March 18, 1930. L. L. GLEZEN ET AL 1,750,666

TOLL CIRCUIT

Filed July 10, 1928 3 Sheets-Sheet 1

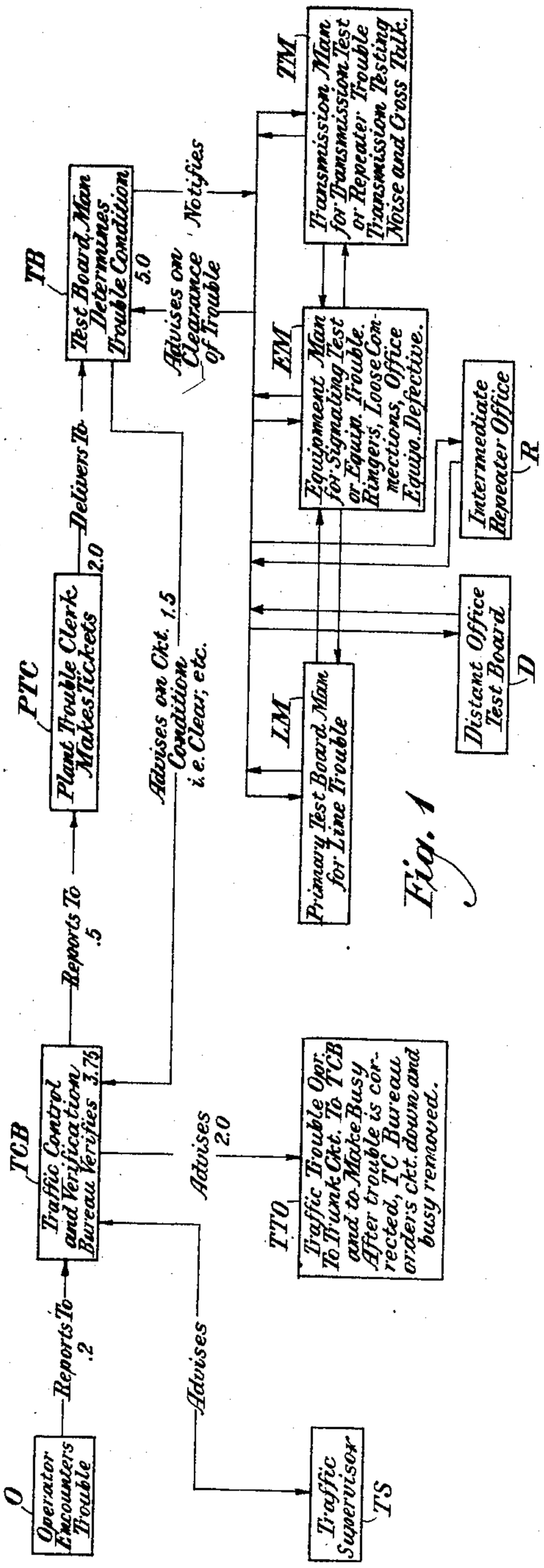

Fig. 1

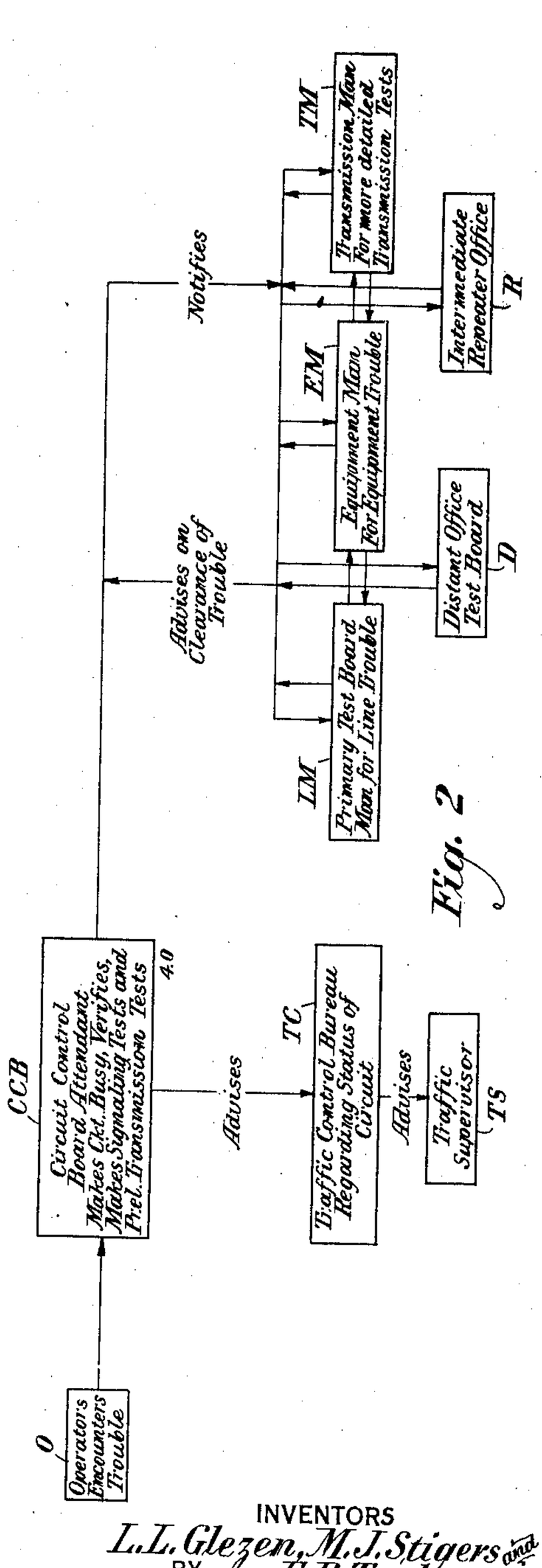

Fig. 2

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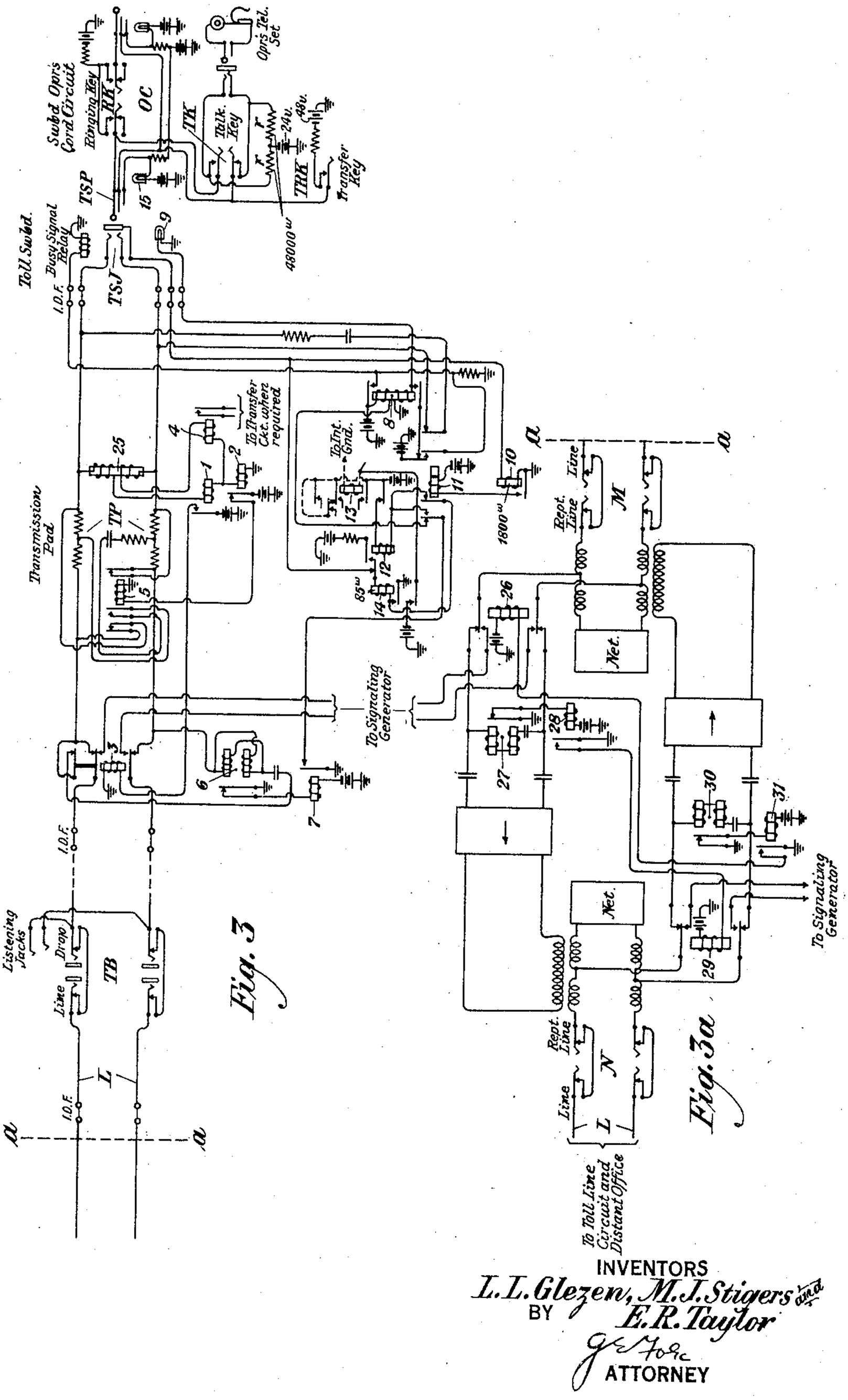

Fig. 3

Fig. 3a

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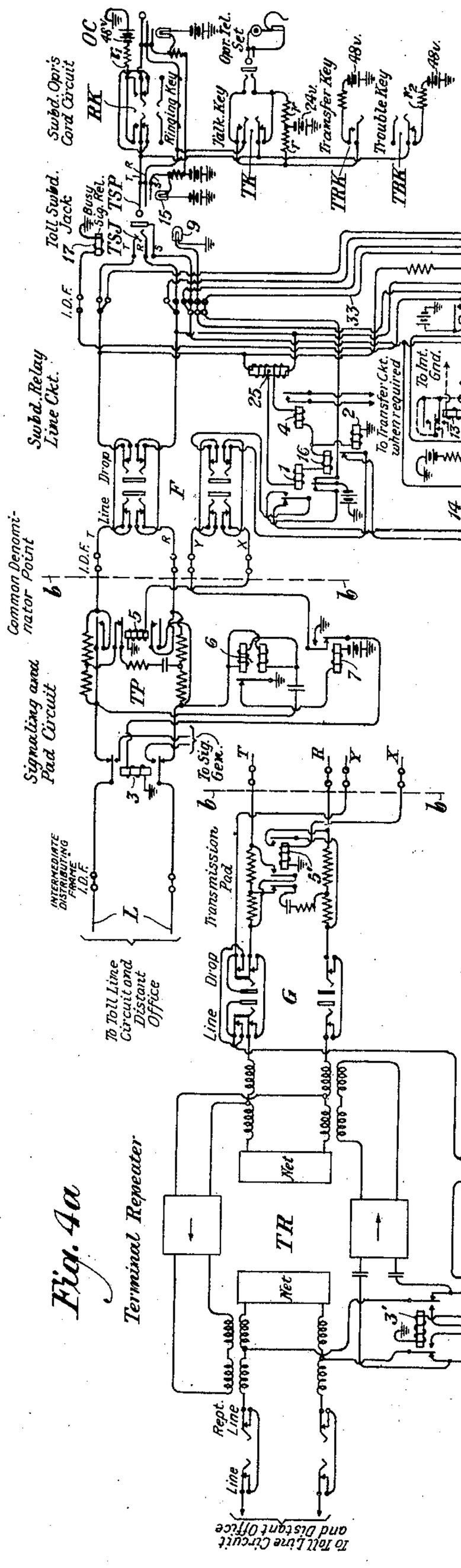

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UNITED STATES PATENT OFFICE

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TOLL CIRCUIT

Application filed July 10, 1928. Serial No. 291,682.

This invention relates to toll circuits and equipment and to improvements in the methods of operating and maintaining such circuits and equipment.

In order to assist in understanding the invention, it is desirable to briefly describe the present arrangement of the toll circuit equipment and the methods of operating and maintaining the toll lines and terminal apparatus.

The operating and maintenance personnel may be divided roughly into two groups: (*a*) a traffic group, which comprises the operators for establishing connections and the supervisory force for routing and supervising the traffic; and (*b*) a plant group whose duty it is to maintain the circuits in proper operating condition, locate the causes of trouble when reported by the traffic group, and to clear the various troubles after the causes have been ascertained.

The various toll lines are multipled before several positions of the operating board to permit the operators to establish connections. If an operator finds a particular line in trouble, she reports this fact to a traffic control bureau which is usually located in some other part of the building and has no direct access to the line. It is desirable that the traffic control bureau verify the fact that the trouble exists before notifying the plant people to clear it and in order to do this, the traffic control bureau orders a trouble operator (who is located at one of the positions of the toll switchboard) to trunk the line to the traffic control bureau. The trouble having been verified, it is reported to a trouble clerk in the plant department who makes out a ticket and delivers it to the testboardman whose duty it is to determine the cause of the trouble. The testboard is so arranged that each testboardman has access to a certain group of lines and the lines are not multipled to other testboard positions. If at the time the trouble is reported to the trouble clerk the testboardman should be busy testing another line, he would not be able to take up the new trouble immediately; and hence the necessity for making out a ticket and delivering it to the testboardman.

As soon as the testboardman has determined the cause of the trouble, he instructs the proper equipment man who has charge of the particular equipment which is in trouble, to clear it. After the trouble is cleared, the equipment man notifies the testboardman, who again tests to determine that the line and apparatus are in proper condition; whereupon he notifies the traffic control bureau that the line is again ready for service.

When the traffic control bureau originally ascertained that the trouble existed, the trouble operator at the toll board was ordered to render the circuit busy and the busy condition existed during the period of making out the ticket, testing and clearing the trouble. Upon receiving the report that the line is again in condition for service, the traffic control bureau must thereupon notify the trouble operator to remove the busy condition so that the switching operators may use the line for traffic.

In the larger offices, the organization time for handling the trouble routine as above outlined, excluding the time actually employed for clearing the trouble, which, of course, varies with the particular trouble involved, averages between 15 and 45 minutes for each case of trouble, depending upon the size of the office. In a large telephone system, this time represents a very large annual cost.

To a considerable extent this excessive routine trouble time is due to the location of the testboard with respect to the lines and equipment over which the testboardman has maintenance control. The testboard jacks are connected serially in the line between the terminal repeaters (where provided) or other line equipment, and the drop equipment, such as the transmission pad, ringing apparatus and circuit operating relays. Therefore, when the testboardman tests the line for trouble, he does not see the line from the switchboard operator's standpoint. Accordingly, tests made from the testboard do not include all of the apparatus used with the line and hence his tests do not necessarily disclose the true operating condition of the line. To test the line he must be provided with duplicate ringing equipment and pad arrangements, thus increasing the cost of equipment. In

making patches from a particular line to another drop, he has to bear in mind the nature and character of the line and the nature and character of the ringing apparatus and pad in the drop to be sure that the one will go with the other, for these various elements differ from each other over a fairly wide range. Furthermore, if it is desired to more or less permanently patch a line entering from one direction to a line leaving in another direction to make a so-called via line between two distant offices through the office in question, the testboardman is not strategically located so as to make such patching connections because the pad and the ringing apparatus are between his position and the drop at the toll switchboard. In making such patches, therefore, he must arrange for special equipment changes to be made by other plant men, so that the one line will work directly into the other regardless of whether or not the lines employ the same kind of ringing apparatus and are otherwise similar in their transmission features.

Where the line is provided with a terminal repeater, the terminal repeater is located on the line side of the testboard and the ringing equipment and pad on the drop side. It is necessary to associate ringing apparatus with the repeater for relaying the ringing currents about the repeater. Inasmuch as the same drop is not always associated with a given line through the testboard, and since the different drops may have different types of ringing equipment associated therewith, it is not convenient, with the testboard located at this intermediate position, to combine the ringing arrangements of the drop with those of the terminal repeater, so that here again there is some duplication of equipment which, if avoided, would represent considerable saving in the cost of apparatus per line.

Applicants have discovered that to a considerable extent the above difficulties may be eliminated if the testboard functions can be performed from a point located so that all of the apparatus normally associated with the line is available for test under the same conditions as apply when the circuit is normally operated. Under these conditions also, the testboardman, in running down troubles and testing the circuit, will see the circuit from the same standpoint as the toll switching operator who uses the circuit in establishing connections. All the essential apparatus associated with the line at the terminal will be between the testboardman and the line, so that it can be placed under direct test by him from his position. It is therefore proposed to abolish the testboard position, as now located with the transmission pad and ringing arrangements between the testboard and the drop. Instead a new board, called the circuit control board, will be provided. At this board, all of the toll lines will be multipled, the multiples being connected to the same point of the line as the switchboard multiples. By connecting the multiples at this point all of the equipment common to the line, except certain relays and lamps which are repeated at each appearance of the line at the switchboard, will be located on the line side of the control board.

The applicants further discovered that when the control board described above is used, it will be possible to so arrange all toll lines that each one will have a so-called common denominator point of such a nature that any toll line may be cross-connected or patched to any drop at that point without consideration of the patching difficulties outlined above, such as type of signaling employed, use of terminal repeater, etc. Obviously, this will greatly facilitate interchanging of lines and drops, which becomes necessary in temporarily replacing defective lines or equipment, or in building up additional circuits to various points to take care of unexpected or short period traffic loads.

The applicants have also discovered that circuits could be patched together at the control board by the use of a relatively simple cord circuit. This will enable a via circuit to be built up on very short notice that will afford through signaling without regard to the type of signaling employed on the circuits patched together.

Another advantage of the control board arrangement is that the routine transmission measurements of circuits may be made from this board without the delay and resultant lost circuit time that now exist in getting the circuits trunked from the testboard or switchboard to the transmission desk.

When trouble is encountered, the toll operator, by merely throwing a switch, will light lamps at each control board position before which the line is multipled. Any testboardman who happens to be idle will, upon seeing the light, be able to take up the trouble at once, verify it and make tests to locate it. No necessity will now exist for the traffic control bureau to make any preliminary verification nor for a plant clerk to make out a ticket, so that these steps and the time taken by them will be eliminated. The time previously taken up by the report from the testboardman to the traffic control bureau will be eliminated as the testboardman, by suitable keys, may cause lamps to indicate at the traffic control bureau whether or not the circuit is out of commission. Also, the functions of the traffic trouble operator will be eliminated as the testboardman will have direct access to the line, so that no necessity for trunking it up to some other position exists. Also, the testboardman can render the line busy by the operation of a suitable key so that the traffic operators will not attempt to use it. It is estimated that this change in the routine for

handling trouble will reduce the routine organization time, exclusive of the actual time for clearing the trouble, to an average of about 5 minutes. This saving of time would represent annually very large money savings in a large toll system such as that of the Bell system.

In addition to the savings due to the decreased time for handling troubles with the system re-arranged as above outlined, there will also be a considerable saving in the cost of apparatus. In order to test the line, the testboardman will no longer have to be provided with ringing equipment and pads, duplicating those formerly on the drop side of the testboard. This is for the reason that, as already stated, this equipment will now be on the line side of the testboardman's position. Furthermore, by eliminating the testboard position and the testboard jacks between the terminal repeater and the ringing equipment associated with the drop, such ringing equipment may be eliminated and the ringing equipment associated with the terminal repeater may directly operate the signal at the drop.

The proposed arrangement will also be more convenient and economical in making patching connections for via circuits. A patching cord may be used by the testboardman to patch one line to another at the control board, so that the ringing equipment associated with the one line will relay through the patching cord to operate an entirely different type of ringing equipment associated with the other line.

The invention will now be more fully understood from the following description, when read in connection with the accompanying drawings, in which Figure 1 is a chart showing the present routine for handling troubles; Fig. 2 is a similar chart showing the trouble routine in accordance with the present invention; Fig. 3 illustrates the terminal arrangements of a typical toll line; Fig. 3ª is a typical terminal repeater which may be used in the line of Fig. 3; Fig. 4 shows a toll line circuit re-arranged in accordance with the present invention and provided with the circuit control board; and Fig. 4ª is a diagram of a terminal repeater and circuits associated therewith which may be used in connection with the line shown in Fig. 4.

Inasmuch as there is no single patent or publication illustrating all of the equipment used in connection with the line at a toll office and describing the trouble routine employed in connection with the maintenance of such lines, it is necessary to illustrate a typical toll line circuit with its associated equipment as shown in Figs. 3 and 3ª, and to describe briefly how the equipment functions under ordinary traffic conditions and how troubles which occur in connection with the circuit are handled.

Referring to Fig. 3, L designates a toll line entering a toll office. At TB the line passes through line and drop jacks of the testboard, the line jacks enabling the testboardman to test the line and the drop jacks enabling him to test the apparatus associated with the drop. The line terminates at the toll switchboard in multiple jacks such as TSJ appearing at the various positions of the toll switchboard, whereby traffic operators are enabled to establish connections with subscribers or with other toll lines. A pad TP is interposed between the testboard TB and the toll switchboard to control the volume of transmission. The line also has associated therewith between the drop at the toll switchboard and the testboard TB ringing equipment comprising the relay 6 for responding to incoming ringing signals and a relay 3 for applying ringing current to ring out over the line. Various controlling relays are also associated with the drop. At the toll switchboard, the operator is provided with an operator's toll cord OC for establishing connections between the toll line and local subscribers or for establishing through connections from the toll line to another toll line leading to a distant subscriber who receives his toll connections through the toll switchboard illustrated.

When the operator desires to ring the distant office she inserts the plug TSP in the jack TSJ and operates the ringing key RK. This applies battery to the tip side of the line and establishes the direct current circuit through the upper winding of the choke coil 25 and through relays 1 and 2 to ground. Relay 2 opens the circuit of relay 5, which cuts the pad TP into the line (the pad being normally shunted out). Relay 1 closes the circuit of relay 3, which applies the signaling current to the line over its inner contacts.

If the operator desires to talk over the line, she operates the talking key TK which bridges her talking set across her cord OC and also connects a simplex circuit through the 11,000-ohm resistances r—r to the tip and ring conductors of the line. The simplex circuit extends through the two windings of the choke coil 25 through the relays 1 and 4 in parallel, and thence through the relay 2. Relays 1 and 4 are marginal and do not operate in series with the high resistances r—r. Relay 2, however, is energized to open the circuit of relay 5 and cut in the pad which should be in the line for local connections, although it is cut out for through connections as will be described later.

It is desirable at this point to note the difference between a local connection, a through connection and a so-called via connection. For a local connection the line is connected through the operator's cord circuit to a trunk

or other circuit leading to a subscriber in the local area in which the toll office is located. In a through connection, each time a call is made, the toll line is connected to another toll line leading from the toll office under consideration to an office at a distant town at which said other toll line is connected to the subscriber. In the case of a via connection, the toll line is also connected to another toll line but in this case the connection is not put up and taken down for every call but is a patching connection established over a period of time to provide an alternative route between two distant cities through the toll office under consideration. In other words, it is to provide a temporary long haul circuit over which calls between the two distant cities are routed.

If the circuit is to be used for a through connection, the operator will actuate her transfer key TRK to signal an operator at another position of the board where such through calls are made. The operation of the transfer key applies battery over the ring conductors of the plug TSP and the jack TSJ, over the ring side of the line through the lower winding of the choke coil 25 and through relays 4 and 2. Relay 4 signals the through operator. In making local connections, each trunk through which a connection is made to a local subscriber is provided with a simplex circuit similar to r—r bridged across the trunk so that relay 2 will be operated to cut in the pad TP. In the case of a through call established by a through operator, however, no such simplex circuit is provided in connection with the trunk or line leading to the distant city to which the connection is made, and hence the relay 2 is not operated. Consequently, the pad TP is eliminated from the circuit.

An incoming ring over the line L passes over the inner back contacts of relay 3 to actuate the ringing relay 6, which opens the circuit of relay 7. Relay 7 closes the circuit from ground, over its back contact through the left-hand back contact of relay 11, and through the upper winding of relay 8. Relay 8 locks up over its back contact and also connects battery to the lamp 9 to signal the toll operator. If the operator should be connected to the line at the time the ringing signal comes in, relay 10 will be operated over the sleeve contacts of the jack TSJ and the plug TSP, thereby energizing relay 11. When relay 7 falls off in response to the ring, therefore, a connection is established over the front left-hand contact of relay 11, through relay 12 to battery over a front contact of relay 13. Relay 12, over its front contact, connects battery to relay 14. Relay 14 locks up to ground over its lower contact and as soon as relay 12 falls off at the end of the ring, relay 14 is connected to battery over the sleeve of the jack TSJ and the sleeve of the plug TSP. The connection of the low resistance of the winding 14 in parallel with the high resistance of the relay 10, which is also in the sleeve circuit, increases the current flow over the sleeve sufficiently to operate the cord lamp 15.

With this brief statement of the general operating features of the circuit, let us consider how troubles are handled. Assuming that for some reason the ringing relay 6 or the relay 7 is out of order when the distant operator rings, she will be unable to attract the attention of the toll operator at the office illustrated as the lamp 9 will not glow. The distant testboardman will ultimately be notified and upon verifying the fact that the operator does not answer, will notify the testboardman at the board TB of Fig. 3 over a telegraph wire. The testboardman will then come in on the line through the testboard jacks at TB to locate the trouble. He, of course, does not know whether the trouble is in the line itself or in the local ringing apparatus. Therefore, he comes in on the line jacks at TB. As the ringing equipment is between this point and the drop, he must be provided with duplicate ringing equipment which he connects to the line at the testboard and instructs the distant testboardman to ring. If he gets the signal, he can then assume that the trouble is in the ringing apparatus associated with the drop and will at once patch the line to a spare drop through the line jacks at the testboard. In doing this, he would have to take into consideration whether the ringer in the spare drop is of such character as to respond to the particular type of ringing current sent from the distant office. He must also consider whether the transmission pad associated with the spare drop is of the right value to work with the particular line. When he attempts to test the ringing equipment 6, 7, etc., from his position, he has no way of determining whether the relays 6 and 7 respond except by noting whether or not the operator answers the lamp 9, whereas if he were located beyond the ringing apparatus, he could have the distant testboardman ring and himself observe how the circuit functioned.

If the toll operator should encounter trouble of any kind, she reports that fact to the traffic control bureau, which verifies it and then reports it to the plant trouble clerk who makes out a ticket and delivers it to the testboardman at TB. The line illustrated appears at only one testboard position and is one of a number of lines appearing at that position, so that the testboardman may be otherwise engaged and unable to take the matter up immediately. Depending on the type of trouble, he is poorly located to make the tests to find certain types of trouble and may have to call over other circuits to the operators or maintenance men to help him in

making the tests to locate the trouble. For example, let us assume that there is some trouble in the pad. The operator would report transmission trouble. When this report finally reached the testboardman, he would, of course, not know the character of the transmission trouble. Upon listening in to the line on the line jacks at the testboard, he would find nothing wrong there. If he plugged into the drop jacks and talked to the operator over the drop circuit, he might not discover that anything was wrong with the pad, because he would be so close electrically to the operator that the trouble might not show up. The result is that he might erroneously report the circuit in good order but if he felt suspicious, he might report it to the plant transmission man to run down. The testboardman is located at the wrong place to analyze trouble of this character, particularly as he would be unable to cause the pad to cut in and out without the assistance of the operator or a plant attendant located where the pad is mounted.

If, as is frequently the case, the line is provided with a terminal repeater, further complications arise. Such a terminal repeater is shown in Fig. 3ª, the right-hand terminals of said repeater being connected to the line terminals at a point *a*—*a*. This terminal repeater must be provided with arrangements for ringing around the amplifiers. For example, when the operator rings out on the line, the ringing current applied thereto over the contacts of the relay 3 is transmitted through the hybrid coil into the upper branch of the repeater and over the contacts of the relay 26 to the ringing relay 27. Relay 27 releases relay 28, which in turn closes the circuit of relay 29 to apply ringing current through the left-hand hybrid coil to the line going to the distant station. Ringing current incoming from the line at the left of the repeater in Fig. 3ª passes through the hybrid coil over the contacts of relay 29 to operate ringing relay 30, the latter releasing relay 31, which in turn closes the circuit of relay 26 and applies ringing current through the right-hand hybrid coil to the circuit leading to the drop. This ringing current passes through the testboard and operates the ringing responsive relay 6 and the associated relays in the manner previously described. The above arrangement, of course, involves duplication of ringing apparatus at the drop and at the repeater, due to the fact that the testboard is connected at an intermediate point. It is, of course, necessary to provide the drop with ringing equipment because the drop may be used with a line which does not have a terminal repeater.

If transmission trouble should occur in the repeater, the testboardman is not well located to judge the cause of the transmission trouble since the repeater and the pad are intimately associated so far as transmission is concerned, and the testboardman is located between them so that he cannot observe how they function together.

It may be desired to use the line shown in Fig. 3 for establishing a via connection from the distant terminal of the line through the toll office illustrated, and thence over a line leading out of said office to another distant office, such via connection to remain set up as an alternative toll line between the two distant points and to be cut out of service so far as toll calls originating at or terminating at the toll board shown are concerned. Such via connection may be established by patching from the line jack at the testboard TB to the similar line jack of the other line. Such a patching connection, however, usually involves the setting up of special ringing circuits and the provision of proper repeater arrangements as the two lines which are to be patched together may have entirely different ringing arrangements at their distant terminals. The testboardman does not have direct access to these various equipment elements and hence is not well located to make via connections.

The routine by which troubles are handled with circuit arrangements such as above described is illustrated by the chart of Fig. 1, which shows the various traffic and plant groups involved, together with their functions. The numbers associated with the various legends represent the number of minutes involved in each stated operation. Bearing in mind that the trouble occurring on a given line must always be ultimately located by a particular testboardman (since the line cannot be multipled at different positions of the board when the testboard jacks are connected serially between the line and the drop as shown at TB of Fig. 3), and bearing in mind further that the trouble is usually first discovered by the traffic force, and that the traffic force must at all times be informed as to whether the circuit is available for use or not, the reason for the routine about to be described becomes apparent.

Referring to Fig. 1, when the operator encounters trouble, she reports to the traffic control bureau TCB. This is usually located at some point in the building somewhat remote from the operating board and it is impracticable to have the various lines of the system multipled to this bureau so that it will at once have access to them. While it is the business of the plant group, and particularly the business of the testboardman, to locate the trouble, it is obviously undesirable to pass the operator's report of trouble to the testboardman without vertifying it, especially where the testboardman has a large group of lines to take care of. In order to verify the fact that the reported trouble exists, the traffic control bureau must order the traffic trouble

operator TTO (who is at an extra multiple position on the main switchboard) to trunk the line to the traffic control bureau. Having verified the fact that the trouble exists, the line must be taken out of service and the traffic control bureau accordingly notifies the trouble operator to make the circuit busy. After the trouble has been cleared, as will be described later, the traffic control bureau must verify the fact that it is clear and order the trouble operator to remove the busy condition. All of these operations, on the average, require about two minutes.

As soon as the traffic control bureau has verified the trouble and has ordered the circuit made busy, it reports the trouble to the plant department, where it is first brought to the attention of a plant trouble clerk PTC whose duty it is to make out a ticket indicating the nature of the trouble, the line involved, etc. This ticket is delivered to the testboardman, whose duty it is to find the cause of the trouble. This operation involves at least 2 minutes. The necessity of making out the ticket arises from the fact that the testboardman must do the testing on all the lines of a group and may, therefore, be busy with another line at the time the trouble now being described is reported.

When the testboardman undertakes to determine the cause of the trouble condition, he is, as has been previously described, poorly located to carry out certain types of tests, particularly tests involving the pad and ringing arrangements. Also, he must make certain of these tests by co-operating with an operator or by co-operating with another plant man. Due to these various conditions, it requires, on the average, at least 5 minutes to determine the cause of the trouble and to make the final test after the trouble has been cleared, as will be described later.

Depending upon the nature of the trouble, the testboardman will notify a plant man of one of several groups to do the actual work of clearing the trouble. If the trouble should be a transmission trouble, such as trouble with the pad or trouble with the terminal repeater, it will be reported to the transmission man TM. If the trouble involves the signaling apparatus or the various relay and other equipment associated with the drop, it would be reported to the equipment man EM. If the trouble were in the line itself, it would be reported to a primary testboardman LM, who is only responsible for the line. If the trouble involves a distant office, the distant testboard D would be notified and if it involved an intermediate repeater, the intermediate repeater office R concerned would be notified.

When the trouble has been cleared, it will be reported by the plant man involved to the testboardman at TB, who will again test the circuits to verify that the trouble has been cleared. The testboardman will then advise the traffic control board as to the circuit condition. Due to the fact that he may not find an attendant at the bureau immediately ready to hear his report, and due to the further fact that, depending upon the nature of the trouble, he may have to make a fairly long report, this operation will involve, on the average, at least 1½ minutes. The traffic control bureau then orders the trouble operator to remove the busy condition and the line is then ready for handling service.

If the various times indicated on the chart for performing the several operations above described be added together, it will be found that the total time is in the neighborhood of 15 minutes. This time is typical of a relatively small office. In larger offices with more complicated equipment, the average routine trouble time may run as high as 45 minutes.

To avoid the difficulties above referred to, and to reduce the routine trouble time, it is proposed to reorganize the circuit arrangement by eliminating the testboard located at an intermediate point between the line and the ringing apparatus and to substitute therefor the new board called the circuit control board. At this board the various lines will not be grouped with a group for each testboardman, but the lines will be multipled to a plurality of testboard positions, so that when any line is in trouble, any testboardman who is at the moment idle can take care of it. Also, the multiples will be connected to the line at the same point as the operator's multiples, so that the testboardman can see the line from the same point of view as the operator. All of the apparatus usually associated with the drop, such as the pad and ringing apparatus and the various circuit controlling relays, will be located on the line side of the control board multiple. As the trouble will usually receive immediate attention due to the multiple arrangement, the verification of the trouble can now be done directly by the testboardman instead of by the traffic control bureau. No longer will any reason exist for making out a ticket on the part of the plant trouble clerk.

A typical circuit arrangement for the central office equipment as thus rearranged is illustrated in Fig. 4. Referring to this figure, it will be observed that the testboard jacks, which in Fig. 3 occur to the left of relay 3, are now eliminated. The point in the circuit represented at *b*—*b* now becomes a common denominator point, so that the drop circuit equipment to the right thereof will be the same for all circuits, however much the lines themselves with their ringing arrangements and pads may vary. All of these features will be to the left of the common denominator point *b*—*b*. When it is desired to patch any line to another drop, this may be done by the

jacks at F which are located at the common denominator point. This function may be performed by a plant man who has nothing to do with testing the line and who need know nothing whatever about the character of the ringing arrangements or the character of the pad or the character of the line itself. The plant man located at the point F may make this patch under the direction of the testboardman or under the direction of some member of the traffic group.

The operator's cord circuit differs from the cord circuit of Fig. 3 in that a trouble key TBK is provided by means of which a large current may be transmitted over the tip conductor to light multiple lamps 19, 19′, etc., at the various positions of the control board CCB. The control board CCB is provided with multiple jacks, such as CCJ, at the various positions thereof, these jacks being multipled with the toll operator's jacks, such as TSJ. Each position of the circuit control board CCB is provided with a testing cord TC by means of which the testboardman may monitor, talk, ring, test the signaling sets or tests the transmission. This cord is also provided with a pad controlling key PCK for cutting pad in and out, and with a sleeve opening key SOK for operating the busy signal 17. Each multiple position of the control board is also provided with a make-busy key MBK for maintaining the busy signal 17 operated at times when the testboardman's cord TC is not connected to the line, as for example, while repairs are being made by another plant man. The testboardman at the circuit control board CCB is also provided with a patching cord PC for making via connections, as will be described later.

If the operator desires to ring the distant office, she operates ringing key RK to put battery on the tip conductor of the jack TSJ as in the case of Fig. 3. The current then flows through the upper winding of the choke coil 25 and through relays 1, 16 and 2. Relays 1 and 2 operate but relay 16 is marginal and does not operate. Relay 2 opens the circuit of the pad controlling relay 5. This circuit, before it was opened, extended from battery, over the right-hand front contact of relay 11 (which was energized by relay 10, which in turn was energized over the ring conductor when the operator plugged in), over the back contact of relay 2, contacts of the line and drop jacks at F, and through the winding of relay 5 to ground. The opening of this circuit cuts in the pad TP which is normally cut out. Relay 1 closes the circuit over the normal contact of relay 16, front contact of relay 1, drop and line contacts at point F, over the Y conductor and front contact of relay 7, through relay 3 to ground. Relay 3 applies ringing current to the line L. Relay 3 was normally connected over back contact of relay 1 and back left-hand contact of relay 11, through upper winding of relay 8 to battery, but did not operate over said circuit because the combined resistances of relays 8 and 3 are sufficiently large to prevent their operation in series.

If the operator desires to talk over the circuit, she operates the talking key TK. This connects the simplex circuit through resistances r—r to the tip and ring sides of the line and results in the energization of relay 2. Relays 1, 16 and 4 are not energized, however, through the high resistances r—r. Relay 2 releases relay 5 and cuts in the pad TP as before.

When a through connection is to be made, the toll switching operator will operate the transfer key TRK applying battery to the ringing conductor and thereby operating relays 4 and 2. Relay 2 cuts in the pad and relay 4 signals the through operator as described in connection with Fig. 3.

If the distant subscriber rings, relay 6 is operated and releases relay 7, thus completing the circuit from ground, over the back contact of relay 7, over the Y conductor, contacts of the line and drop jacks at F, back contact of relay 1, extreme left back contact of relay 11, and through the upper winding of relay 8 to battery. Relay 8 locks up through its lower winding and through its lower contact also completes a circuit for the lamp 9. If a ringing signal should occur while the operator's cord circuit OC is plugged into the jack TSJ, the sleeve relay 10 will be energized to complete the circuit of relay 11 so that the circuit previously described as completed by the relay 7, passes over the conductor Y, back contact of relay 1, front left-hand contact of relay 11 to relay 12, and through relay 12 to battery. Relay 12, upon being energized, completes a circuit from battery, over its front contact, through the winding of relay 14, over the inner left-hand front contact of relay 12, over the outer front contact of relay 12 and thence over the circuit previously described to ground at the contact of relay 7. Relay 14 locks up at ground over its lower contact and as soon as relay 12 is released at the termination of the ringing signal, the low resistance of the relay 14 is connected over the back contact of relay 12 in parallel with the high resistance of relay 10 in the sleeve circuit. The current is thus increased over the sleeve circuit so that the lamp 15 associated with the cord circuit may glow.

If the ringing apparatus 6—7 should be in trouble so that the distant operator could not signal the operator at the jack TSJ, the matter would ultimately be reported to the testboardman at the distant end, who in turn would call the testboardman at the circuit control board CCB. This call might be made over a telegraph line or it might be made

over a spare telephone line. The testboardman would plug his cord TC into the jack CCJ and would then be connected to the line over the normal contacts of his monitoring key MK without disturbing the transmission over the line L. He may make the circuit busy by closing the sleeve-opening key SOK which connects battery over the sleeve conductor of the jack CCJ in multiple with the sleeve of the operator's jack TSJ and thence through the winding of relay 10. Relay 10, upon being energized, closes the circuit of relay 11, which in turn, at its inner front right-hand contact connects battery to the toll switchboard signal 17. The testboardman can ring the distant operator in the same manner as the toll operator rings over the jack TSJ by throwing his ringing key RCK, thus putting battery on the tip of the jack CCJ, to operate relay 1, which in turn operates relay 3 as already described. In the case of the particular trouble now under consideration, having gotten the distant operator, he would ask the distant operator to ring back over the circuit and if the ringing apparatus performed properly, this should result in the relay 6 releasing relay 7 to cause the lower resistance of the relay 14 to be connected in shunt to the high resistance of the relay 10 in the sleeve circuit. This would increase the current over the conductor 30 to the sleeve of the jack CCJ so that if the key SOK is closed, the lamp 18 should light. If it fails, he at once knows that there is trouble in the ringing equipment in relays 6 and 7.

He may now test the ringing equipment by closing the signaling test key STK. This results in sending out a ringing current of predetermined value over the line conductors, through the tip and ring contacts of the jack CCJ. This current flows over the conductors 31 and 32 and out through the upper drop and line jacks at point F, and thence into the relay 6. If the relays 6 and 7 properly operate, his signal lamp 18 sould respond. If lamp 18 fails, he knows definitely that the ringing equipment 6—7 is in trouble and he notifies an equipment man to clear the trouble. Relays 6 and 7 are definitely associated with the line and will be repaired with the line out of service. The testboardman therefore throws the key MBK to actuate the signal 17 until the trouble is cleared. After the equipment man reports that the trouble is cleared, the testboardman can operate his testing equipment as before, and if it tests o. k., he will release the key MBK and withdraw the plug of his cord TC. The circuit is now in condition for use.

As already noted, the operator's cord circuit OC is provided with a trouble key TBK. Therefore, if at any time the operator finds the line in trouble, she will merely throw this key TBK. This connects the 48-volt battery through a small resistance r_2 to the tip contact of the jack TSJ. The resistance r_2 is much smaller than the resistance r_1 associated with the ringing key RK and hence the current flowing over the tip side of the line through the upper winding of the choke coil 25 and through the relays 1, 16 and 2 is sufficiently great to operate the marginal relay 16 in addition to the relays 1 and 2. The relay 2 causes the pad TP to be cut in, although this operation is of no importance at this time. Relay 16 opens the circuit controlled by relay 1, so that the operation of relay 1 is prevented, and at the same time closes a circuit from battery, over conductor 33 to operate the signal lamps 19, 19′, etc., associated with the line at the various multiples of the control board CCB. The first idle testboardman observing the glowing of the lamp plugs in his cord TC and by throwing his key MK, talks to the operator and obtains information from her as to the trouble. The operator then withdraws her plug TSP from the circuit and the signal lamps 19, 19′, etc., are effaced.

No necessity exists for the traffic control bureau to make any preliminary test or for a plant trouble clerk to make out a ticket, as the trouble is handled at once by an idle testboardman by reason of the multipling of each line at a plurality of positions at the circuit control board. The testboardman is connected to the circuit at the same point electrically as the operator, and he, therefore, is in a position to hear and observe the same things that she does. In ringing over the circuit he uses the same signaling equipment as the operator and is located on the same side of the pad. He can test the signaling equipment by throwing the key STK and he can make transmission tests by throwing the key TMK which connects his transmission testing set to the line. By means of the pad control key PCK, he makes a simplex connection to the tip and ring conductors of his cord, thereby operating relay 2 without operating relays 1, 16 and 4 in a manner similar to that described in connection with the operator's talking key TK. This enables him to cut the transmission pad in and out as he makes transmission tests to determine whether or not the pad is the cause of the trouble. By means of his key SOK he can temporarily render the line busy by actuating the signal 17. If, however, he finds the circuit will be out of service for some time, he may throw the key MBK to actuate the signal 17 independently of his cord circuit. This also actuates signal lamps 20 and 21, the former being located at the traffic control bureau and the latter at a supervisory plant bureau to inform those departments that the circuit is out of service.

If, while the circuit is out of service, the traffic department desires an alternative cir-

cuit set up to take its place, it notifies the plant department. If the line is in trouble, the plant man assigned to make the patch, makes the patch from the drop jack at F of the line in trouble to the corresponding line jack of another line. If, however, it is the drop which is in trouble, the plant man patches from the line jack of the line L at the point F to the drop jack of a spare drop. In either case the plant man making the patch need not concern himself about the character of the line or the character of the drop, as the drop circuits are all alike and will fit in the line.

If the operator notices transmission trouble, she operates the trouble key TRK as before, giving a signal at the circuit control board. An idle testboardman then plugs in with his cord TC at the jack TCJ and by means of the transmission testing set observes that the transmission is bad. The operator withdraws as before described as soon as she has reported the trouble. The testboardman, as soon as he finds that transmission is bad, operates the key SOK to render the circuit busy to the traffic force. He then calls a testboardman at the distant office on a telegraph order wire and by throwing his transmission test set and cutting the pad in and out by means of his key TCK, he can tell whether the trouble is in the pad. If it is not in the pad, it is presumably in a repeater. If his transmission equipment should show that the transmission is very much greater one way than it is in the opposite direction, the trouble is almost certainly due to a repeater. The particular repeater causing the trouble can be located in the usual way by the cooperation of the testboardmen at various repeater points.

If the line L is provided with a terminal repeater, the arrangement of the terminal repeater may be as shown in Fig. 4ª, the apparatus in this figure being substituted for the apparatus shown at the left of the point *b*—*b* in Fig. 4. Here it will be seen that the testboardman is located on the drop side of both the repeater and the pad, so that he can make tests and verify trouble from the same standpoint as observed by the operator. Since the testboard with its series jacks in the line has been eliminated, the ringing equipment 3, 6 and 7 associated with the line L is no longer necessary as the ringing equipment 3′, 6′ and 7′ associated with the repeater will take its place, and thus it is unnecessary to duplicate ringing equipment where a terminal repeater is employed.

The operation of the ringing equipment will, of course, be obvious. When the repeater rings by applying battery to the tip of the line, the relay 1 is operated as previously described and connects battery over the back contact of relay 16, over the front contact of relay 1, over the conductor Y, over the front contact of relay 7′, and through relay 3′ to ground. Relay 3′ connects the signal generator to the midpoints of the left-hand hybrid coil of the repeater and so rings out over the line. The incoming ringing signal over the line passes from the midpoints of the left-hand hybrid coil of the repeater, over the lower path of the repeater and over the normal contacts of relay 3′ to operate the ringing responsive relay 6′. Relay 6′ releases relay 7′ and connects ground to the Y conductor to operate the signal lamp 9 or the operator's lamp 15, as the case may be.

If the office illustrated in Fig. 4 is at an intermediate point between two distant offices and it is desired to establish an alternative toll line between the two distant offices via the intermediate office illustrated, the testboardman may patch two lines together by means of his patching cord PC, plugging one end of the patching cord into the jack CCJ of the line L leading to the one station, and the other end of the cord into a jack corresponding to CCJ of another line leading to the other station. The keys MBK associated with the two lines thus patched together will be thrown to render the lines busy to the traffic operators at the office illustrated. The patching cord is not provided with a simplex connection so that the pad TP will be cut out of circuit. An incoming ring on the line L applies current to the sleeve conductor 30 in the manner previously described to operate relay 22. Relay 22 operates relay 23 so that battery is applied to the tip of the opposite plug over the left-hand front contact of relay 23. Applying battery to the tip will obviously cause a ringing signal to be transmitted over the line which is patched to the line L. If ringing takes place in the reverse direction, the incoming ring from the other line applies ground to the sleeve of the lower plug of the cord PC to operate relay 24, which in turn operates relay 23, thus connecting battery over the left-hand front contact of relay 24 and inner left-hand contact of relay 23 to the tip conductor of the upper plug, and thence over the tip contact of the jack CCJ and over the tip contact of relay 32 to actuate the relay 1, which in turn actuates the ringing relay 3 as previously described.

The method of handling troubles with the apparatus arranged as described in connection with Figs. 4 and 4ª is indicated by the chart of Fig. 2. Comparing this chart with the chart of Fig. 1, it will be seen that the functions of the traffic control bureau and the plant trouble clerk in verifying trouble and reporting it to the testboardman have been eliminated. Instead of the testboard position TB, we now have a circuit control board at CCB to which reports of trouble are made directly by the operator. These troubles are taken up promptly by an idle attendant at CCB who is able to verify the trouble and

locate its cause in an average time of 4 minutes as compared with 5 minutes in Fig. 1, because of his better location to handle the trouble in the circuit arrangement of Fig. 4. No time is taken up in ordering the line trunked up to the verification bureau. The circuit control board attendant advises the traffic control bureau TC of the condition of the circuit by simply throwing the key to operate a lamp. At the traffic control bureau there is a lamp corresponding to each circuit so that this bureau can know at any time the condition of all the circuits involved.

When the lamp appears at the traffic control bureau the attendant operates a key LK extinguishing the light. From the position of the keys he knows the condition of the circuits. When the plant attendant again restores the circuit to service he removes the busy condition by restoring the MBK key to normal. This again brings in the lamp at the traffic control bureau indicating the restoration of the circuit to service and the attendant restores the key LK to normal, again extinguishing the lamp.

The plant layout board merely shows by the number of lamps burning, such as 21, those circuits out of service.

As soon as the testboardman at the circuit control board has located the cause of the trouble, he notifies the proper plant man, such as the transmission man, equipment man, etc., to clear the trouble. When the trouble is reported to him as cleared, the testboardman need not take up any time whatever in advising the traffic control bureau of the condition of the circuit as he merely releases a key to put out the lamp at the traffic control bureau, thereby indicating that the line is in condition for service. This act at the same time effaces the busy signal at the operator's board so that the operator can use the circuit. As will be noted, the improved method of handling the trouble reduces the routine time to an average of less than 5 minutes as compared with the 15 minute average of the old method.

It will be obvious that the general principles herein disclosed may be embodied in many other organizations widely different from those illustrated without departing from the spirit of the invention as defined in the following claims.

What is claimed is:

1. In a toll system, a toll line, an operator's toll board, said line being multipled to a plurality of positions of said toll board to enable operators to establish connections therewith, auxiliary signaling and transmission equipment associated at the toll board end of the line, a circuit control board, multiple connections from said line to a plurality of positions of said circuit control board, said multiple connections being associated with the line at the same point as the multiple toll board connections, and a testing cord for each of several positions at the circuit control board whereby transmission and signaling tests may be made of the line and equipment associated therewith at the toll board.

2. In a toll system, a toll line, an operator's toll board, said line being multipled to a plurality of positions of said toll board to enable operators to establish connections therewith, a circuit control board, multiple connections from said line to a plurality of positions of said circuit control board, said multiple connections being associated with the line at the same point as the multiple toll board connections, and means whereby an operator at the toll board can signal at one or more positions of the circuit control board before which the line is multipled in case of trouble.

3. In a toll system, a toll line, an operator's toll board, said line being multipled to a plurality of positions of said toll board to enable operators to establish connections therewith, a circuit control board, multiple connections from said line to a plurality of positions of said circuit control board, said multiple connections being associated with the line at the same point as the multiple toll board connections, means whereby an operator at the toll board can signal at each position of the circuit control board before which the line is multipled in case of trouble, and a testing cord for each of several positions at the circuit control board whereby transmission and signaling tests may be made of the line and associated equipment.

4. In a toll system, a toll line, an operator's toll board, said line being multipled to a plurality of positions of said toll board to enable operators to establish connections therewith, a circuit control board, multiple connections from said line to a plurality of positions of said circuit control board, said multiple connections being associated with the line at the same point as the multiple toll board connections, means whereby an operator at the toll board can signal at each position of the circuit control board before which the line is multipled in case of trouble, a testing cord for each of several positions at the circuit control board whereby transmission and signaling tests may be made of the line and associated equipment, and means whereby an attendant at the circuit control board may render said line busy.

5. In a toll system, a toll line, an operator's toll board, said line being multipled to a plurality of positions of said toll board to enable operators to establish connections therewith, a circuit control board, multiple connections from said line to a plurality of positions of said circuit control board, said multiple connections being associated with the line at the same point as the multiple toll board connections, means whereby an opera-

tor at the toll board can signal at each position of the circuit control board before which the line is multipled in case of trouble, a testing cord for each of several positions at the circuit control board whereby transmission and signaling tests may be made of the line and associated equipment, and means associated with the testing cords whereby an attendant at the control board may render said line busy.

6. In a toll system, a toll line, an operator's toll board, said line being multipled to a plurality of positions of said toll board to enable operators to establish connections therewith, a circuit control board, multiple connections from said line to a plurality of positions of said circuit control board, said multiple connections being associated with the line at the same point as the multiple toll board connections, means whereby an operator at the toll board can signal at each of several positions of the circiut control board before which the line is multipled in case of trouble, a testing cord for each position at the circuit control board whereby transmission and signaling tests may be made of the line and associated equipment, and means at the circuit control board whereby an attendant may render said line busy independently of the testing cord.

7. In a toll system, a toll line, an operator's toll board, said line being multipled to a plurality of positions of said toll board to enable operators to establish connections therewith, signaling and transmission elements associated with said line, a circuit control board and multiple connections from said line to a plurality of positions of said circuit control board, said multiple connections being associated with the line at a point between its connection to the toll board and said signaling and transmission elements.

8. In a toll system, a toll line, an operator's toll board, said line being multipled to a plurality of positions of said toll board to enable operators to establish connections therewith, signaling and transmission elements associated with said line, a circuit control board, multiple connections from said line to a plurality of positions of said circuit control board, said multiple connections being associated with the line at a point between its connection to the toll board and said signaling and transmission elements, and a testing cord for each of several positions at the circuit control board whereby transmission and signaling tests may be made of said line, signaling and transmission elements.

9. In a toll system, a toll line, an operator's toll board, said line being multipled to a plurality of positions of said toll board to enable operators to establish connections therewith, a terminal repeater associated with said line, signaling equipment associated with said repeater whereby ringing signals incoming from the line may cause direct operation of a signal at the toll board and whereby ringing current may be applied to the line under control of an operator at the toll board, a transmission element between said repeater and said toll board, a circuit control board, and multiple connections from said line to a plurality of positions of said circuit control board, said multiple connections being associated with the line at a point between its connection to the toll board and said signaling and transmission elements.

10. In a toll system, a toll line, an operator's toll board, said line being multipled to a plurality of positions of said toll board to enable operators to establish connections therewith, a terminal repeater associated with said line, signaling equipment associated with said repeater whereby ringing signals incoming from the line may cause direct operation of a signal at the toll board and whereby ringing current may be applied to the line under control of an operator at the toll board, a transmission element between said repeater and said toll board, a circuit control board, multiple connections from said line to a plurality of positions of said circuit control board, said multiple connections being associated with the line at a point between its connection to the toll board and said signaling and transmission elements, and a testing cord for each position at the circuit control board whereby transmission and signaling tests may be made of said line, repeater, signaling equipment and transmission element.

11. In a toll system, a plurality of toll lines, an operator's toll board, each of said lines being multipled to a plurality of positions of said toll board to enable operators to establish connections therewith, different types of signaling equipment associated with certain of said lines, a drop connection comprising auxiliary apparatus of the same type associated with each line between said signaling equipment and the toll board, and a switching point in each line between said signaling equipment and said auxiliary apparatus whereby any line may be switched to any drop connection regardless of the character of the signaling apparatus associated with the line.

12. In a toll system, a plurality of toll lines, an operator's toll board, each of said lines being multipled to a plurality of positions of said toll board to enable operators to establish connections therewith, different types of transmission pads associated with certain of said lines, a drop connection comprising auxiliary apparatus of the same type associated with each line between said transmission pad and the toll board, and a switching point in each line between said transmission pad and said auxiliary apparatus whereby any line may be switched to any drop

connection regardless of the character of the transmission pad associated with the line.

13. In a toll system, a toll line, an operator's toll board, said line being multipled to a plurality of positions of said toll board to enable operators to establish connections therewith, a circuit control board, multiple connections from said line to a plurality of positions of said circuit control board, said multiple connections being associated with the line at the same point as the multiple toll board connections, a patching cord at each position of the circuit control board whereby said line may be patched to another toll line to establish a via connection for long haul toll traffic between two distant points, and means to render said line busy at the toll board for local traffic when such a via connection is established.

14. In a toll system, a toll line, an operator's toll board, said line being multipled to a plurality of positions of said toll board to enable operators to establish connections therewith, a circuit control board, multiple connections from said line to a plurality of positions of said circuit control board, said multiple connections being associated with the line at the same point as the multiple toll board connections, a patching cord at each position of the circuit control board whereby said line may be patched to another toll line to establish a via connection for long haul toll traffic between two distant points, and means to render said line busy at the toll board for local traffic when such a via connection is established, said patching cord having means to relay ringing signals from one line to another.

In testimony whereof, we have signed our names to this specification this 7th day of July, 1928.

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