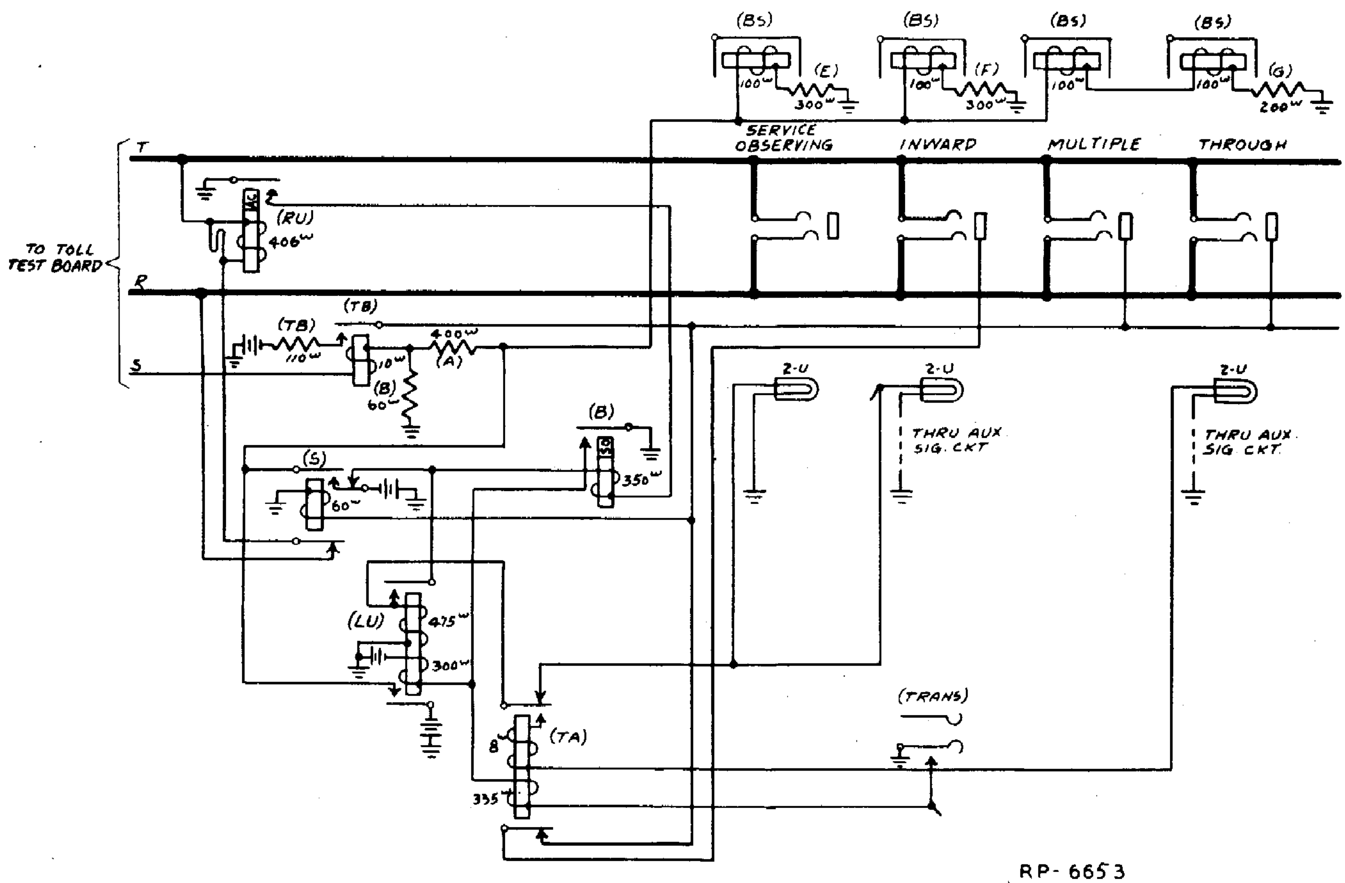

Fig.4 Toll Line Circuit

system is used the line operator can establish a connection to the local "B" operator directly over a toll switching trunk without the use of a call wire. These two systems will be discussed in more detail in a later section dealing with toll traffic.

If the call is intended for this toll office the inward operator will complete the connection over a toll switching trunk in a similar manner to that previously described under the toll cord circuit. If, however, the call is intended for a more distant office, the call is transferred to

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the thru operator who merely acts as a tandem operator and passes the call to the desired point.

QUESTIONS

1. What is the function of a recording trunk circuit ?
2. Trace the operation of a recording trunk circuit from Figure 1.
3. Trace the operation of a recording cord circuit from Figure 2.
4. Trace the operation of a toll cord circuit from Figure 3.
5. Trace the operation of a toll line circuit from Figure 4.

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SECTION 4

TOLL TRAFFIC AND THE METHODS OF HANDLING IT - PART 1.

GENERAL

The telephone service which is furnished to the subscribers of the Bell System is divided into two general classes, local or exchange service and toll service. The basis of this classification of service is the method of charging for it. In return for the payment of a local or exchange service charge, the subscriber is furnished a telephone instrument which is connected to a switchboard and he receives, also, service to all other stations in his local service area. In case the subscriber makes a call for a station which is outside of his local service area, an additional charge is made for each such call. This additional charge is called a toll charge and the amount of it, in general, varies with the distance between the calling and called stations, the duration of the conversation and the class of call made. A call of this kind for a station outside of the subscribers local area is known as a toll call, and collectively such calls are termed toll traffic. The circuits over which such traffic is handled are referred to as toll circuits, and the operators whose work consists largely or entirely of handling such traffic are called toll operators, etc. This is the broadest significance of the term toll and the one usually employed in engineering and traffic work. The term Toll is used sometimes in a rather restricted sense which will be referred to later, but in general engineering work the broad meaning of the term will be the one usually encountered.

The term Long Distance in its broadest sense as it is now used in dealing with the public, refers to that portion of the toll traffic in any given area which is handled through recording or CLR operators. It includes all of the toll traffic except that which is handled by the local switchboards on an A - B basis.

In the early development of the telephone business it was the practice of the parent Bell Company, which owned the controlling patents covering the telephone, to grant licenses to operate in certain territories to locally organized companies. These companies, which have developed into the Associated Companies of the present day, handled in general all of the service both local and toll, in their respective territories. The traffic between the territories of the Associated Companies was in general handled by a separate organization which is now the Long Lines Department of the American Telephone and Telegraph Company. Many modifications in this original plan have been made during the development of the telephone business and numerous cases now exist where the traffic is not divided strictly in accordance with it. As a resuly of this division of the toll traffic between companies, in some of the largest areas such as New York and Philadelphia, both the Associated Company and the Long Lines Department have large toll switchboards each handling its own traffic. In these places it has become the practice for the purpose of training subscribers and operators to distinguish between the toll boards, to refer to a call which is handled by the Long Lines Department on its toll board as a Long Distance call, and to refer to a call which is handled by the Associated Company on its toll board as a Toll call. This is a specialized use of these terms brought out by the necessity of distinguishing by some short and easily remembered terms between the traffic handled by the Long Lines Department and the traffic handled by the Associated Companies. A more exact method of naming these calls would be to refer to them as a Long Lines Department toll call and an Associated Company toll call.

Both the local and the toll service furnished to the subscribers of the Bell System may be divided into various different classes. The toll service only will be described in this course.

The toll service may be classified in accordance with the operating method used in handling the traffic and from a rate standpoint. Considered from this latter standpoint, the different classes of toll service which are furnished subscribers are illustrated by the following classes of calls.

1. Station-to-Station Call.
2. Person-to-Person Call.
3. Appointment Call.
4. Messenger Call.

A Station-to-Station call is one on which the person originating the call does not specify a particular person to be reached at the called station but gives only the number of the telephone station desired or the name or address under which the telephone is listed.

A Person-to-Person call is one on which the person originating the call specifies a particular person to be reached at the called place.

An appointment call is a Person-to-Person call on which communication is to be established at a specified time.

A messenger call is a Person-to-Person call on which the called party is not available at a telephone connected to the Bell System, and on which the Telephone Company assumes

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the responsibility of notifying him, by messenger or other means to come to a public pay station.

In making rates for the toll traffic, the station-to-station call is, in general, taken as the basis. Broadly speaking the rate for this class of call is quoted in multiples of 5 cents and is based upon the air line mileage between the calling and called points and the duration of the call. The rates for person-to-person, appointment and messenger calls are determined by adding suitable differentials to the rates for station-to-station calls. Under certain conditions if communication is not established on one of these three classes of calls a limited charge known as a report charge is made.

Standard Methods of Handling Toll Traffic

With the introduction of the new combined line and recording method, commonly known as the CLR method, of handling toll traffic, many of the older methods are rapidly being discontinued. As a result of this, toll traffic may now be divided into two general classifications, namely A-B traffic and Toll Board Traffic. The general features of the A-B method will be described briefly in this section and the general features of the Toll Board method will be described briefly in the section following.

In the description of these methods which follow, only the equipment and operating features which are encountered in connection with manual equipment are covered. The modifications in the methods which are required due to the introduction of the dial system in local offices will be covered in the next section.

Of the classes of toll calls described earlier in this paper, only Station-to-Station calls are handled by the A-B method, while all four classes, Station-to-Station, Person-to-Person, Appointment, and Messenger calls are handled by the Toll Board Method.

With the A-B method the traffic is handled entirely on local switchboards and in some cases on tandem boards. With the Toll Board method, as the name implies, the traffic is handled at a toll switchboard and the toll board operator has responsible charge of the call.

THE A-B-METHOD OF HANDLING TOLL CALLS

In the A-B method of handling toll traffic the circuits are terminated at one end in local switchboards, which are easily accessible to the local operators and at the other end in local or tandem switchboards. When a subscriber originates a toll call to a nearby point he gives the number of the called station to the operator as when making a local call. The "A" operator handles the call, timing, ticketing and supervising it. She completes it over a toll circuit which ends in a jack at her position. The method of operation the "A" operator follows is, in general, the same as that followed in local practice.

Figure 1 shows the arrangement of circuits for an A-B call between offices which are connected by a group of straightforward trunks. Under this condition a tandem office is not required. Such a call would be placed by a subscriber at Longacre 4321 in Manhattan to

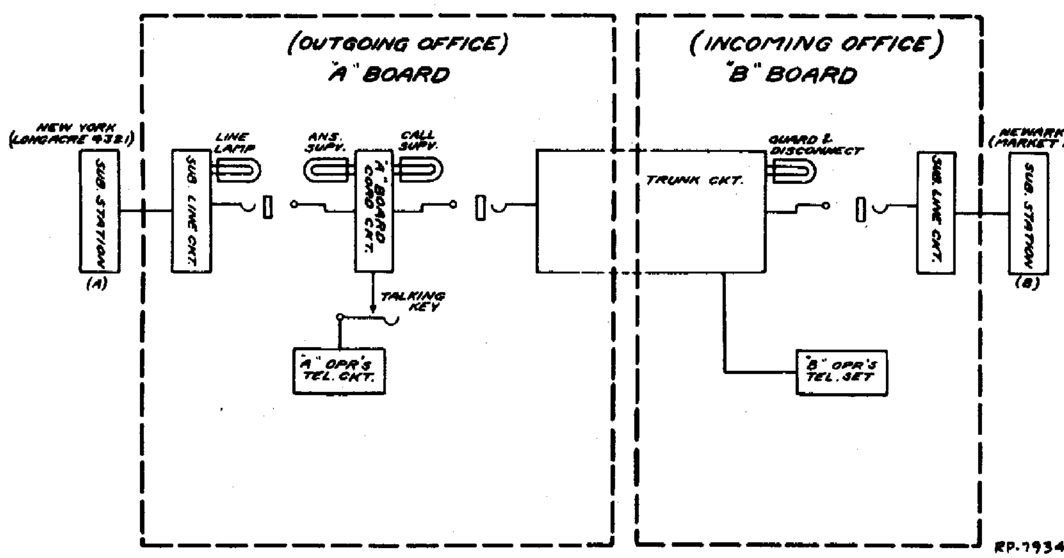

Fig. 1 A-B Call Completed Over Straightforward Trunks

a subscriber at Market 1234 in Newark. These two offices are connected by groups of direct trunks. In figure 1 the calling subscriber is referred to as (A) and the called subscriber as (B). When the subscriber at (A) removes the receiver from the switchhook, operations occur in the line circuit at the "A" board which cause the line lamp to be lighted. The operator answers the call by inserting the plug of the back or answering cord of a pair of subscribers cords into the answering jack or a multiple jack of the calling subscribers line. This causes the line lamp to be extinguished. The operator connects her telephone set to the cord circuit and to the calling subscribers line by operating the talking key in the cord circuit. The subscriber gives the exchange name and telephone number of the desired subscribers station in exactly the same manner as if a local connection were desired. The "A" operator must know that the called telephone is in an exchange to which toll charges are made. She makes out a ticket of the call including the number of the calling telephone together with the exchange name and number of the called subscribers station. The ticket on which this information is recorded is a special form of ticket used only for calls of this type. The "A" operator then takes up the associated calling cord and connects it to the jack end of a trunk to the desired office after having found that trunk idle either by means of the usual busy test or by signals of the idle trunk and position indicating system. The calling supervisory lamp is lighted and the "A" operator then awaits two spurts of tone as a signal that the "B" operator is connected to the trunk and is ready to take the call. If a steady tone is heard it is an indication that the "B" operator is busy at another position. This will occur only during the light load period when the "B" operator is handling several "B" positions. The "B" operator will receive a signal which will call her attention to a particular position where the call is waiting. When the "A" operator receives the two spurts of tone over the trunk she repeats the number but not the office name of the called subscribers station to the "B" operator. The "B" operator sets up party ringing if necessary and then takes up the plug of the selected trunk, indicated by a flashing guard signal, and taps the tip of it against the sleeve of a multiple jack of the called subscribers line as a means of making a busy test. If the line is busy a click will be heard in the "B" operators receiver. In case the line is not found busy, the "B" operator inserts the plug into the multiple jack of the subscribers line. This causes the flashing guard lamp to be extinguished and machine ringing to be sent out on the line to ring the called subscribers bell. When the called party removes the receiver from the hook, ringing current is automatically disconnected and the supervisory lamp of the calling cord is extinguished, indicating to the "A" operator that the talking connection has been established between the calling and called subscribers. When the calling supervisory lamp is extinguished the "A" operator notes the time from the position clock and enters it on her ticket.

When the conversation is finished and both subscribers have replaced their receivers on the switchhooks the front and back supervisory lamps in the "A" board cord circuit are lighted as disconnect signals to the "A" operator, who removes the plugs of the "A" cord circuit from the subscribers line and also from the trunk jack. When the calling cord is removed from the outgoing trunk jack the "guard and disconnect" lamp at the "B" position is lighted as a disconnect signal to the "B" operator who removes the plug of the trunk from the jack of the called subscribers line thereby restoring the circuits to normal.

If the "B" operator had found the called subscribers line busy she would have inserted the plug of the trunk into a jack which was connected to a busy back interrupter. This would have caused the calling supervisory lamp in the "A" operators cord circuit to be lighted and extinguished as a busy signal to the "A" operator. Upon receipt of this signal the "A" operator would remove the plug of the calling cord from the trunk jack and operate the cord circuit talking key and inform the calling subscriber that the called line was busy. Upon receipt of the disconnect signal from the calling subscriber the "A" operator would remove the plug of the answering cord from the answering jack, restoring the circuits at her office to normal.

Figure 2 illustrates the conditions for an A-B call between two offices which are so widely separated that the common supervisory relays will not operate over the trunks connecting them. In this case the trunks are operated on a two way ringdown basis and no order wires are provided. A call from a subscriber at Haverstraw, N.Y. to a subscriber at Spring Valley, New York would be handled on this basis. In originating such a call the subscriber at Haverstraw calls the operator as on a local call and gives her the exchange name and number of the called subscribers telephone. The operator makes out a ticket as was described for the above call. She then plugs into an outgoing trunk jack to the desired office with the calling or front cord of the pair used in answering the calling subscriber, and operates the ringing key. The connection between the calling cord and the jack of the outgoing trunk circuit causes the "calling" or front supervisory lamp in the cord circuit to be lighted as an indication that there is no connection established with the opposite, or inward end of the trunk. The connection with the calling cord also causes

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the ringdown signal to be disconnected from across the outgoing end of the trunk. This is done in order that the outgoing ringing

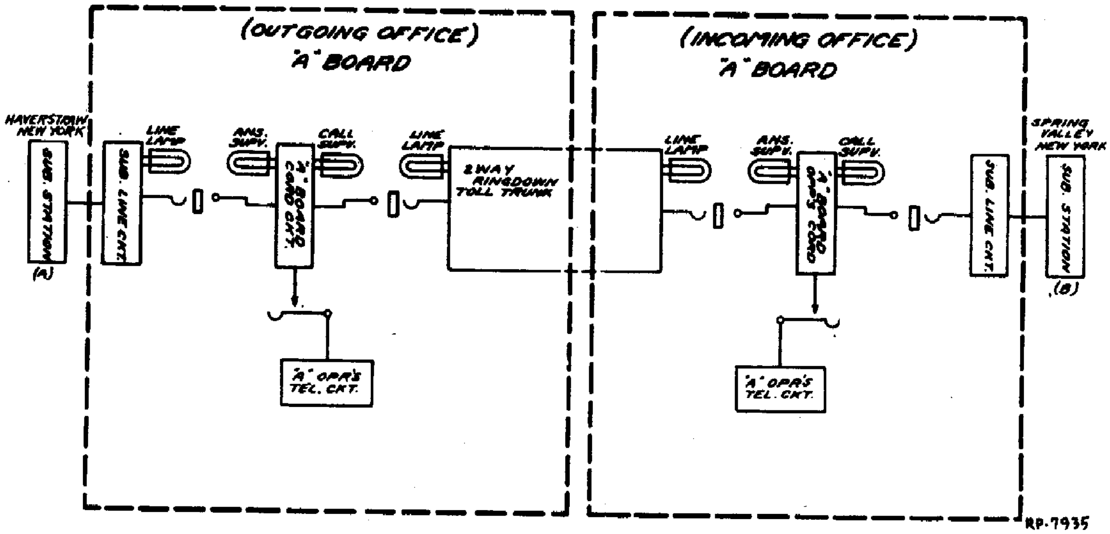

Fig. 2 A-B Call Completed Over Ringdown Trunks

current will not operate this signal when the operator signals the distant office. The ringing current does, however, cause the operation of relays in the incoming office which causes the line lamp associated with the trunk to be operated as a signal to the operator that some other office is calling her. She answers by inserting the plug of a regular "A" board subscribers answering cord into the answering jack or a multiple jack of the incoming trunk circuit. This causes the line lamp to be extinguished and closes a bridge across the trunk circuit which causes the operation of relays in the outgoing end of the trunk. The operation of these relays causes the calling supervisory lamp in the originating operators cord circuit to be extinguished as an indication that the operator in the called office has answered. The cord circuit talking keys in both offices are operated and the originating operator in response to the other's question "number please" repeats the name of her own office and the number of the called subscribers telephone. The inward operator picks up the calling cord of the pair with which the connection is started, makes the busy test on a multiple jack of the called subscribers line and if the line is found idle, inserts the plug of the calling cord in the multiple and rings the called line. The called subscriber answers giving the inward operator a signal by causing the calling supervisory lamp in her cord circuit to be extinguished and the conversation is started. The originating operator does not have direct supervision over a call of this class and the timing is not accurate. When the conversation is finished, the calling subscriber hangs up his receiver and the originating operator receives a disconnect signal in the form of a lighted answering supervisory lamp. She goes in on the connection by operating her talking key and challenges. If no answer is received the plugs are removed from the jack. If, however, the called subscriber wishes to recall the other party, he will signal the inward operator by moving the switchhook up and down thus causing the calling supervisory lamp,in the inward operators cord circuit to be flashed. The inward operator recalls the outward operator by withdrawing and then inserting her answering cord into the trunk jack several times, and the outward operator recalls the calling party by ringing him. The operator who originates the call always disconnects first. In the case of this call it is the outward operator. When the plug of the calling cord is removed from the outgoing trunk jack the answering supervisory lamp is lighted in the inward operators cord circuit. The inward operator thereupon disconnects, restoring the circuits to normal.

In cases where the offices are located as shown in Figure 3, calls from one point to another at a distance, pass through a tandem office. As shown in the sketch we shall take the case where five points are to be connected, #1 and #2 in New Jersey, #3 in Manhattan, and #4 and #5 in Brooklyn and Long Island. If these offices were all connected by direct trunks as indicated in Figure 4 the cabling layout would be a very expensive one. A separate group of trunks would be required to work in each direction between each two offices. However, by placing a tandem office at #6 as shown in Figure 3, groups of trunks from each office to the tandem office would permit the same result

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to be obtained with a saving of many miles of cable.

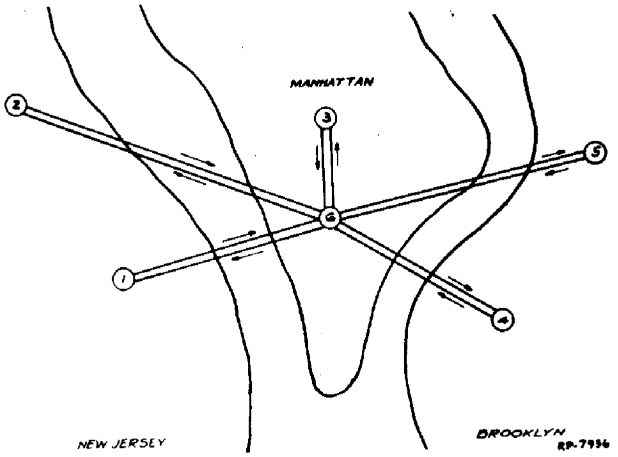

Fig. 3 Diagram of Tandem Connections

Figure 5 shows the circuit arrangement used on a call between subscribers in two exchanges where the connection will have to be built up through a tandem board. It will be noted on figure 5 that the trunks incoming to the tandem office terminate in plugs and the trunks outgoing from the tandem office terminate in jacks. These trunks are designed to be used for tandem calls only and are always of the call circuit or straightforward type. The completing trunks, that is, the trunks from the tandem office to the exchange in which the called subscribers telephone is located are the following call circuit or straightforward types.

Machine Ringing Trunks equipped with mechanically locking gang keys or a set of common ringing keys per position.

Keyless Ringing Trunks.

Manual Ringing Trunks.

It may be desirable to extend the tandem method to certain offices not equipped with "B" positions in order that the "A" operator may not have to discriminate in completing tandem calls to such offices. In such cases the circuits should be arranged to employ the regular call circuit or straightforward types of completing trunks. There may be certain offices in which a call circuit cannot be provided owing to lack of facilities, and in such cases completing trunks arranged for straightforward operation may be employed. In this case the order is passed by the "A" operator over the trunk itself after the tandem connection has been established. Interposition trunks will sometimes be required at the tandem positions for completing connections to desks or other special positions.

A call from a subscriber at Longacre 4321 to a subscriber at White Plains 9876 would be handled through the Westchester tandem

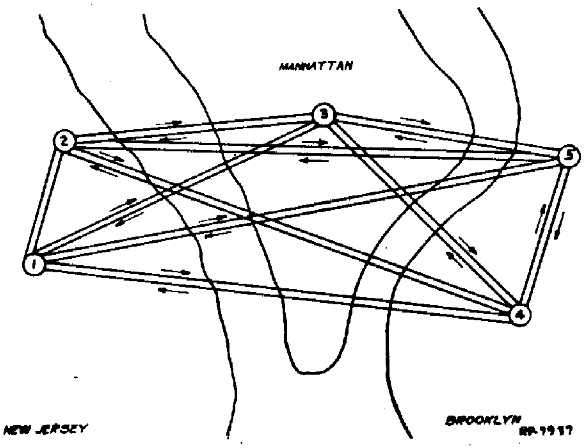

Fig. 4 Diagram of Direct Connections

office. The subscriber initiates the call by calling the "A" operator in his own exchange and gives the exchange name and number of the called subscribers telephone as on a local call. The operator makes out a ticket of the call then takes up the associated calling cord and connects it to the jack end of a trunk to the tandem office after having found that trunk idle by means of the usual busy test. It will be necessary for the "A" operator to know which exchanges are reached thru the tandem office and which are reached over direct trunks. The calling supervisory lamp is lighted and the "A" operator then awaits three spurts of tone as a signal that the tandem operator is connected to the trunk and is ready to take the call. The "A" operator then passes only the name of the called subscriber office to the tandem operator. The tandem operator takes up the plug of the trunk, indicated by a flashing guard signal, and selects an idle trunk to the desired office. When the plug of the tandem trunk is inserted into the outgoing trunk the guard lamp of the tandem trunk is extinguished and the tandem operator is disconnected from the trunk. The connection is now completed thru the tandem office and the "A" operator awaits two spurts of tone as a signal that the "B" operator is connected to the trunk and is ready to take up the call. The "A" operator then repeats the number but not the office name of the called subscribers station to the "B" operator. The "B" operator sets up party ringing if necessary and then takes up the plug of the selected tandem completing trunk, indicated by a flashing guard signal, and if the subscribers line is idle, inserts the plug of the trunk into the jack of the desired line. This causes the flashing guard lamp of the tandem completing trunk to be extinguished and machine ringing to be sent out on the line to ring the called subscribers bell. When the called party answers, the supervisory lamp of the calling cord in the originating office is extinguished indicating to the "A" operator that the talking connection has been established between the calling and called subscribers. When the calling supervisory lamp is extinguished the "A" operator notes the time from the position clock and enters it on her ticket. When the conversation is finished and the called subscriber replaces the receiver on the switchhook, the guard and disconnect lamp at the tandem operators position is lighted as is also the calling supervisory lamp in the "A" operators cord circuit. Upon receipt of this signal and when the calling subscriber has replaced the receiver on the switchhook which causes the answering supervisory lamp to be lighted, both the "A" operator and the tandem operator disconnect. When disconnection takes place at either the "A" or the tandem position, the "guard and disconnect" lamp associated with the completing trunk at the "B" board is lighted as a disconnect signal, whereupon the "B" operator disconnects from the called subscribers line restoring the circuits to normal. The timing of the call is handled in a manner similar to that described previously in this section.

There are certain calls which may be passed through as many as two tandem offices, but in case more than two tandem offices are required, the call is not handled on an A-B basis but is passed to a CLR operator and the call completed by her over a toll line.

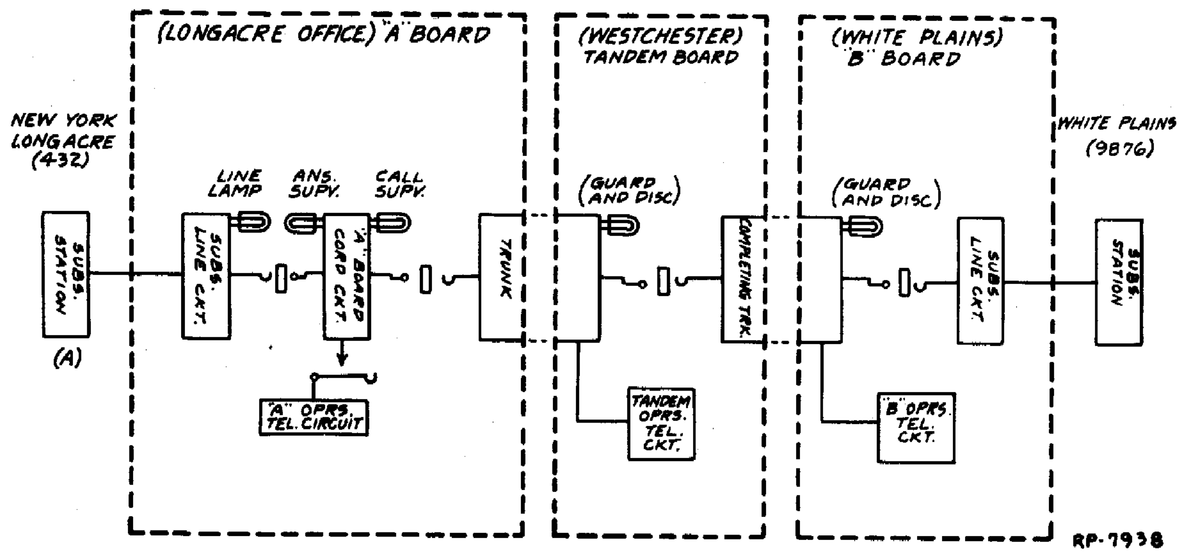

Fig. 5 A-B Call Completed over Straightforward Trunks Thru a Tandem Office

QUESTIONS

1. Explain the difference between long distance or toll board traffic and A-B toll traffic.

2. Give the four classes of calls furnished the subscriber by toll service and define each.

3. What class of service is rendered only by the A-B method?

4. On A-B service which operator handles the supervision, the timing, and the ticketing of a call?

5. Trace a call handled by the A-B method using straightforward trunking circuits from the originating to the terminating subscriber.

6. Trace a call handled by the A-B method using ring-down circuits from the originating to the terminating subscriber.

7. What advantage is gained by the use of a tandem office ?

8. Trace a call handled by the A-B method, over straightforward trunking circuits through a tandem office, from the originating to the terminating subscriber.

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SECTION 5

TOLL TRAFFIC AND THE METHODS OF HANDLING IT - PART 2

TOLL BOARD METHOD OF HANDLING TOLL TRAFFIC

In the Toll Board method of handling toll traffic the circuits are terminated at both ends in toll switchboards. When a subscriber originates a Long Distance call, the local "A" operator connects him thru to a toll operator who supervises and times the call, whereas, on short haul toll traffic, the call is supervised and timed by the local operator as described under A-B traffic in the previous section.

This Toll Board traffic may be subdivided into two general classifications, namely, the combined line and recording, CLR, method and the delayed method. With the CLR method the call is completed while the calling subscriber stays at the telephone. Calls which cannot be completed within approximately three minutes are handled by the delayed method.

Toll switchboards from a traffic standpoint may be classified under three headings, namely, Outward, Inward and Thru. Outward positions are used to handle CLR and delayed traffic in the originating toll office and also inward ticket work at the terminating toll office. Inward positions complete calls from distant toll offices to subscribers in the area served by the terminating toll office. Thru positions in the toll system perform a similar function to that of the tandem positions in the local system. In small offices certain outward positions are often used for handling thru traffic.

CLR METHOD

Before the introduction of the CLR method all Long Distance calls were handled on a delayed basis, that is, after the Recording operator in the toll office received the details of the call from the originating subscriber, he was told to hang up and that that he would be informed when the desired connections had been completed. The ticket made out by the Recording operator was sent to a directory desk where the routing and other necessary information was added to the ticket. The ticket was then sent to a Line operator who established a connection back over a toll switching trunk to the calling subscribers line thru the local "B" switchboard and called the distant office over a toll line. When the distant operator had reached the called party, the Line operator then applied ringing current over the switching trunk to the calling subscribers line thus completing the call.

With the new method, the Combined Line and Recording operator acts both as a recording operator and as a line operator, completing the call whenever possible while the calling subscriber waits at the telephone. Calls may be completed to the distant toll office in one of two ways depending upon the amount of traffic involved and the distance between the toll centers. These two methods are the ringdown and the straightforward. The ringdown method will be described first as it is in most common use.

Figure 1 shows the arrangements of circuits for a Long Distance call between two subscribers completed by the CLR ringdown method. When the calling subscriber calls the local operator and announces that a long distance connection is wanted, the busy test and the connection to the toll office over a recording trunk is made with the calling cord of the pair of cords used to answer the calling subscriber. When the CLR operator sees the lighted lamp associated with the recording trunk she operates the listening key and inserts the plug of a trunk cord into the associated jack thus extinguishing the lamp. The CLR operator requests the desired number and records this information on a ticket. She then determines from a list at her position whether or not CLR service is given for the class of call or to the desired point requested. All Messenger calls, Appointment calls, inward collect calls to pay stations, and calls for build-up circuit points to which CLR service is not rendered, are handled at delayed positions. After the CLR operator records the details of the call and has determined that she cannot complete it by the CLR method, she requests the calling subscriber to hang up and informs him that he will be called when connections to the desired station have been completed. The ticket is then forwarded to the delayed board.

If, however, the call can be completed by the CLR method, the CLR operator inserts the plug of a toll cord of another pair into a toll line to the desired point and operates the associated ringing key for two seconds. With the listening key of the toll cord operated and the listening key of the trunk cord restored to normal, the CLR operator awaits the answer of the distant toll operator. When the distant operator answers, the CLR operator gives the name of the called exchange and the station number, and after the distant operator repeats the number the CLR operator enters on the ticket the time that the call was passed. The CLR operator then picks up the trunk cord of the pair on which the toll circuit is being held, and after locating an idle toll switching trunk to the "B" operator in the office of

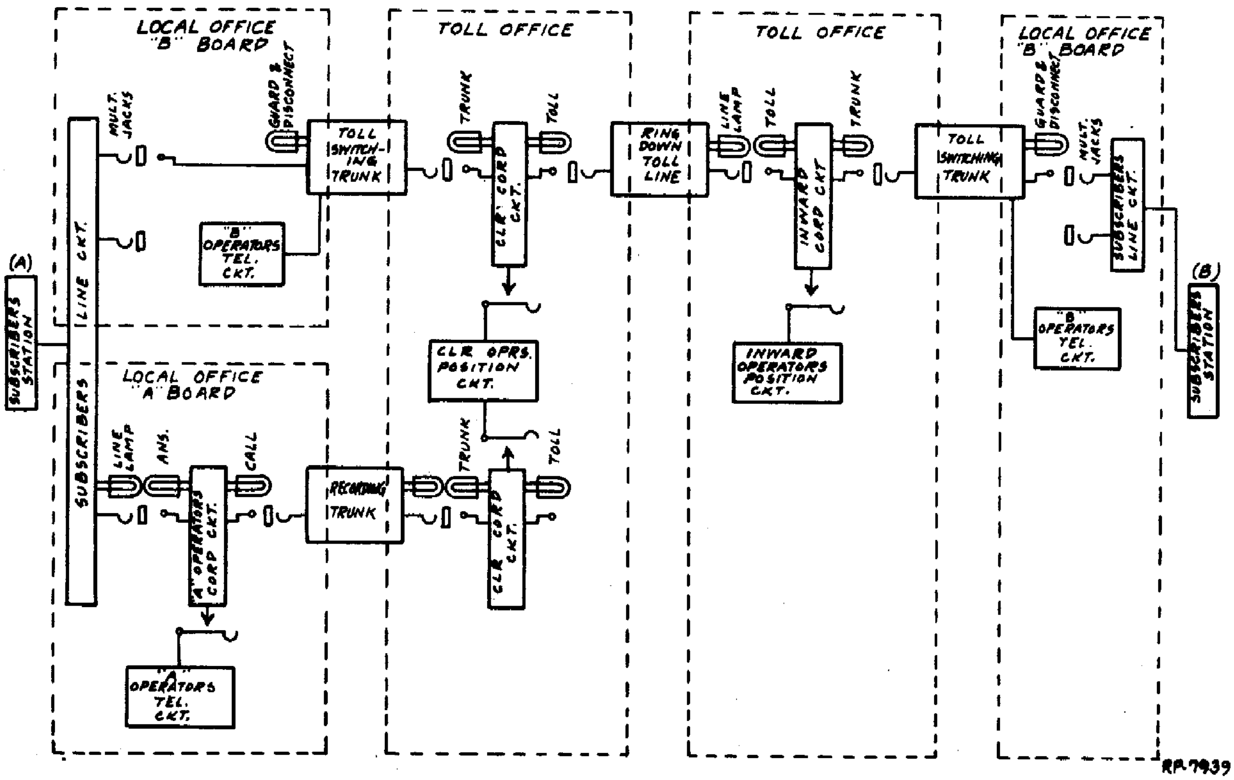

Fig. 1 Long Distance Call Completed By CLR Method Over Ring Down Toll Lines

the calling subscriber, inserts this cord into the trunk and awaits two spurts of tone as an indication that the "B" operator is ready to receive the call. The CLR operator then passes the number of the calling subscriber and says "without", indicating that she wants the connection made to the subscribers line without a busy test, since the line is being held on the recording trunk. When the trunk is connected thru, the supervisory lamp of the trunk cord is out, indicating that the subscriber still has the receiver off the hook. When this connection is made, the trunk cord connected to the recording trunk is released. The local "A" operator observes a lighted supervisory lamp associated with the calling cord and disconnects both the answering and the calling cords. When the called station answers, the ticket is stamped with the calculagraph to record the starting time of the conversation. The CLR operator throws the associated listening key to the monitoring position and listens to see that the conversation has started satisfactorily. The monitoring key is used as it does not cause as great a transmission loss on the line as the listening key and also as it excludes operating room noise from the line because of the operators transmitter being removed from the circuit.

When the inward operator in the called toll office observes a line lamp, lighted as a result of ringing current being applied to the line by the originating CLR operator, the inward operator throws a listening key and inserts the associated trunk cord into the jack associated with the lighted lamp, thus extinguishing the lamp. The toll cord supervisory lamp is out. The inward operator answers the call with the name of her office and awaits the called number. When the inward operator receives this information she says "right" and with the trunk cord of the pair inserts it into an idle switching trunk to the desired local office and awaits two spurts of tone. When this tone is heard, the inward operator passes the number but not the office name to the local "B" operator. After the plug end of the toll switching trunk in the local office is inserted into the desired line, as is indicated by a lighted trunk cord supervisory lamp at the inward position, the inward operator operates a ringing key which causes ringing current to be applied to the line of the called party to ring his bell. If the desired subscriber was on a party line, the local "B" operator would have operated a key corresponding to the party letter. When the inward toll operator applied ringing current to the toll switching trunk, a relay would operate in the local trunk circuit to cause ringing current of the proper polarity to be sent out on the called subscribers line. When the called subscriber removes the receiver from the hook, the trunk cord supervisory lamp is extinguished at the inward toll position as an indication to the inward operator that the subscriber has answered.

Should the CLR operator wish to recall the distant toll operator, or should the distant toll operator wish to recall the CLR operator for any reason, ringing current is a applied to the toll line by the operator wishing to recall, thus causing the supervisory lamp of the toll cord at the receiving office to flash until the listening key is thrown to answer the signal.

When the conversation is completed and the calling party hangs up, the CLR operators trunk cord supervisory lamp lights as a disconnect signal at the originating toll office. The CLR operator then releases the toll circuit, stamps the ticket with the calculagraph and releases the calling line. When the called party hangs up, the supervisory lamp associated with the inward operators trunk cord lights. The inward operator first releases the toll line at the distant end and then the called line thus completing the disconnection of the circuits used for handling the call.

Should the called station be busy the distant operator will give a report and after the CLR operator has acknowledged it, the CLR operator will inform the calling subscriber of the fact and he will be called when the distant station can be reached. However, the calling subscribers line will still be held over the toll switching trunk. After three minutes have elapsed, the CLR operator will make another attempt to secure the desired line and if successful, the originating subscriber will be notified. If the CLR operator cannot secure the desired line in approximately 10 minutes, the call will be transferred to the delayed position for completion.

There are three main reasons why the recording trunk circuits from the manual office are not used for completing the connection between the calling and the called subscribers on a toll call. First, the toll switching trunk is provided with 48 volt instead of the customary 24 volt transmission battery. This arrangement gives approximately 4 T.U. better transmission than would be obtained by talking thru the usual 24 volt subscribers cord circuit and the manual recording trunk circuit. It is more economical to equip a few toll switching circuits with higher grade transmission facilities than all the regular subscribers cord circuits in the office.

Second, the use of the toll switching trunk provides a method of checking the calling subscribers number. If he were to give the wrong number, the toll switching "B" operator would be unable to establish a connection to the calling line. Third, the toll switching trunk provides a means for placing the direct supervision of the calling line in the hands of the toll operator. The toll operator can control the ringing and, by means of the trunk supervisory lamp, can determine whether or not the receiver is on the switchhook at the calling station. This would not be possible were the call completed thru the local "A" operators cord circuit.

Straightforward toll lines have recently been developed for use on short haul routes to replace such as those formerly operated on a call circuit basis. For example traffic between New York and Philadelphia is handled by this straightforward method. The operating features are similar to the ringdown method previously described, with the following exceptions. Full switchhook supervision from the called station is obtained at the outward toll, or CLR position. Disconnection from the toll line by the outward operator gives a disconnect signal simultaneously to both the inward toll and the terminating toll switching operators if the called subscribers receiver is on the hook. No recall feature is provided such as on ringdown trunks. It is necessary to use an additional trunk to recall the distant inward operator. The straightforward trunks are used for one way traffic only, a separate group being provided for traffic in each direction. In fact the method used for operating these straightforward toll lines is not very dissimilar from the method used for operating local straightforward trunks described under A-B toll in the previous section.

DELAYED CALLS

All calls which cannot be completed by the CLR method, such as calls that have to be built up at two or more points, calls to subscribers that have been busy for more than 10 minutes, Messenger calls, Appointment calls or other calls that require more than three minutes for completion are handled at delayed positions. Delayed positions are often called point-to-point positions for the reason that a certain position may handle traffic to points whose first letter begins with A, B,& C, another position may handle traffic to points whose first letter begins with D, E & F, etc. It is thus an easy matter to refer a subscriber who requests information regarding the progress of his call to the operator who is handling it.

When a call cannot be completed by the CLR method, the CLR operator forwards the ticket to a directory desk where any additional information, if necessary, is placed on the ticket. The ticket is then routed to a delayed position handling calls to the desired point. When the delayed operator endeavors to complete one of these calls she first secures the calling subscribers line over a toll switching trunk to assure the accessibility of this line when the called party is reached. The distant toll office is then called with the toll cord of the pair. When the call is of the person-to-person class, the originating toll operator will request the terminating toll operator to complete the call to the desired subscribers line and

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when the called station answers, the originating operator requests information as to whether or not the called person is available. If the called person is ready to talk, the calling party is notified by the originating operator and thus the connection is completed. If the called person is not available, the operator will leave word to have him call his long distance operator, if requested by the calling subscriber. During the interval the originating operator releases the toll line and also the subscribers line.

Some classes of service require a ticket being made out at both the originating and the terminating toll centers; a Messenger call and a Collect call are examples of this type. When the originating delayed operator reaches the inward operator in the distant office, she requests that her call be transferred to the outward board. It is the duty of the outward operator at the distant office to record the details of the call, to supervise the call at her end of the line and to render any necessary reports to the originating operator.

PNEUMATIC TUBE OPERATION

When the tickets covering the details of calls, that are to be completed at delayed positions, have been made out by CLR operators, it is necessary that these tickets be forwarded to the proper delayed operators with as little delay as possible. In addition to this, it is necessary that some of the tickets be routed to the directory desk first, in order that the directory operator may look up numbers of called subscribers in distant exchanges. The pneumatic tube system provides for a central distributing desk with operators who are provided with lists of different point-to-point operators positions and the names of the offices to which they are handling calls. When a ticket has been made out by the CLR operator, it is sent directly to the distributing desk and from there to the proper outward operator. When the distributing operator starts a ticket to the outward toll operator, she operates a key which lights a pilot lamp at the distributing table. When the ticket arrives at its destination, a switch is operated by the ticket itself which lights two pilot lamps at the toll positions and causes the pilot lamp at the distributing position to be extinguished, indicating to the distributing operator the safe arrival of the ticket. When the toll operator removes the ticket from the valve in which the tube terminates, a relay is operated which causes the two ticket pilot lamps to be extinguished. One tube termination serves two operators, one at the left and one at the right position. Arrangements are provided so that when either of these toll operators has sufficient tickets, she operates a key which lights a lamp as a signal to the supervisor that this operator can handle no more calls. When the keys associated with both positions at any one tube terminal are operated, the pilot lamp at the distributing position is extinguished, indicating to the distributing operator that no more tickets are desired at these positions.

SERVICE OBSERVING

Service observing provides three things. First, information regarding the speed, accuracy and dependability of the service. Second, data valuable for supervisory purposes in regard to the technical quality of the operating work and the most economical use of the operators and toll line time, also data valuable in regard to the accuracy with which the operators follow instructions and the accuracy of the ticket records. Third data valuable for engineering purposes.

To effect improvements in the toll work, it is necessary to have data in regard to the work of the individuals on the board. However, in order to meet the fundamental purposes of the observing plan, it is necessary to distribute the routine observation over all kinds of traffic handled by all operators and this condition makes it impracticable to obtain conclusive data in regard to the work of individuals. It requires supplementary observing to obtain conclusive data of this kind.

The traffic for toll service observing of recording trunks, toll lines, and toll operators telephone sets is as follows:

When a call for long distance is referred to a CLR operator, the lamp at a multiple of the recording trunk at the service observing board lights. The service observing operator plugs into the jack with a cord and enters on a ticket, provided for the purpose, the details of the call. When the recording operator has finished ticketing the call, the observing operator disconnects from the trunk. The toll line selected by the toll operator will be indicated to the observing operator by the operation of the busy signal associated with the toll multiple at the service observing board. The observing operator then plugs into the jack of the line selected with a cord and monitors. Another cord can be used to listen on an operators telephone set whenever it is considered necessary to locate the operator who is handling the call under observation.

Arrangements are provided so that the service observing operator can originate a call to any operator whom she desires to check. To do this, she uses her desk set to make the call.

MODIFICATIONS IN THESE METHODS WITH LOCAL DIAL OFFICES

When dial equipment of either the panel or step-by-step type is installed in local

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offices it is necessary to make some changes in these methods.

A-B Method

With the A-B method the procedure on the part of the subscriber in placing a call is to dial zero which will connect him to an operator who will handle his call. From this point on his procedure remains the same as with manual equipment. The subscribers procedure is the same whether he is connected to a step-by-step or a panel type office.

The trunking methods employed for handling A-B toll calls originating in step-by-step offices or panel offices at manual "A" positions are the same, in general, as have been used in manual offices in the past, except that dialing trunks are usually employed to other step-by-step dial offices and either cordless "B" or semi-mechanical cord and district systems are employed to other panel dial offices.

In manual offices connected to step-by-step offices either dialing trunks or straightforward trunks to a cordless "B" board are employed, and in manual offices connected to panel type offices either dialing trunks, key indicator trunks or straightforward trunks to a cordless "B" board are employed for handling the A-B toll business.

CLR Method

When a dial subscriber wishes to make a call to a distant point he dials Long Distance and is connected to the CLR operator over a recording-completing trunk to the originating toll center. When the CLR operator obtains the details of the call she completes the connection with the toll cord of the pair used to answer the recording trunk. The dial subscriber is not connected back thru a toll switching trunk as was the case in manual practice. The recording trunks used to terminate the dial calls are high grade circuits using 48 volts for transmission instead of the low grade 24 volt recording circuits used in manual practice.

Should the call be of such a nature that the CLR operator cannot complete the connection immediately, the dial subscriber is told to hang up and the ticket is routed to the delayed board. When connection has been established by the delayed operator to the called station, the calling party is notified over a toll switching trunk.

The toll switching trunks from the delayed toll board to a dial office are terminated on selectors in the local office, since it is not practicable to terminate these trunks on cords and plugs appearing in front of the subscribers multiple in the manner followed at present in manual offices. These selectors in the toll switching trunks can be actuated in different ways to cause a connection to be completed between a toll switching trunk and a dial subscribers line. These methods are, in general, different depending upon whether the dial office is of the panel type or step-by-step type and it has been found desirable to adopt different methods as standard with the two different types of equipment.

With panel type offices three different methods of operating the switching trunks have been considered. The first is the cordless "B" method in which a toll switching operator located at a cordless "B" position in the local office controls the operation of the selectors in the switching trunk. The toll operator with this method follows substantially the present operating practice with manual local offices. Two other methods have also been investigated, in both of which the operation of the selectors in which the toll switching trunk terminates is controlled from the toll board. The first of these is the so-called key indicator method, and the second involves the use of a position dial circuit which may be associated with each toll cord to control the selectors in the local central office.

The operating advantages of the key indicator method appears to warrant its use in every case with panel type equipment as compared with the method employing dials. The use of the key indicator method, however, involves a large expenditure at the toll board in connection with the first machine switching office that is put in service and it has been found in the case of the larger cities that the operating savings at the toll switching positions and at the toll board are not sufficient to justify the use of the key indicator method in these cases at the start as compared with the cordless "B" method. The key indicator method will, in general, prove in over the cordless "B" method where the amount of traffic over the toll switching trunks, which will be completed to local dial offices by this method, is from 10 to 15% of the total toll switching trunk traffic. Whether it can be proved in in any given case depends to a large extent on local conditions, such, for example, as the life of the toll switchboard in which it is proposed to install key indicator equipment, the ability to make use elsewhere of any cordless "B" equipment which may be removed from a local office, etc. All indications at present are that the key indicator arrangement or some modification of it, wherein the connections over toll switching trunks are controlled from the toll board, will be the most economical arrangement to employ ultimately when all or a large part of the toll switching trunk traffic is completed to dial offices. Even in the case of the larger cities such as New York and Chicago where cordless "B" equipment is now being installed initially, it will probably be found economical to replace it with key indicator equipment or

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some modification of it at some future time, when a comparatively large percentage of the toll switching trunk traffic is completed to dial offices.

Connections from the toll office over toll switching trunks to local step-by-step dial offices may be made in one of two ways; by the use of dialing trunks or by the recently introduced cordless "B" system. The key indicator method has been under consideration but seems unlikely to be adopted since it involves considerable expence over the present systems.

The use of dialing trunks is the cheaper of the two methods and is at present standard practice with the No. 3 toll switchboard. However, the new cordless "B" system applied on a straightforward basis gives quicker service and is more satisfactory in areas where there are a large number of manual offices working into the step-by-step dial office.

QUESTIONS

1. What operator handles the supervision, the ticketing and the timing of a toll board call?
2. What is meant by the CLR method of handling traffic?
3. What is meant by the delayed method of handling traffic?
4. What are the advantages of the CLR method?
5. Under what conditions must a call be handled by the delayed method?
6. Trace a call handled by the CLR method over ring-down circuits from the originating to the terminating subscriber.
7. Why are not recording trunks used for completing a connection between the called and the calling subscriber?
8. What is meant by a point-to-point position, a CLR position, a delayed position, an outward position, an inward position, a through position?
9. Under what conditions is it necessary to originate two tickets on a call?
10. What is the necessity for a ticket distributing system in a large toll office?
11. Describe briefly the Pneumatic Tube System of ticket distribution.
12. What is the necessity for service observing?
13. What modification is made in the method of completing an A-B call when the connection is established through a dial office?
14. What modification is made in the method of completing a CLR call when the connection is made through a dial office?

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SECTION 6

*TOLL SWITCHBOARDS- NO. 3 TYPE

In the early days of telephony the toll signaling apparatus consisted of a magnetic drop in the line and a drop or ringer in the cord. With the advent of common battery signaling in the local plant,relays and lamps replaced the old type drops and the subscriber was given means for calling the toll operator on a toll connection by operating the switchhook instead of ringing.Up to this time the toll operators were located at the local switchboard and had direct access to the subscriber's line, but with the growth of toll and local traffic, it was no longer economical to place the toll operators at the local board. This led to the development of a separate toll switchboard called the No.1 board, which had access to the subscriber's line over switching trunks between the toll and local boards. For many years the No.1 switchboard filled the needs of the time but with the expansion of the toll service and the growth of machine switching local service, it became evident that new arrangements were desirable. The No. 3 toll switchboard was developed to meet the new requirements and it has the following advantages as new installations are required.

(a) Reduction in apparatus, resulting in equipment economies.

(b) Improved maintenance arrangements.

(c) More readily adapted to modifications required by new operating methods.

In discussing the features of the No.3 board, frequent comparisons will be made with the No.1 switchboard to set forth the changes which have been made in the design of the new circuits.

MAIN FEATURES

Cord Simplified by Locating Supervisory Relays in Line and Trunk Circuits

The cord circuit of the No. 1 switchboard is equipped with two supervisory relays. One of these relays responds to 20-cycle current and gives the toll operator a ringing signal, indicating that the distant operating is calling. The second relay responds to direct current received from the switching trunk and gives the operator switchhook supervision of the subscriber. Associated with these two relays are other relays which prevent false signals, and permit the operator to make a busy test or use the cord for a terminating or a through connection. This cord is shown in Fig. 1.

In the No. 3 switchboard the ringing relay and the direct-current supervisory relay, which were formerly connected across the tip and ring conductors of the cord circuit, have been moved from the cord to the line and switching trunk, respectively, and the cord circuit has been simplified as is illustrated in Fig. 2. In this board the line and trunk signals are transferred to the cord over the sleeve circuits. This is accomplished by using a nominal sleeve resistance of 1,800 ohms for the line and trunk circuits and connecting the lamps in the sleeves of the cord. Under these conditions there is not sufficient current flowing in the sleeve to light the lamp, but when a ringing signal is received over a line and a cord is associated with that line or when a receiver-on-the-hook signal is received over a switching trunk,the sleeve resistance of the line or trunk is changed from 1,800 ohms to 80 ohms, which increases

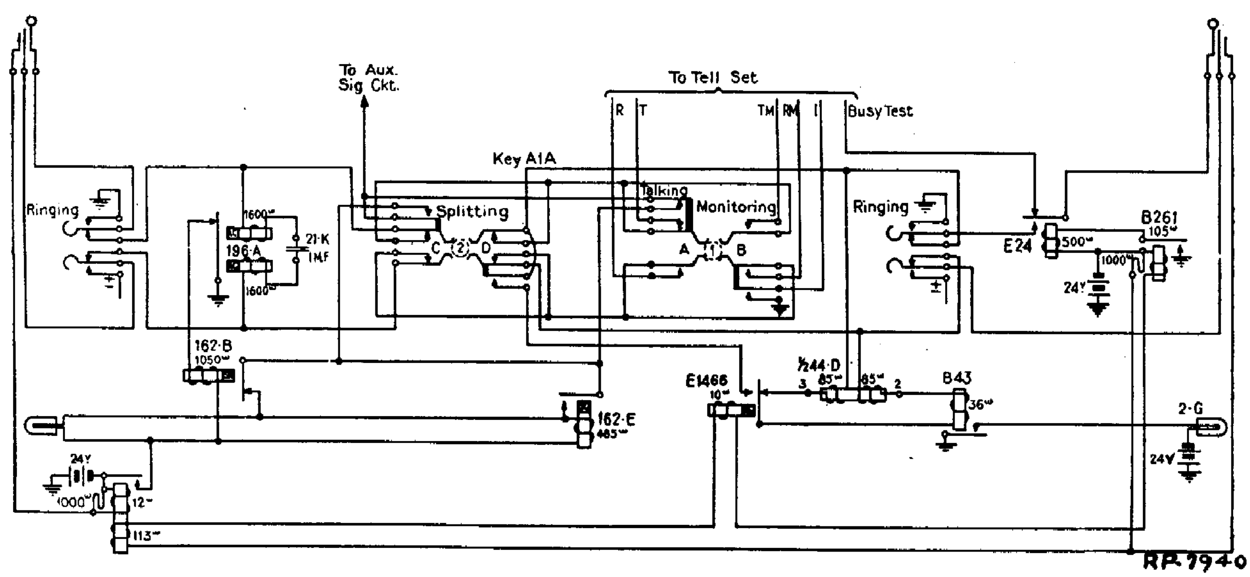

Fig.1 High impedance toll cord for toll switchboard No.1

*This section is a reprint of a paper on the Toll Switchboard No.3 published in the Bell System Technical Journal, January 1927, written by J.Davidson of the American Telephone and Telegraph Company. This article was copyrighted in 1927 by the American Telephone and Telegraph Company.

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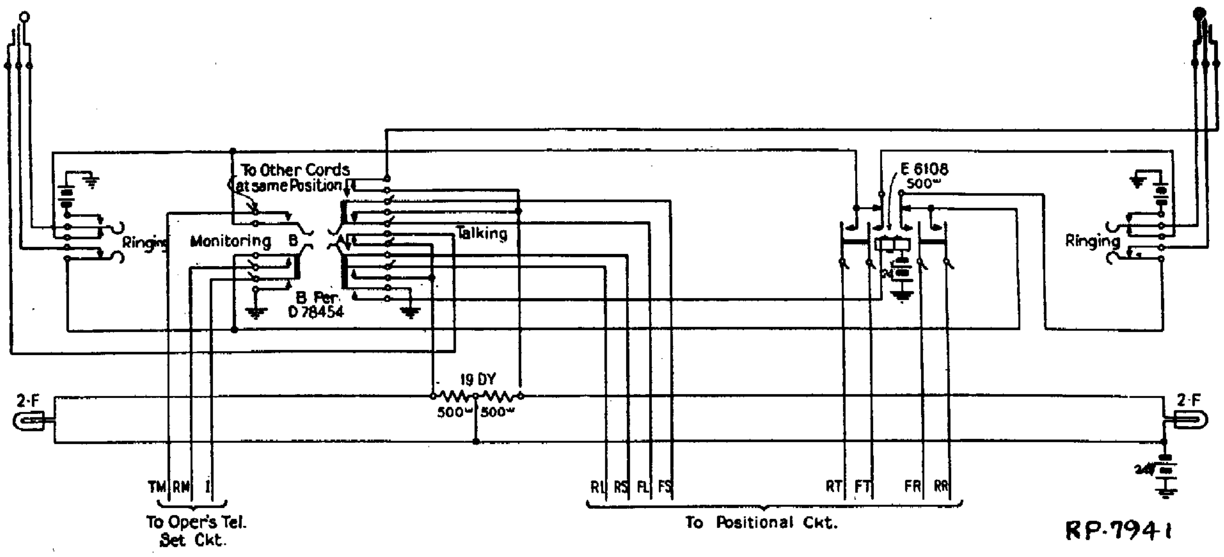

Fig.2 Toll cord for toll switchboard No.3

the current in the sleeve of the cord sufficiently to light the lamp.

Line Relay Functions in Twofold Capacity

The majority of toll lines in the plant today are of the ringdown type and the operator at one end calls the operator at the distant end by ringing over the line. To receive this ringing signal in the No.1 board, the lines are equipped with relays which respond to the ringing current received from the distant end of the line and give a line signal. After the operator answers this signal by connecting a cord to the line, the line relay is disconnected and replaced by the ringing relay in the cord which responds to further rering signals over the line. This arrangement of the line and cord, as well as the switching trunk for the No.1 board, is shown schematically in Fig.3.

By transferring the ringing relay from the cord to the line in the No. 3 toll board, this relay is made to function in a twofold capacity, that is, to give the line signal as well as the cord rering signal. When a call is received from a distant point, the apparatus in the line functions to light the line signal and this remains lighted until a toll cord is inserted in the line jack. Further signals over the line cause the apparatus in the line to light the lamp in the cord. This is obtained by changing the sleeve resistance of the line from 1,800 ohms to 80 ohms and is illustrated in schematic form in Fig.4. As in the past, the line signal is multipled before several operators and appears as a steady illuminated lamp which is extinguished by an operator answering the call. The cord signal appears before one operator and has been changed from a steady lamp signal to a flashing signal for the purpose of ob-

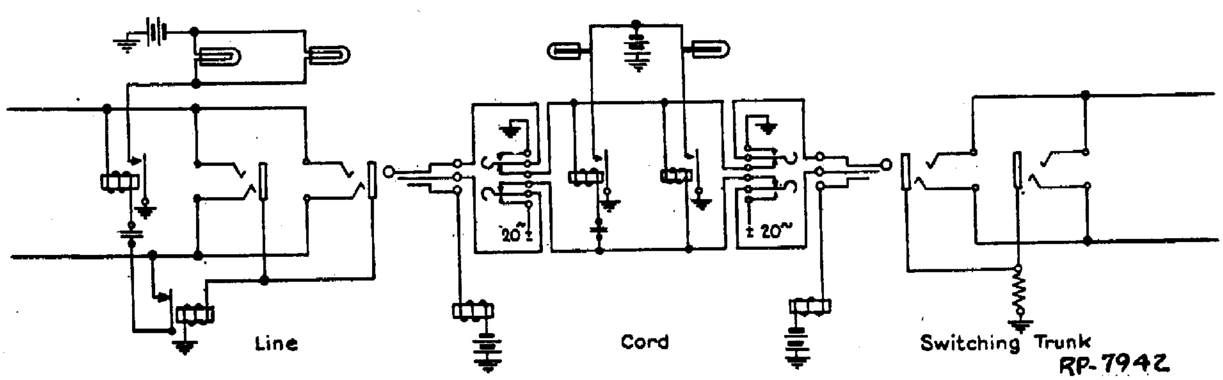

Fig.3 Schematic:Toll switchboard No.1 circuits

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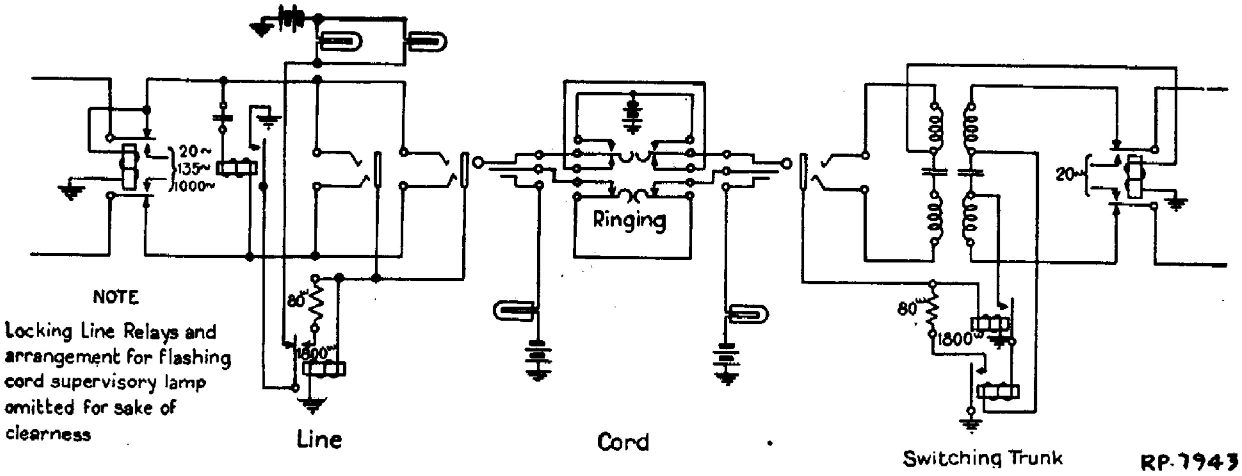

Fig.4. Schematic: Toll switchboard No.3 circuits; monitoring and positional circuit keys are not shown

taining prompt attention on the part of the operator. The cord signal is extinguished when the operator connects to the circuit by the operation of the talking key. This connects an additional 600 ohms in the sleeve circuit, which releases relays which are held operated in the line circuit and control the lamp.

Composite Ringer Simplified

In order that the toll lines may be used for telegraph as well as telephone service, composite sets are often connected into the line circuit at each end. These composite sets are electrical filters which separate the telephone and telegraph currents and direct the telephone currents to the switchboard and the telegraph currents to the telegraph equipment.

When composite sets are connected in the lines terminating in a No. 1 switchboard it is also necessary to connect a composite ringer in the circuit between the composite set and the switchboard. This is necessary because the 20-cycle current, which is used as ringing current from the switchboard, is in the telegraph range of frequencies and consequently will not pass through the telephone branch of the composite set. The composite ringer substitutes for the 20-cycle outward ringing current received from the switchboard, a higher frequency current which will pass through the telephone path of the composite set. Likewise on incoming ringing signals, the ringer substitutes for the higher frequency current which comes over the line and through the telephone path of the composite set, a 20-cycle current which will operate the ringing relays of the line or cord circuits. A schematic of the composite set and composite ringer, as used with the No.1 board, is shown in Fig.5.

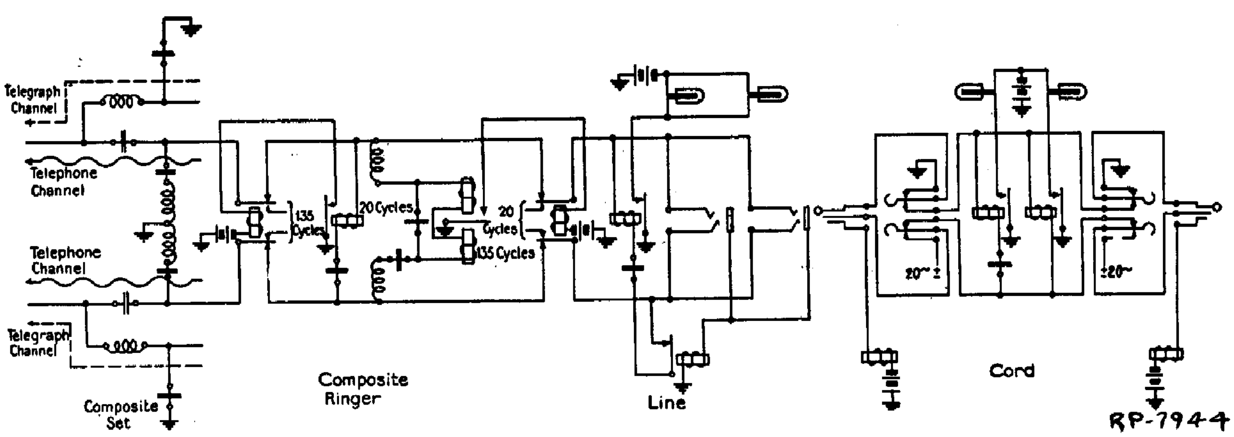

Fig.5 Schematic: Composite ringer and composited toll line for toll switchboard No. 1

In general, the composite ringer for the No.3 switchboard has been greatly simplified and made a part of the terminating line equipment. This has been accomplished, as illustrated schematically in Fig.4,by arranging the line circuit so that a relay may be cross-connected in the line to receive the 20-cycle, or the higher frequency ringing current, and arranging this relay so that it gives the line signal or the cord supervisory signal direct without going through the step of changing ringing frequencies.

Furthermore, the practice of using 20-cycle current in the cord circuit for ringing has been discontinued and ringing is

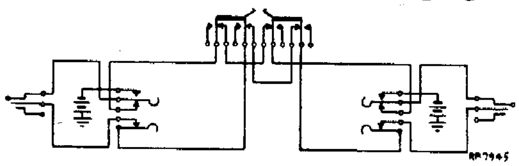

Fig.6 Schematic: Toll cord talking circuit; talking key normal for toll switchboard No.3

effected in the No.3 switchboard by connecting 24-volt direct current through the ringing key to the tip conductor of the cord. This current operates a relay of the line or trunk circuit which applies the proper frequency of ringing current to the line or trunk circuit. By this arrangement one relay in the line circuit accomplishes the same result as was accomplished by several relays in the composite ringer. As the ringing current leads to the relay in the line are brought through terminals on the frames, the line can be readily changed for any desired frequency of ringing current.

<u>Elimination of Transfer Key from Face of Inward Switchboard.</u>

In the past the practice has been to provide one or two transfer keys per line for each multiple appearance of the line lamp at the inward toll switchboard. The function of these keys is to transfer the inward call from the inward switchboard to the outward delayed positions or to the thru positions. With the No.3 toll switchboard, the use of these transfer keys individual to the line and appearing in the face of each section of the inward switchboard has been discontinued and the transfer is effected by a transfer key in the positional circuit which may be used to transfer a call on any line.This key applies 24-volt battery either directly or through a resistance to the ring conductor of the line and operates the proper transfer relay in the toll line and causes lamps individual to that line to light at the outward or through positions. This feature not only effects a saving in equipment but saves the space in the face of the switchboard which was formerly occupied by the transfer keys.

<u>Use of Positional Circuit</u>

Another circuit feature of the No.3 switchboard which marks an improvement over switchboard No.1 is the use of a so-called positional circuit in which is located much equipment such as splitting keys, dialing keys, etc.,which heretofore were individual to each cord. Under normal conditions the tip and ring conductors of the front cord are connected to the tip and ring conductors of the corresponding back cord with no shunts across the circuit. This is illustrated in Figure.6.

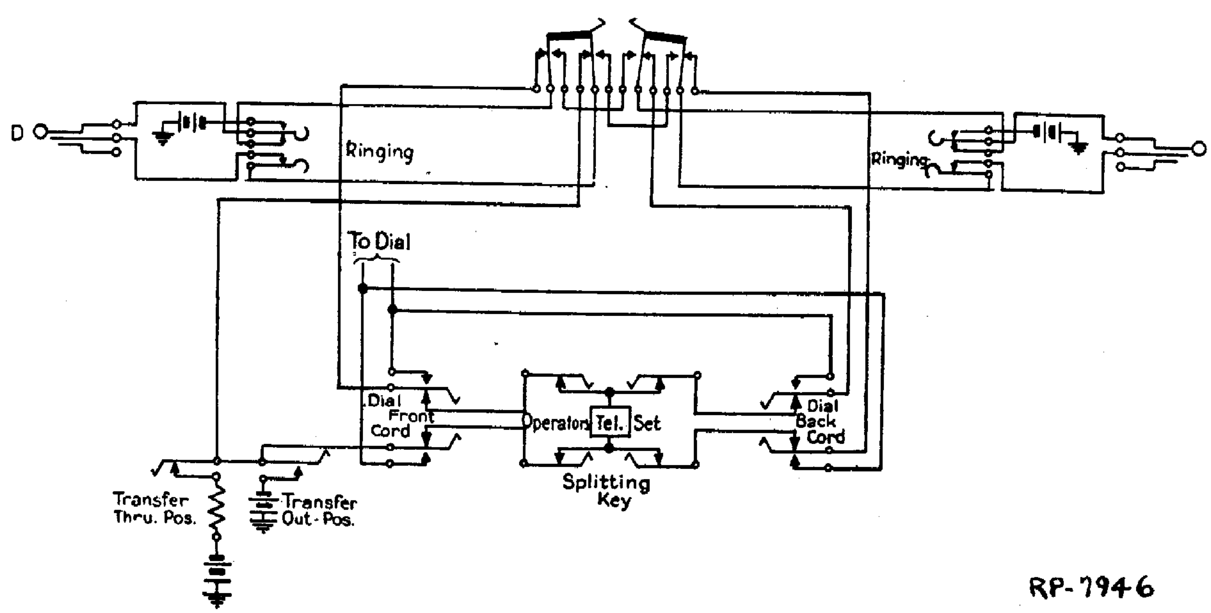

Fig.7 Schematic:Toll cord positional circuit;talking key operated for toll switchboard No.3

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By the operation of the talking key associated with each cord circuit, the positional circuit is connected between the front and back cords and the operator's telephone set is connected across the circuit as illustrated in Fig.7. With the talking key of any cord operated, the operator may

(a) Dial on either the front or the back cord.

(b) Split the talking circuit between the front and the back cords.

(c) Transfer an inward call from the inward to the outward or the through positions.

This circuit arrangement not only effects substantial economies but it is much more flexible and will lend itself to new developments without requiring changes in the cord circuit.

Monitoring and Ringing Keys Individual to Cords

The monitoring and ringing keys are, as in the past, individual to each cord.

Switching Trunk Features

In the No.3 toll switchboard a repeating coil which has a high impedance to 20-cycle ringing current is used in the outgoing end of the switching trunk. This arrangement has equipment and signaling advantages. Also where loaded toll switching trunks are involved, the use of a repeating coil of the type referred to, but having the proper transmission characteristics, has the advantage of reducing reflection losses by providing for a uniform terminal impedance of the switching trunks.

PRINCIPAL ADVANTAGES

Equipment Economies

As has been pointed out, the expansion in toll business, together with recent developments in the telephone art, have been such that with the circuit arrangements used in the past there has been a growing necessity to add equipment to the cord circuit with the result that the positions are becoming congested with apparatus. With the circuit arrangements outlined for the No.3 toll switchboard, however, the transfer of the signaling apparatus from the cord to the line and switching trunk makes a marked simplification in the cord and incidentally reduces the congestion in the section. Also it should effect a substantial economy in equipment because of the fact that we are approaching a situation where there are approximately 60 per cent. more cords than lines and 25 per cent. more cords than switching trunks.

The use of the positional circuit and the elimination of the individual splitting key from the toll cord has simplified the switchboard keyshelf. This simplification together with the equipment savings effected by the simplification of composite ringers and the transfer of the supervisory relay equipment from the toll cord to the toll line and switching trunk circuits has effected substantial economies.

Maintenance

In addition to the saving in first cost of equipment the No.3 switchboard facilitates maintenance. The ordinary toll cords in an office must be suitable to work with any toll line terminating at the switchboard and consequently with the circuit arrangement used in toll switchboard No. 1, the ringing relay in all the toll cord circuits must be maintained to operate in connection with the longest as well as the shortest line circuit. In the case of the No.3 toll switchboard, however, the ringing relay is individual to the line and consequently may be adjusted to meet the operating conditions of that line. Long lines with severe ringing conditions require the relay to have a sensitive adjustment while short lines with easy ringing conditions permit a less sensitive relay adjustment to be used which is more easily maintained.

Easily Adaptable to Machine Switching Methods

The introduction of machine switching requires provision for dialing on the trunks and may in the future require the same feature for dialing over toll lines. Such provision in the boards previously employed requires the addition of the necessary keys and relays on a "per cord" basis, whereas with the No.3 board the equipment can be placed in the positional circuit, without any change in the cord circuit. This results in a great economy in apparatus and makes a change to a dialing basis rather simple.

SUMMARY

It is interesting to note in conclusion that heretofore an increase in cord circuit apparatus has necessarily followed the development of new and improved switchboard systems and the extension of the area of long distance communication. For example, the magneto cord with a single drop bridged across the circuit sufficed in the early days of small magneto boards. The advent of the common battery multiple switchboard brought the necessity for extending switchhook supervision to the toll operator, and resulted in the condenser-type cord consisting of 5 relays, now largely abandoned because of the relatively large transmission loss introduced by it. The high-efficiency cord consisting of 8 relays resulted from the demand for a cord having a minimum transmission loss, and additional complications have resulted in the requirement for dialing in machine switching areas, each

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improvement, of course, increasing the number of relays in the cord circuit. The No.3 system, on the other hand, makes possible by the transfer of apparatus to the line and switching trunk and by the use of common positional equipment the relatively simple toll cord shown in Fig. 2 in which the individual apparatus is limited to two keys and one relay per cord. This provides in many cases a toll cord suitable for either inward, outward or through operation, reduces the apparatus congestion in the section and results in decreased maintenance, while being easily adapted to the future trend in toll develepement.

QUESTIONS.

1. What two functions does the ringing relay perform in the No.3 Toll Line Circuit?

2. How is it possible to change a No.3 Toll Line Circuit operating on 20-cycles to operate on 135-cycles or on 1000-cycles?

3. How is transfer now accomplished on the No.3 Toll Switchboard?

4. What are the functions of the position circuit?

5. What keys are individual to each cord?

6. What are the advantages of the new toll switching trunk?

7. Why does the reduction of equipment on the cord circuit and the addition of equipment in the line circuit effect a saving in the toll office?

8. How does the new switchboard effect a saving in maintenance?

9. How does the new circuit arrangement of a No.3 Toll Switchboard lend itself to future use with dial offices?

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