

Aug. 9, 1932.

J. E. GARDNER

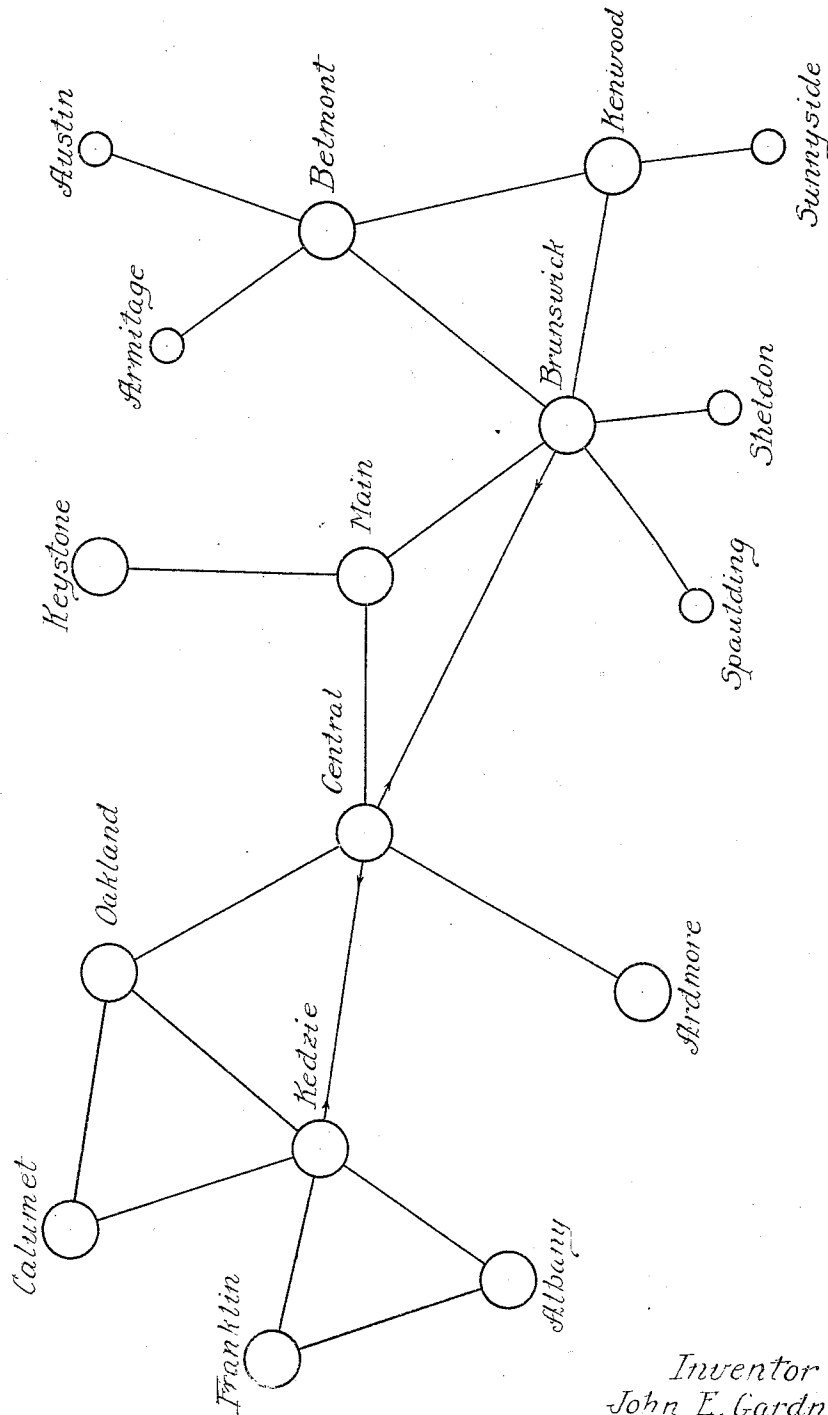
1,870,621

AUTOMATIC TELEPHONE SYSTEM

Original Filed Nov. 21, 1927

18 Sheets-Sheet 1

Fig. 1.



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Aug. 9, 1932.

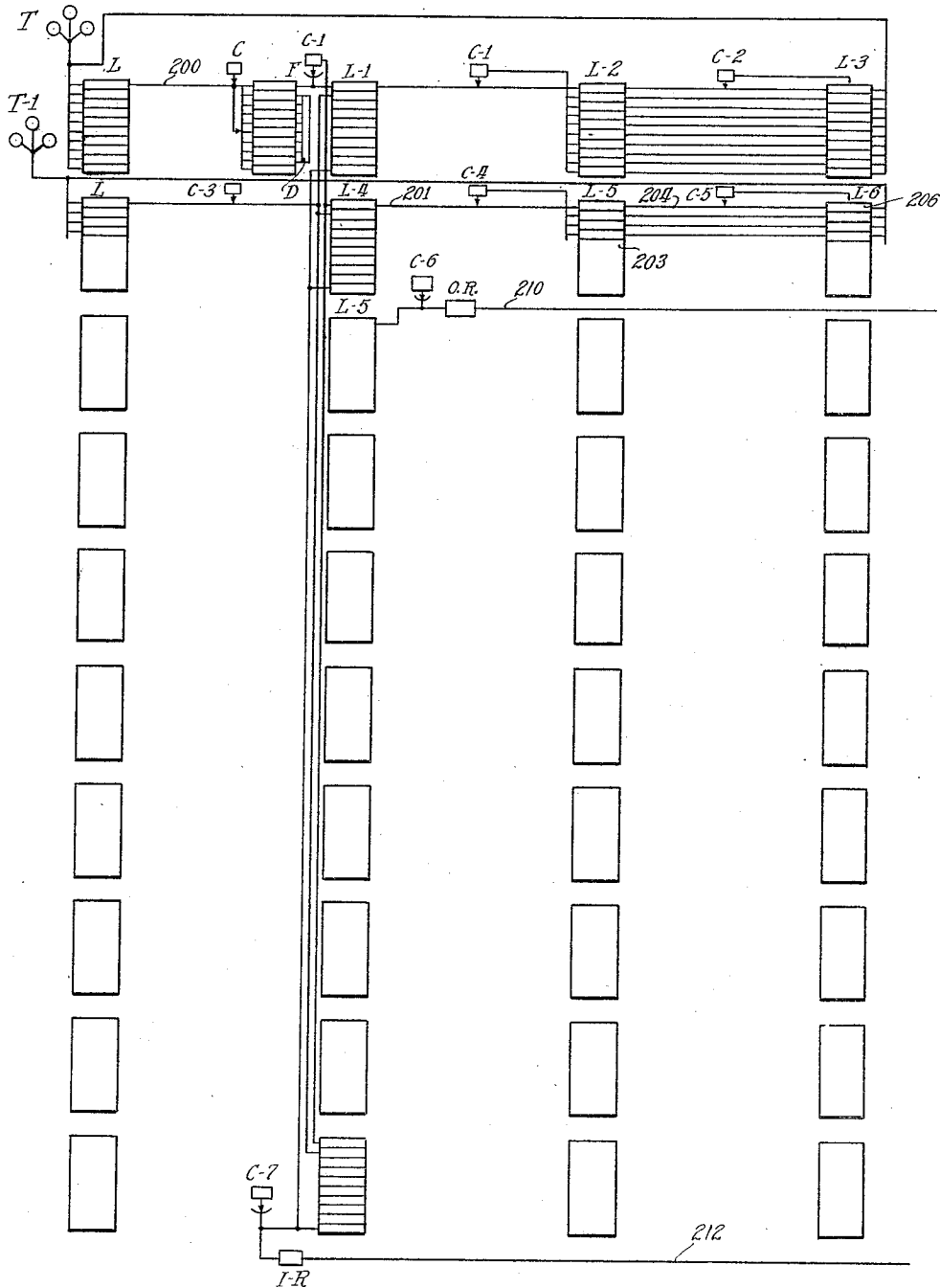
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AUTOMATIC TELEPHONE SYSTEM

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18 Sheets-Sheet 2



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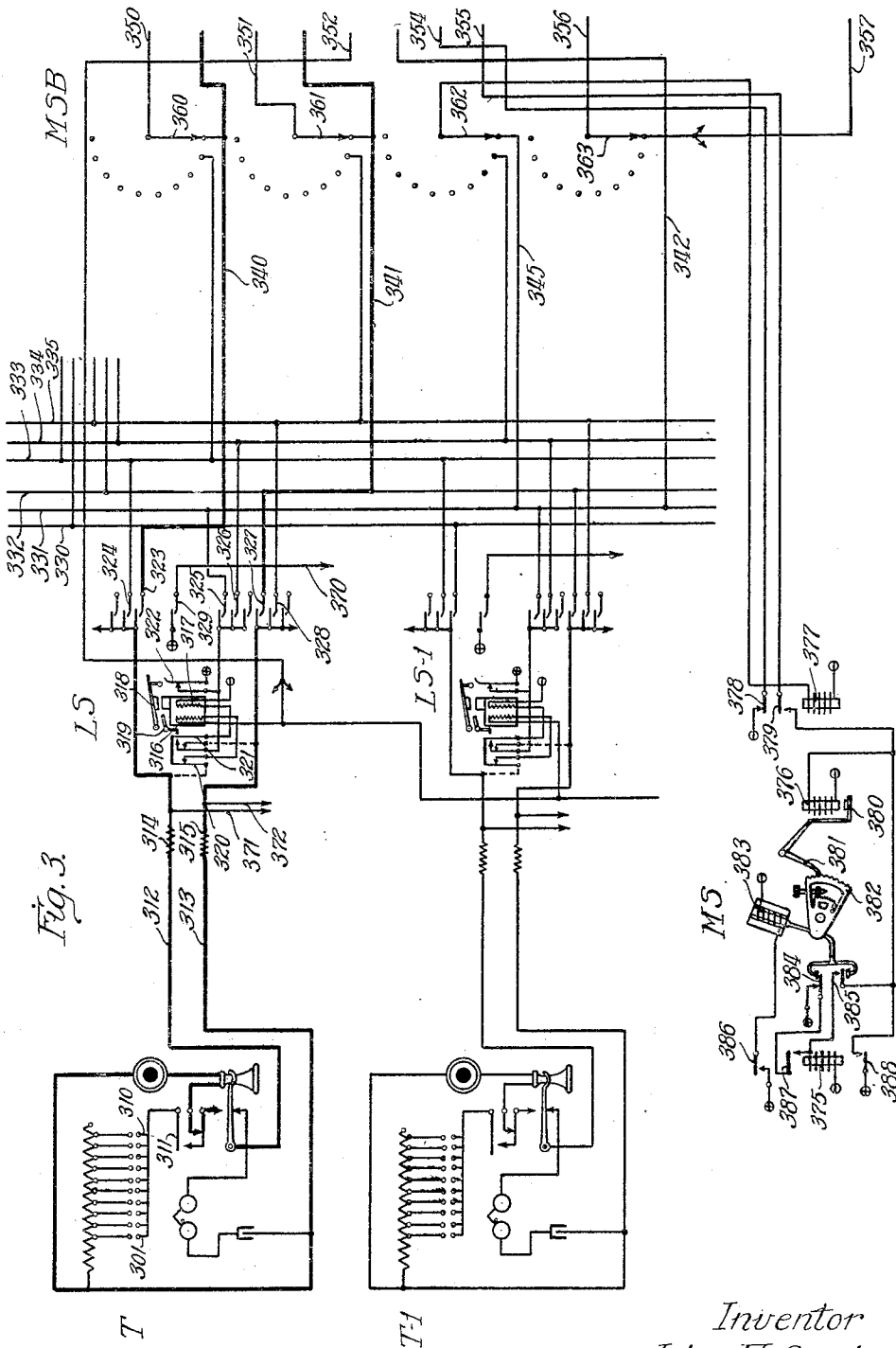
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18 Sheets-Sheet 3



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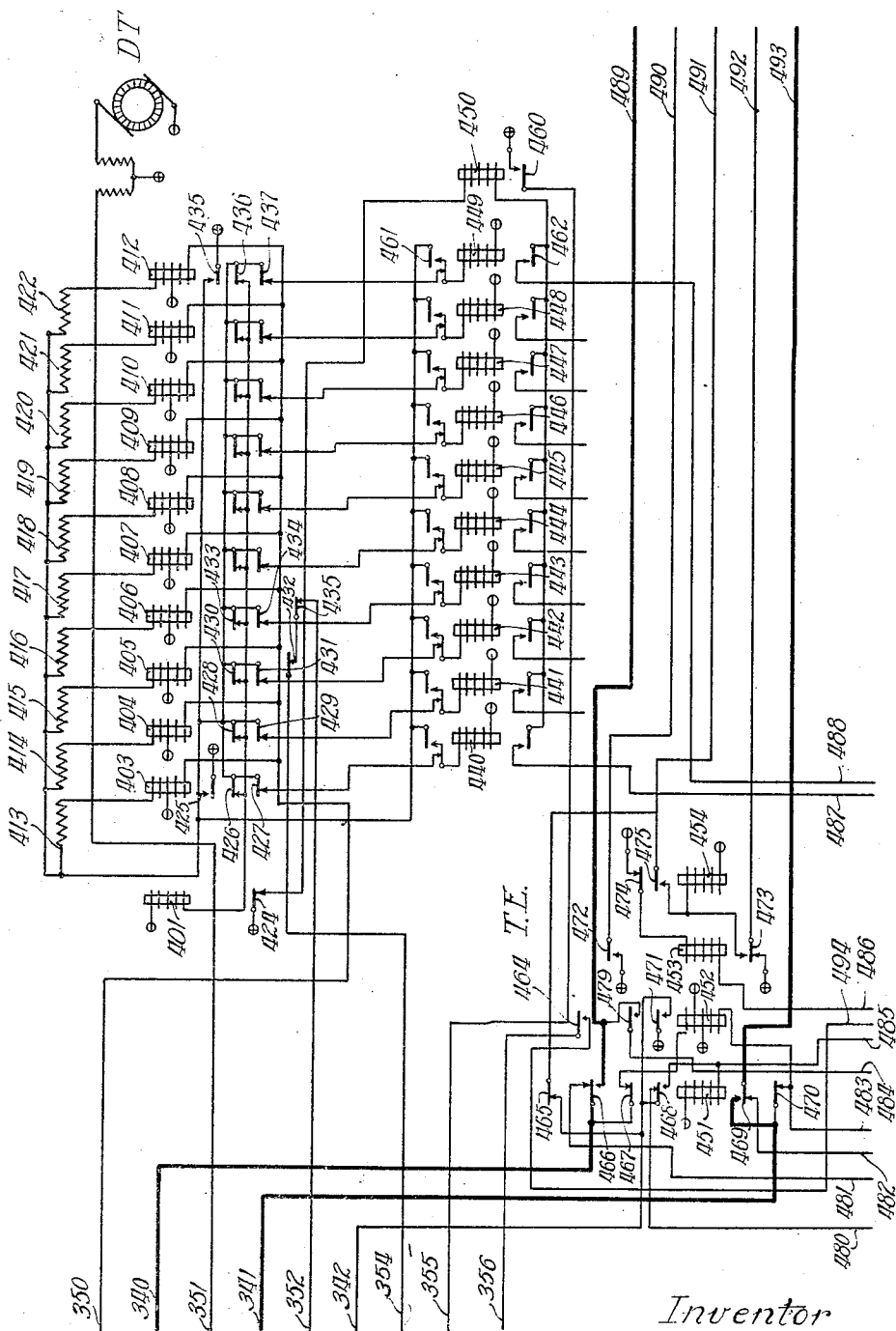
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AUTOMATIC TELEPHONE SYSTEM

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18 Sheets-Sheet 4

Fig. 4.



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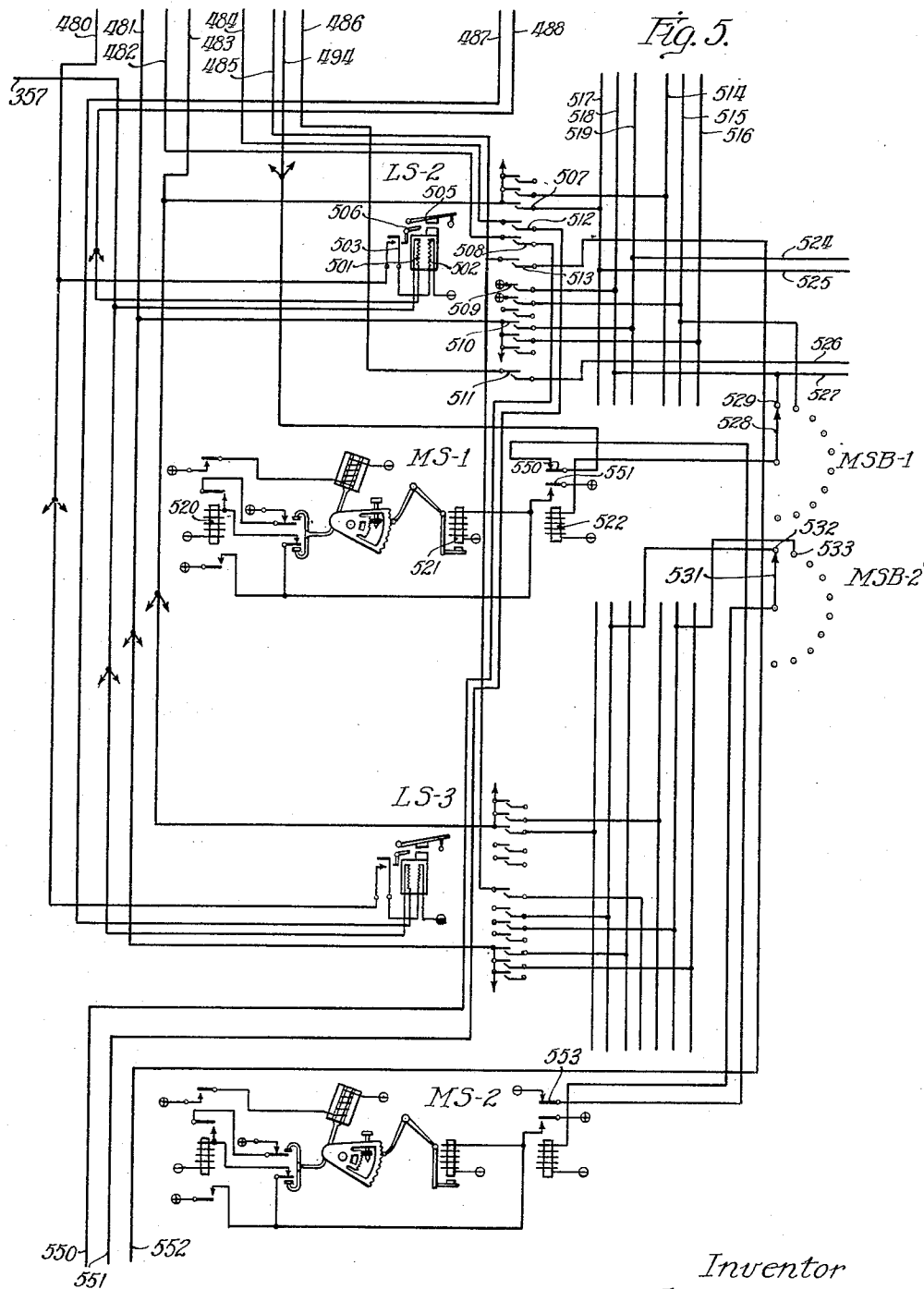
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18 Sheets-Sheet 5



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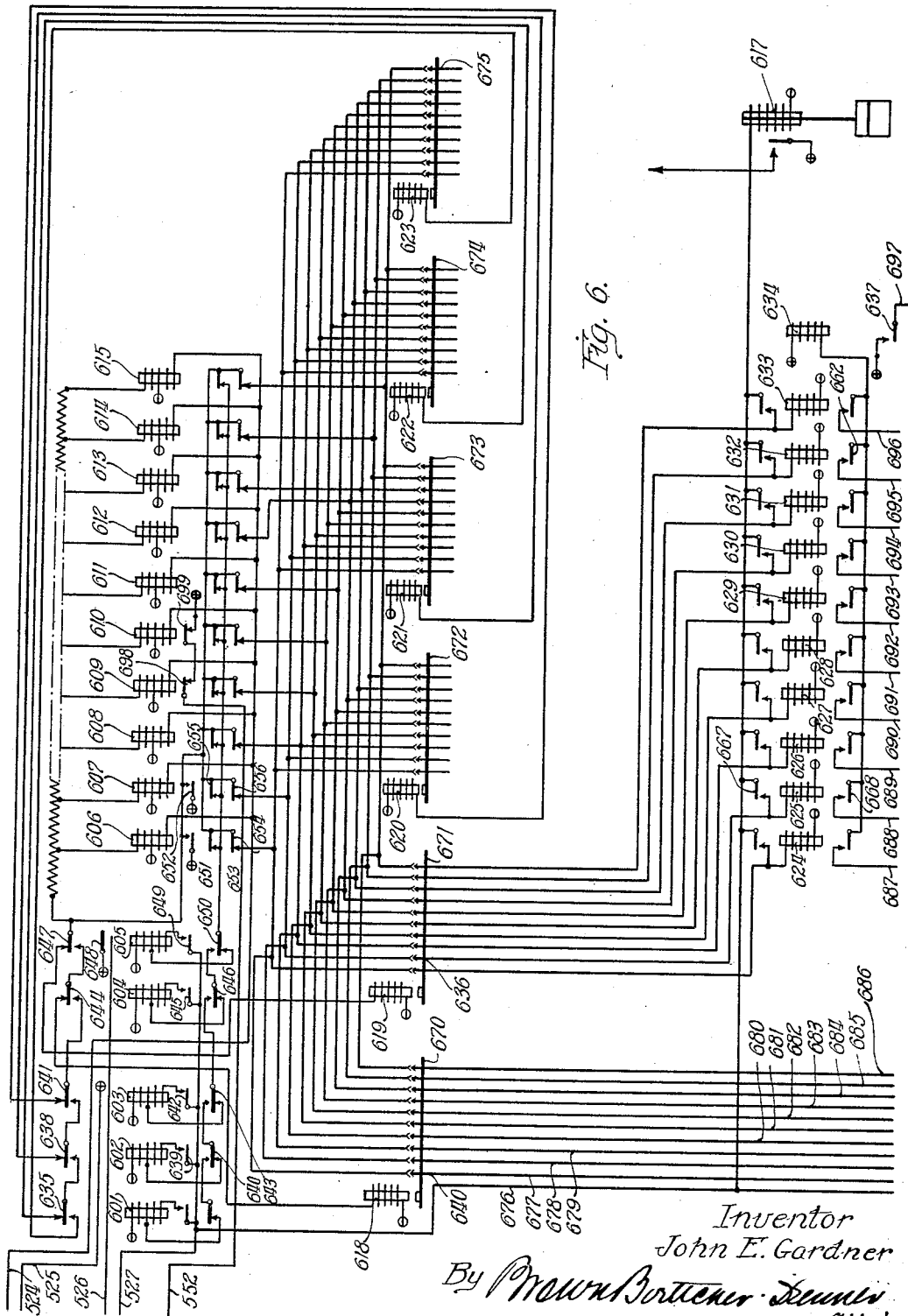
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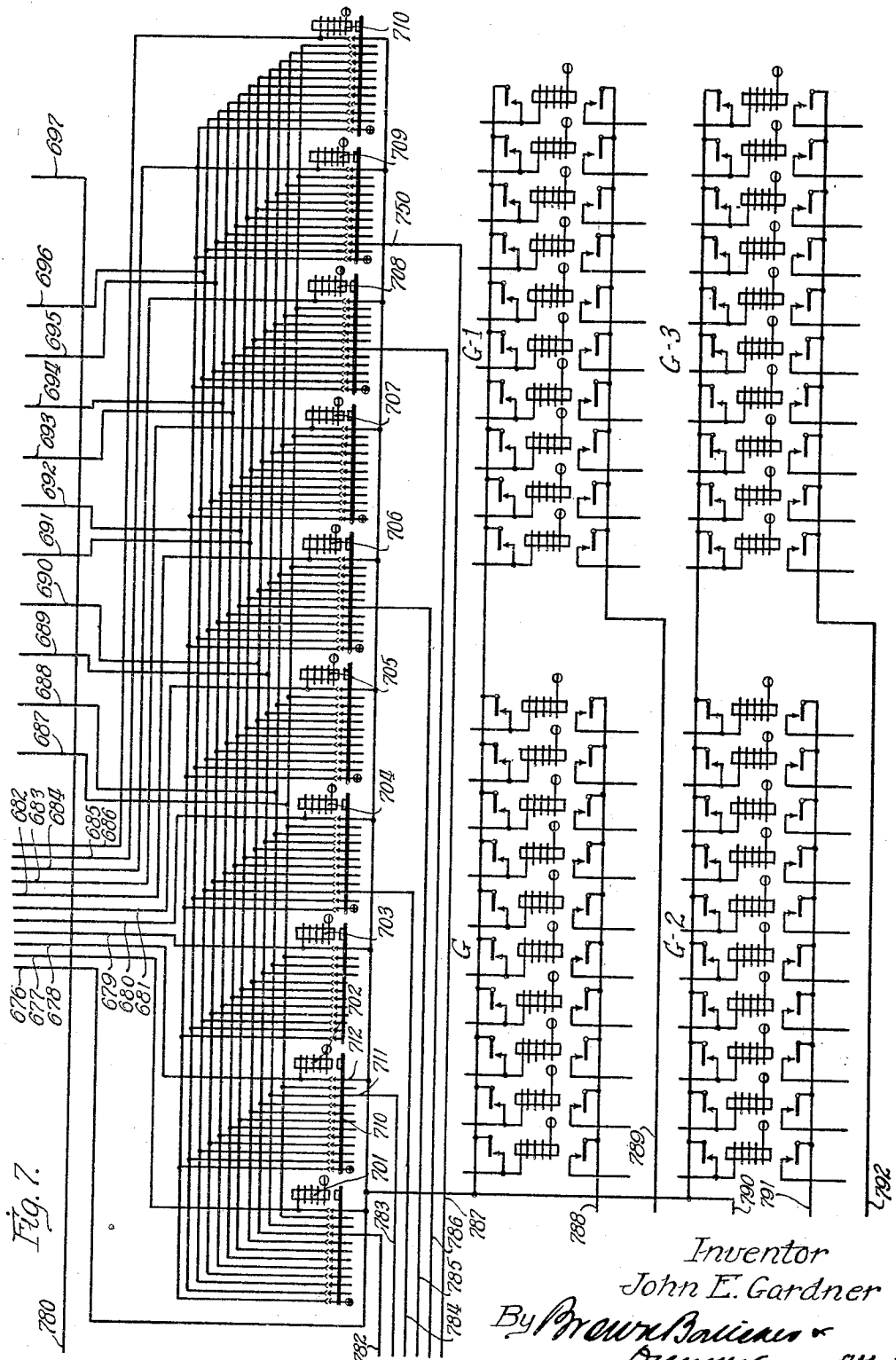
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AUTOMATIC TELEPHONE SYSTEM

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18 Sheets-Sheet 7



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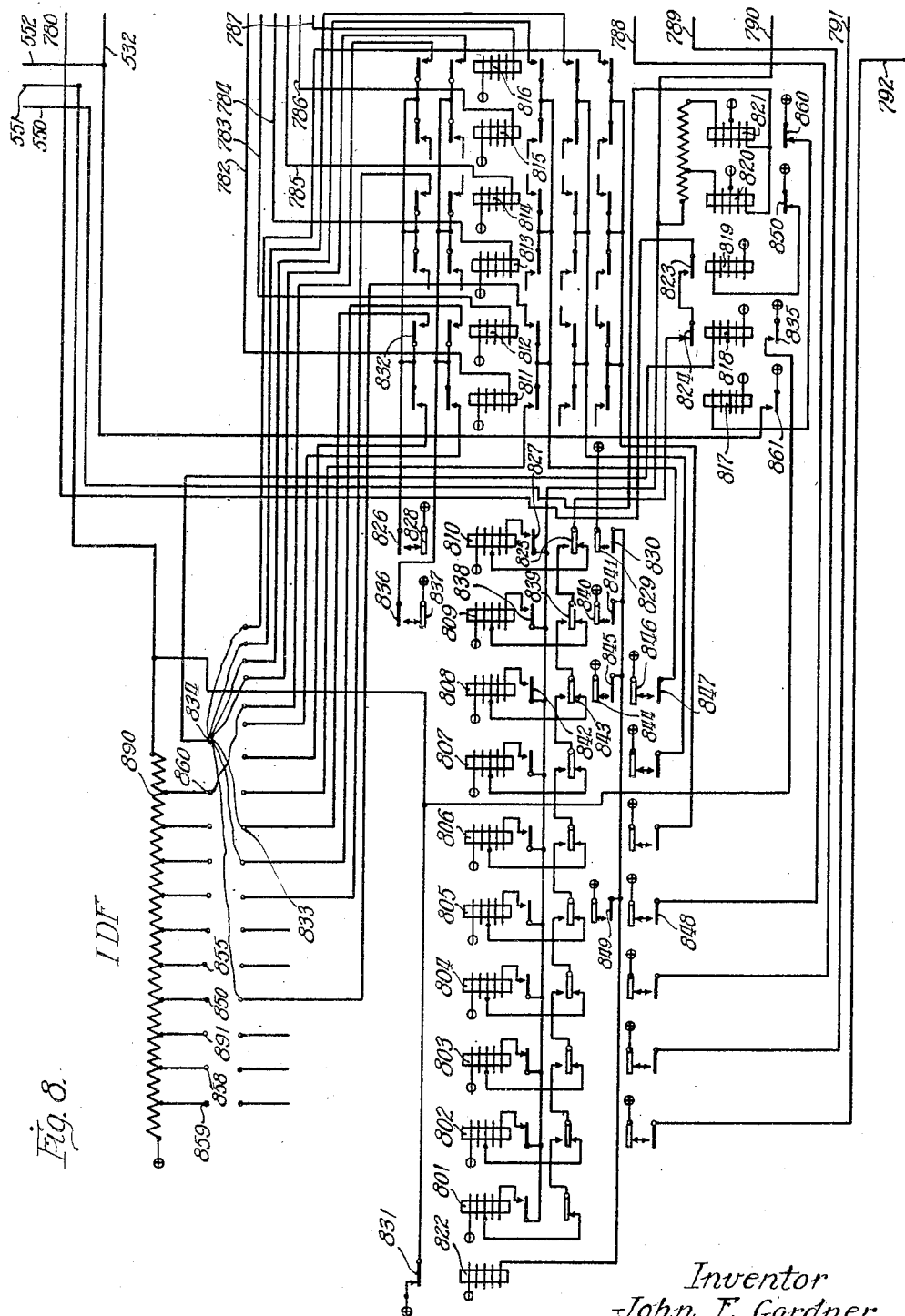
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AUTOMATIC TELEPHONE SYSTEM

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18 Sheets-Sheet 8



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AUTOMATIC TELEPHONE SYSTEM

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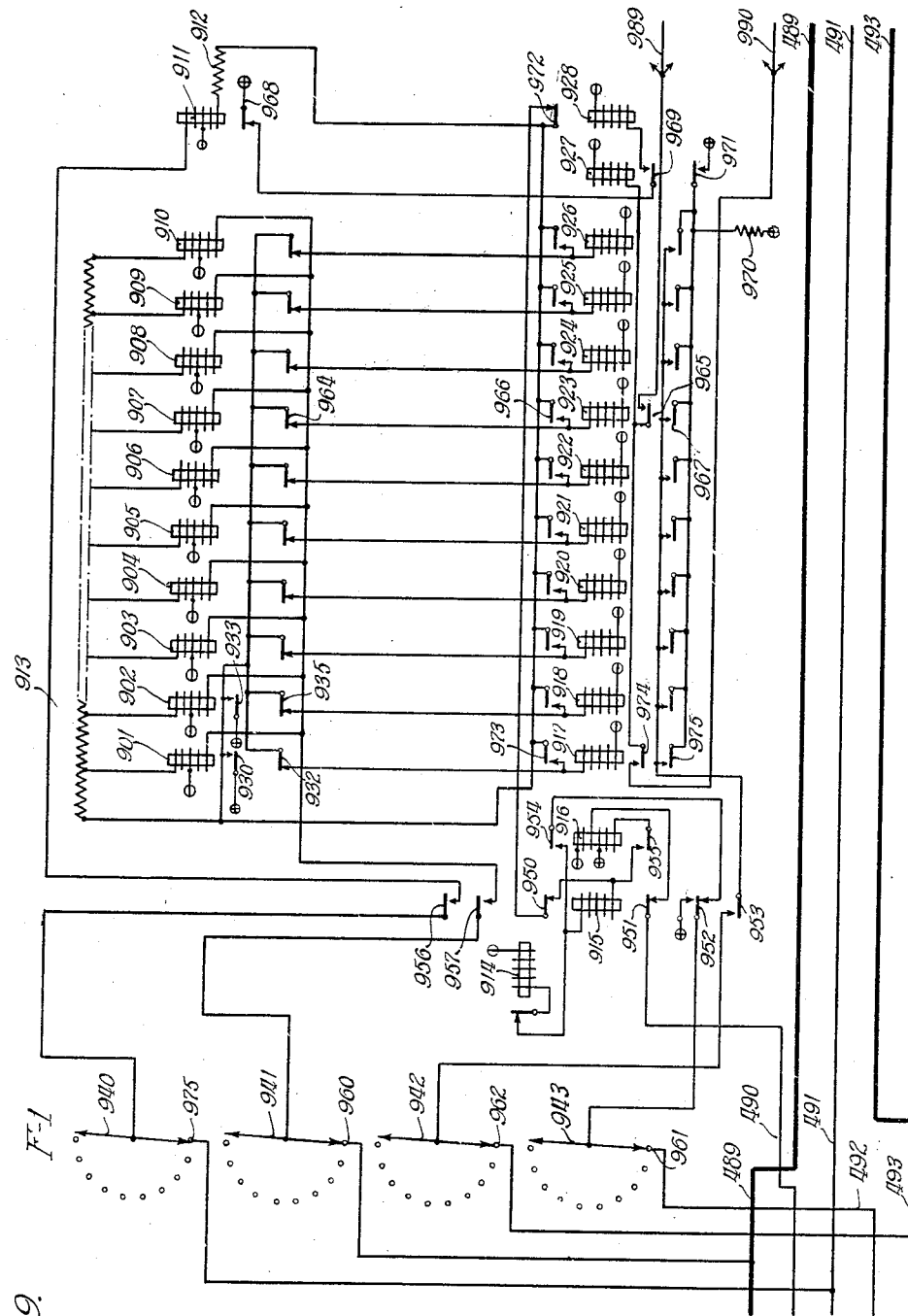


Fig. 9.

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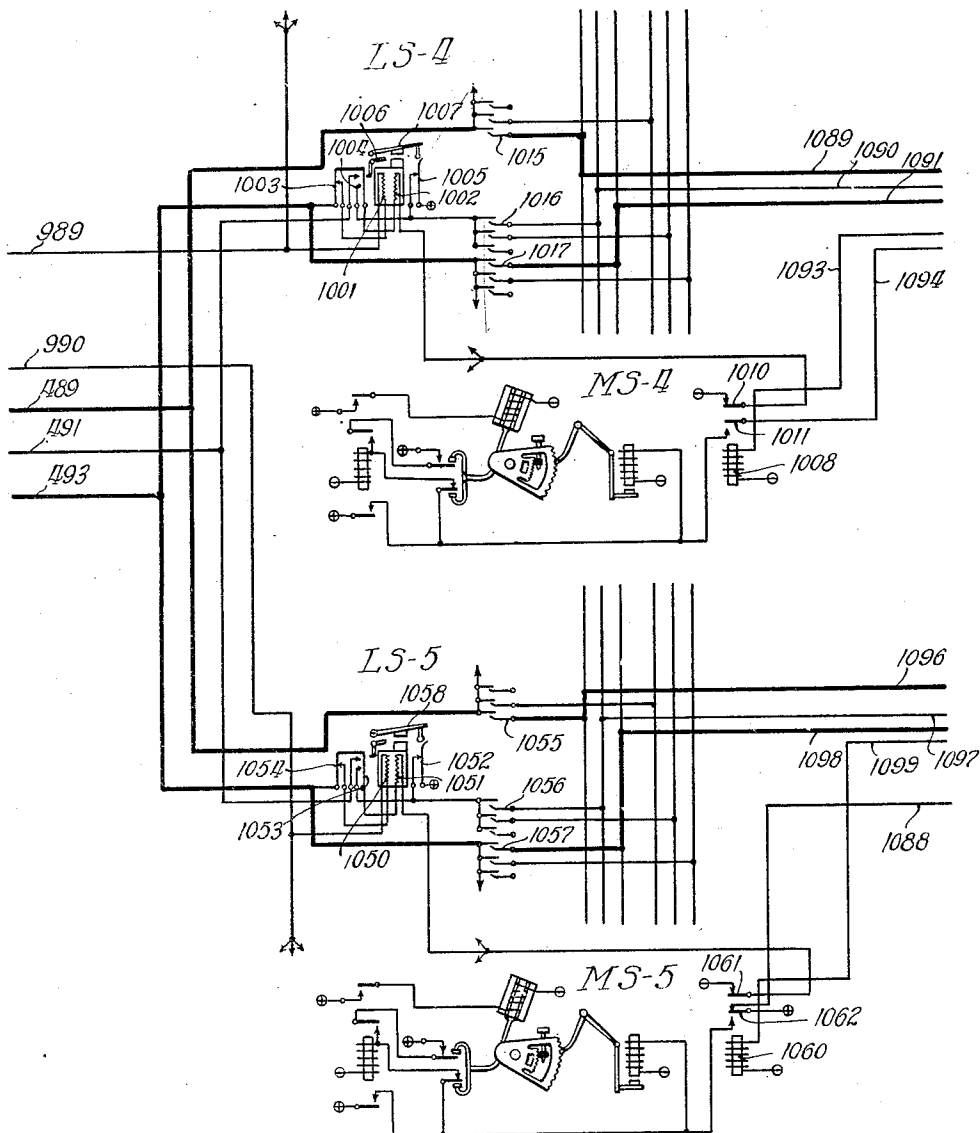
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Fig. 10.



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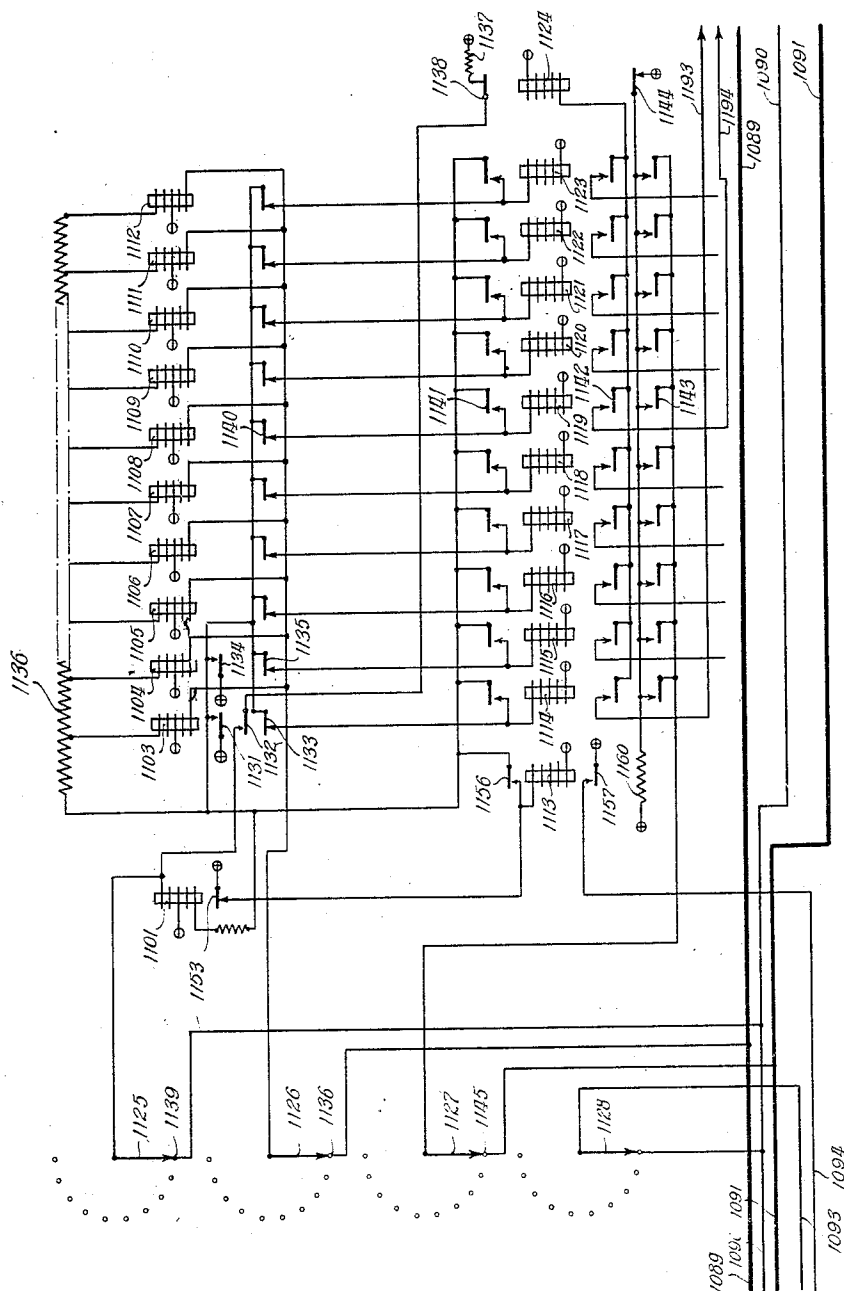
AUTOMATIC TELEPHONE SYSTEM

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Fig. 11.

M. S. B-1.



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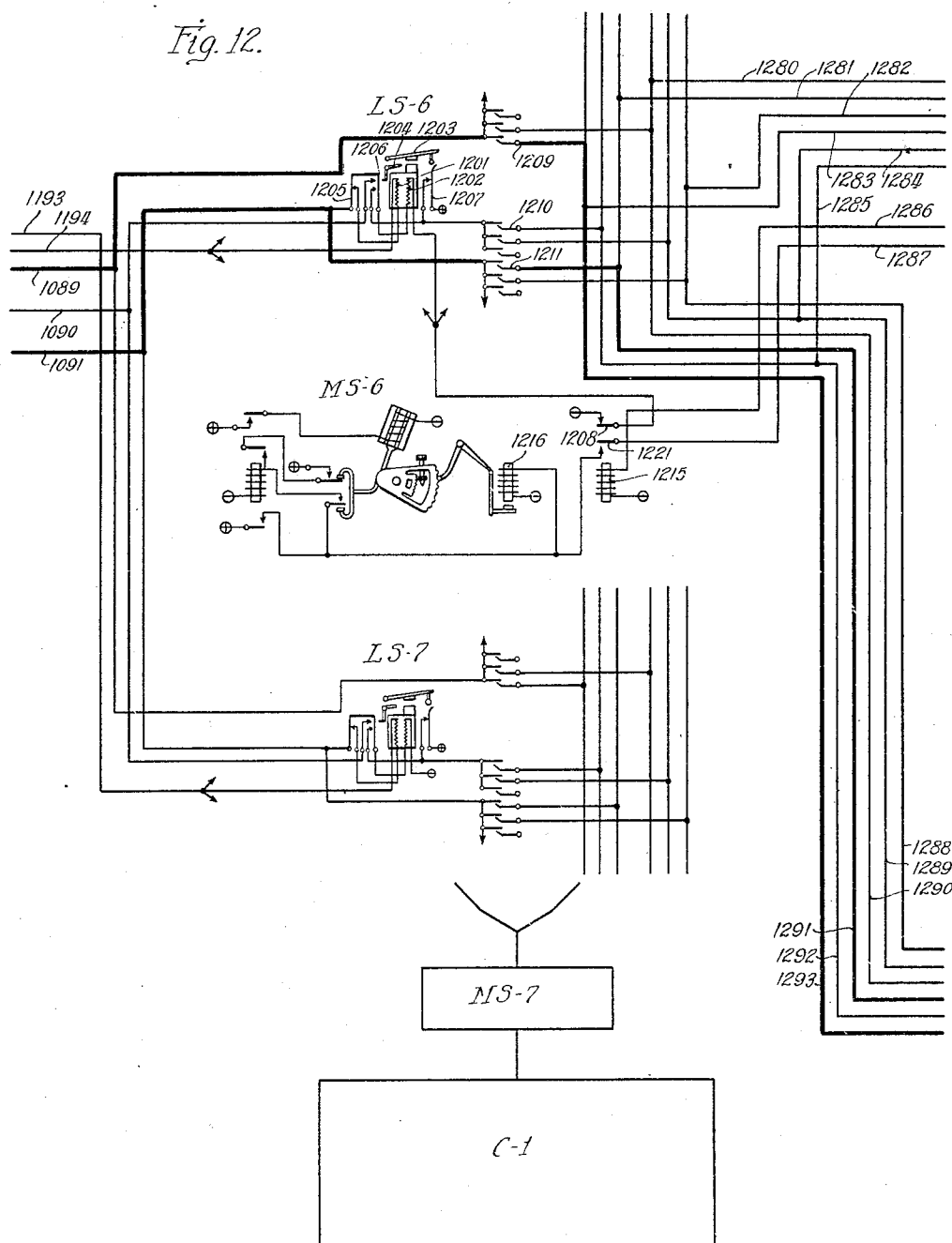
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AUTOMATIC TELEPHONE SYSTEM

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Fig. 12.



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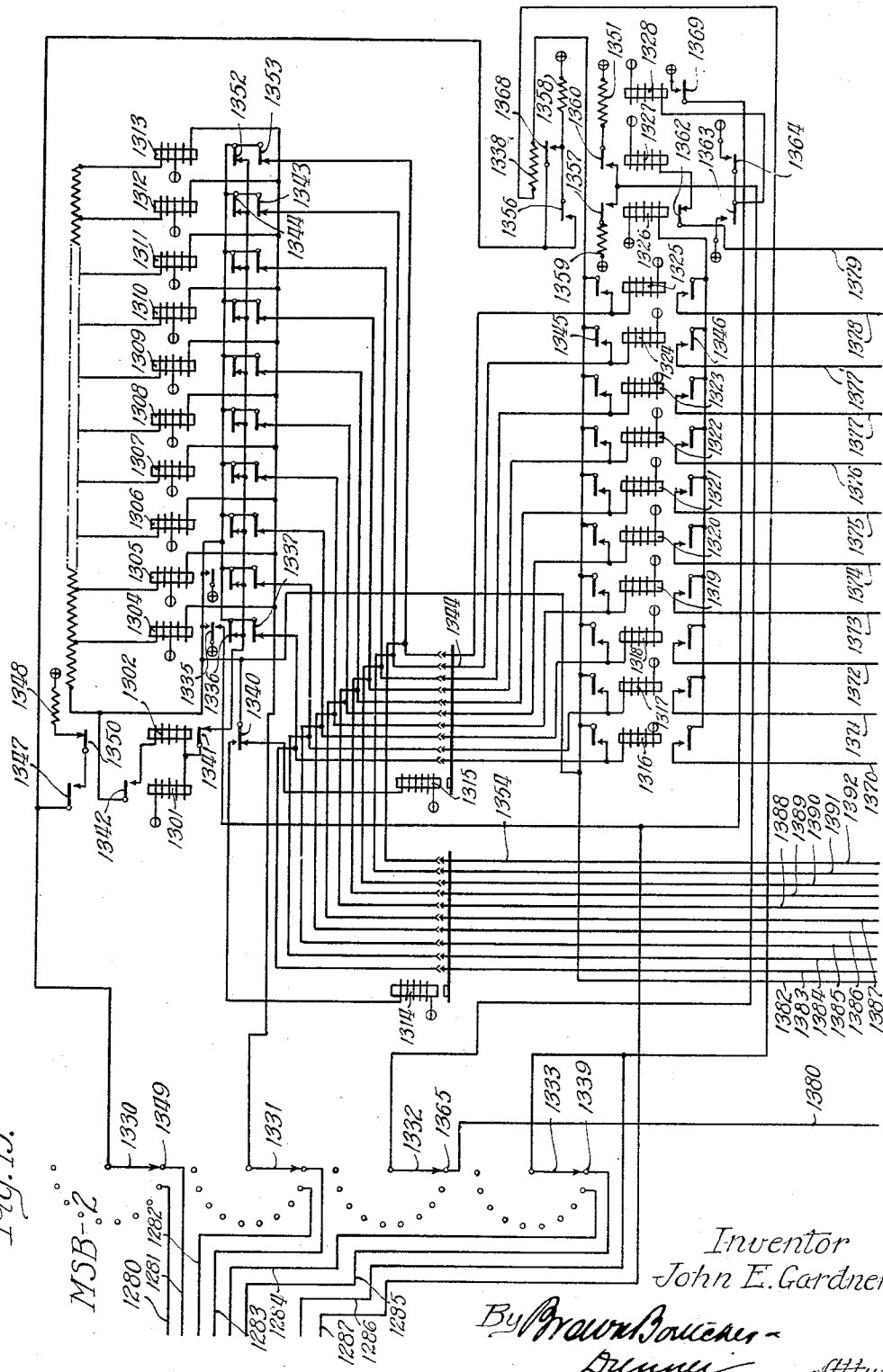
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AUTOMATIC TELEPHONE SYSTEM

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18 Sheets-Sheet 13

Fig. 13.



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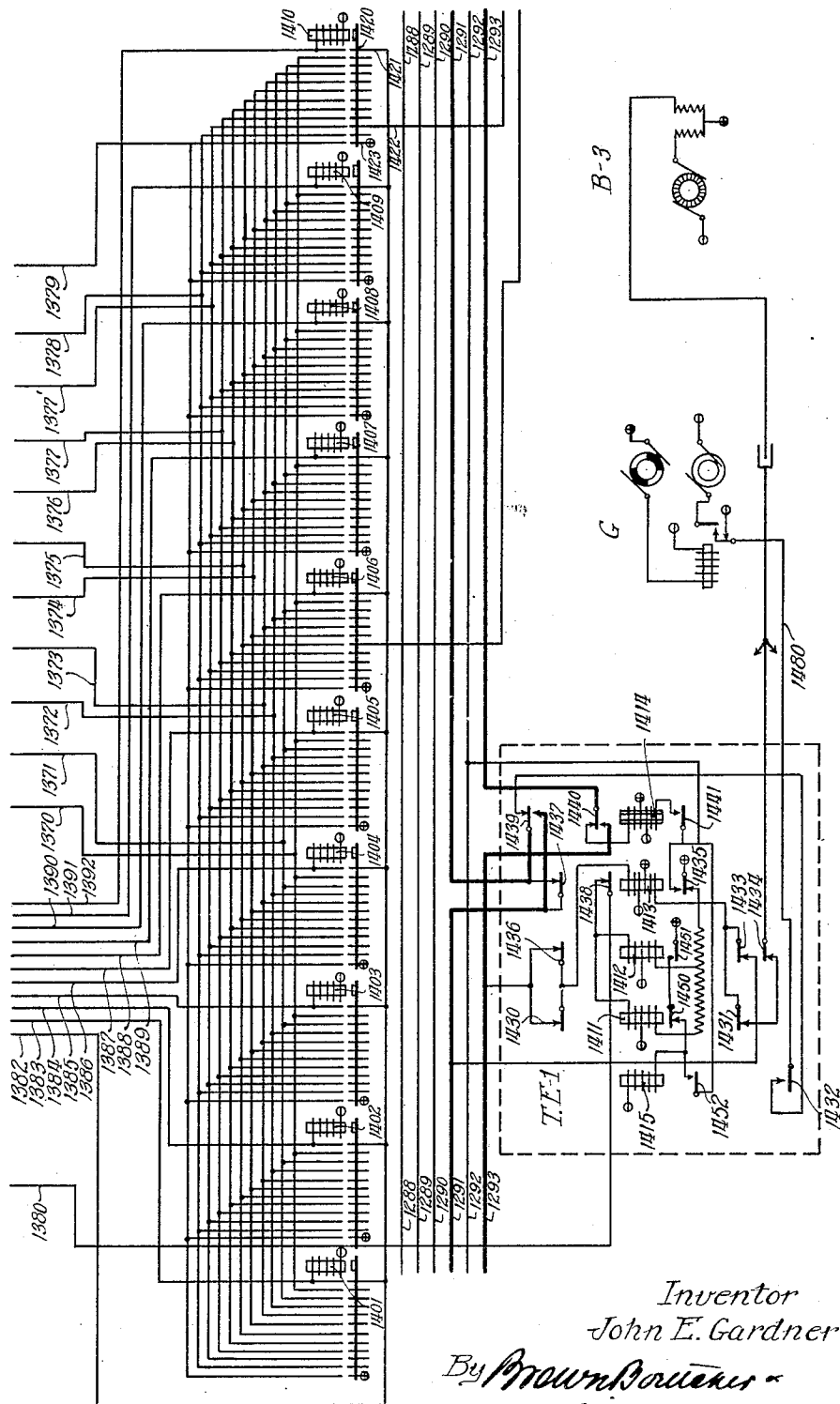
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Fig. 14.



Aug. 9, 1932.

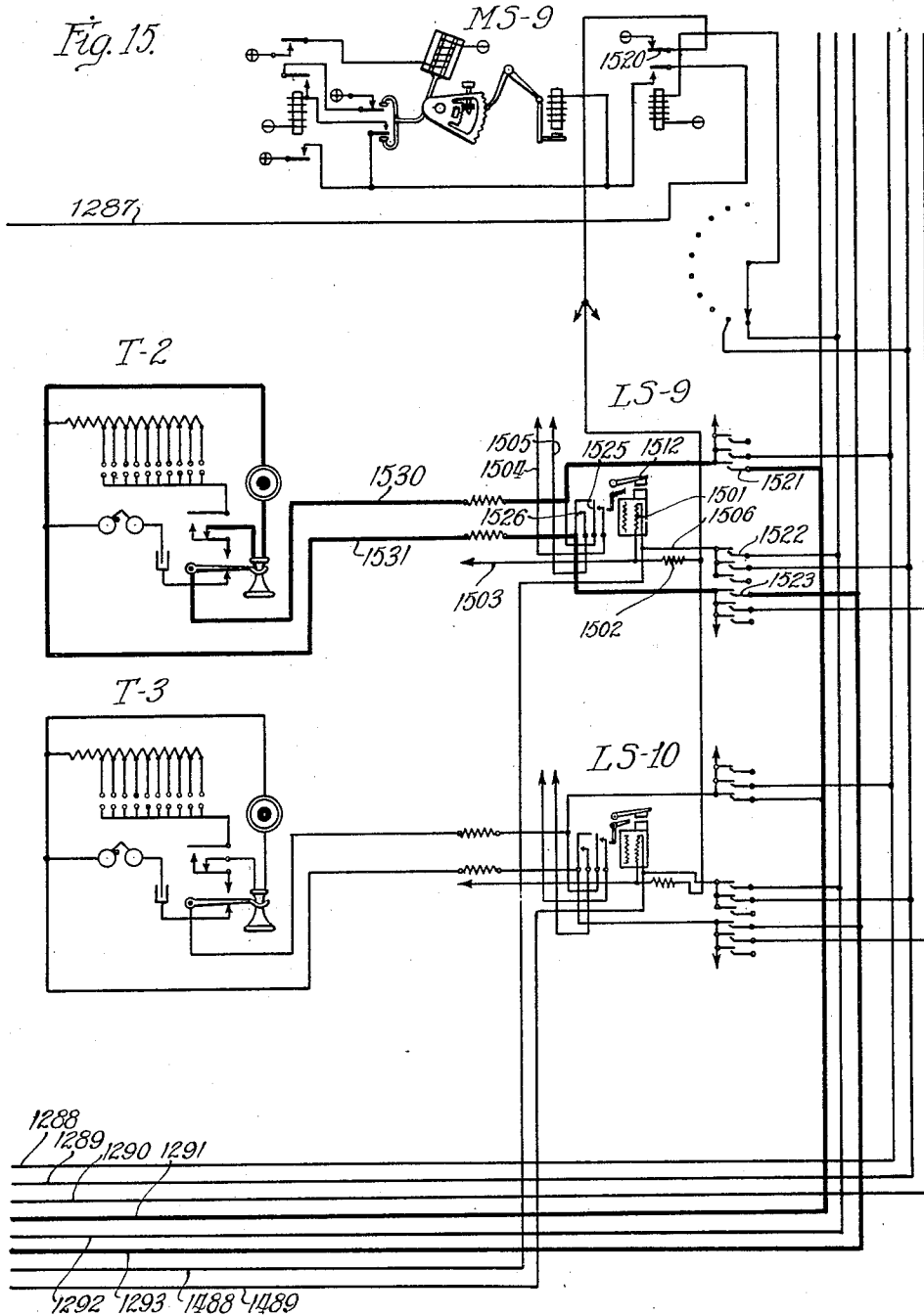
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AUTOMATIC TELEPHONE SYSTEM

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18 Sheets-Sheet 15



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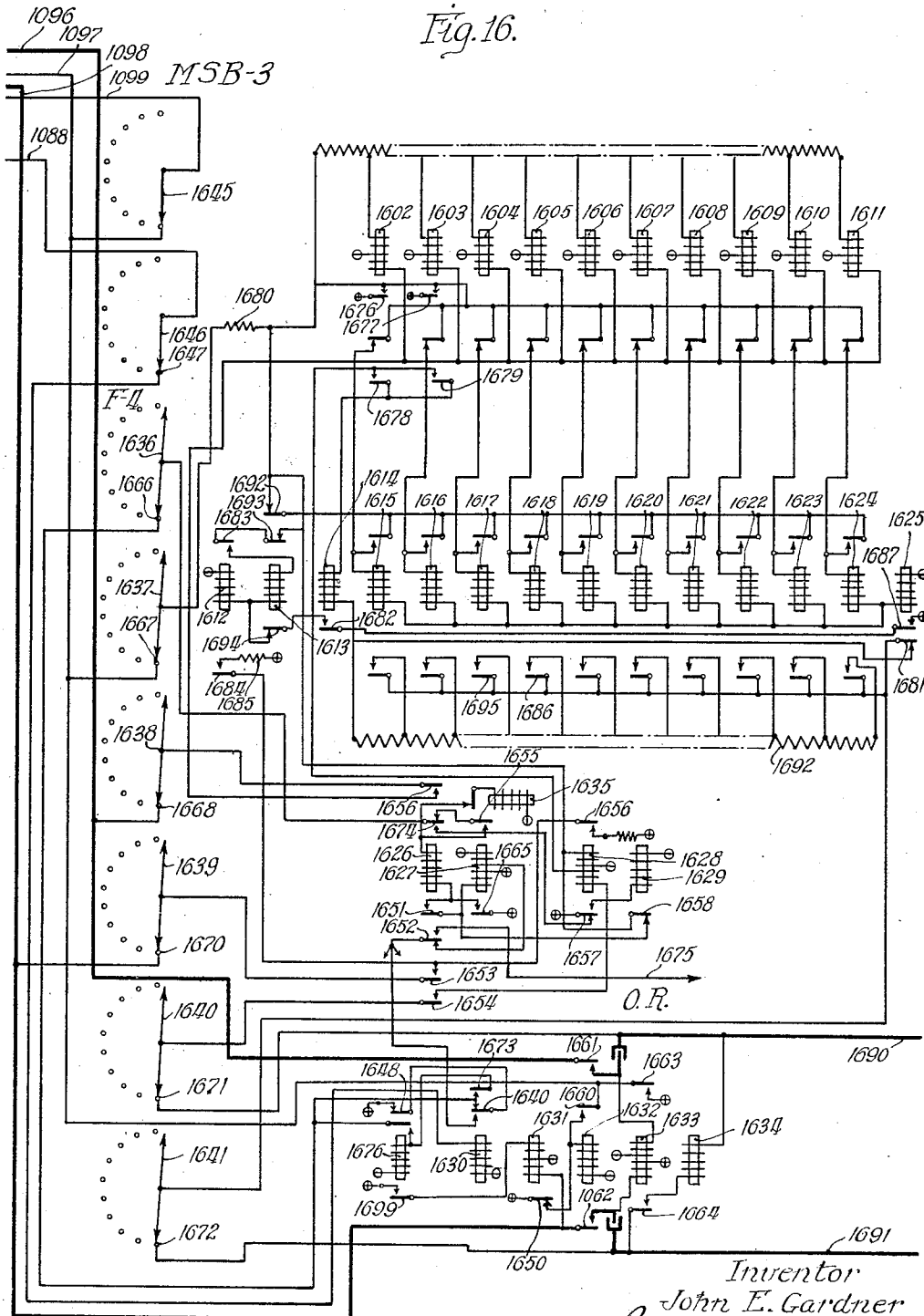
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18 Sheets-Sheet 16

Fig. 16.



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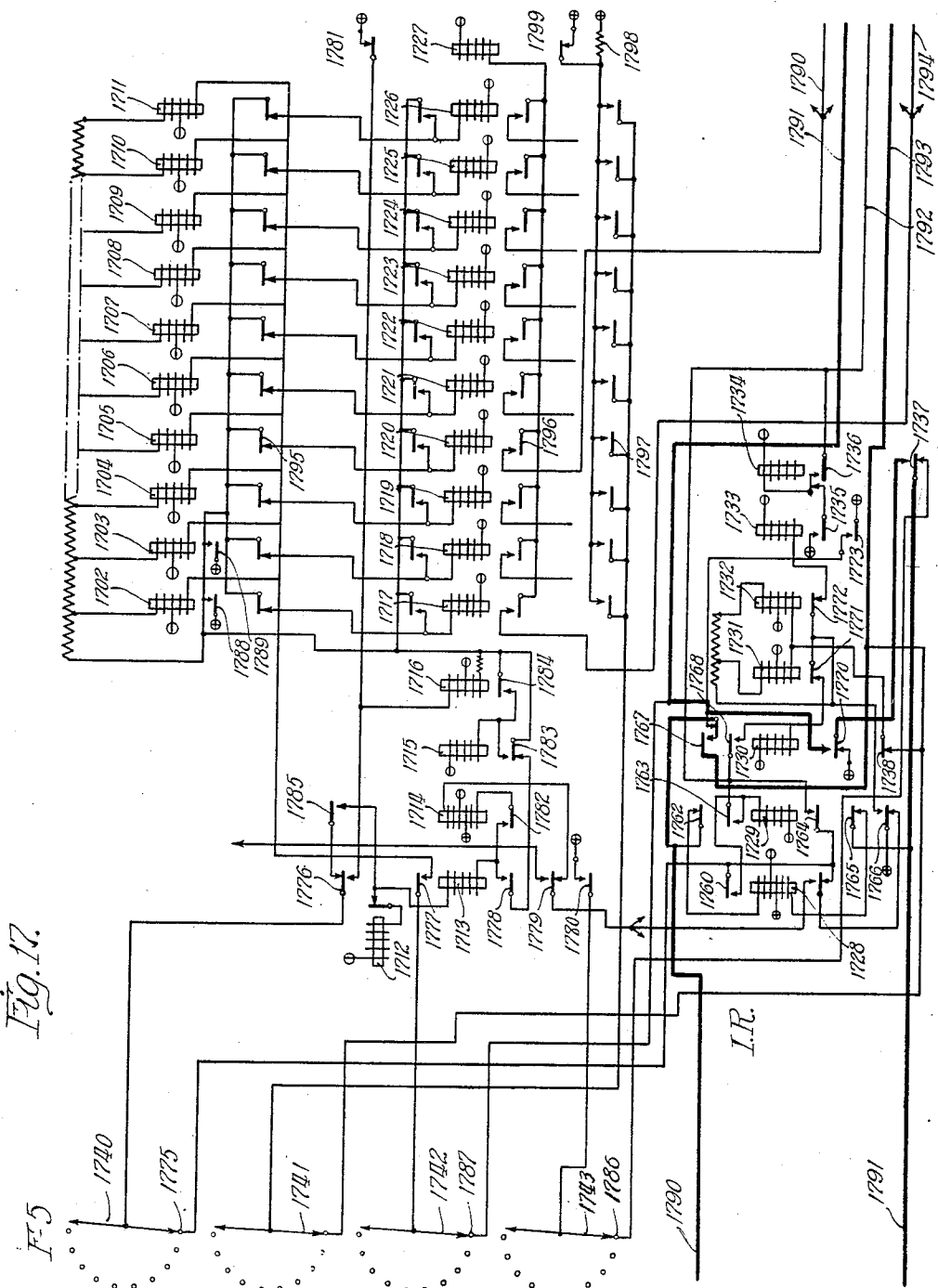
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18 Sheets-Sheet 17



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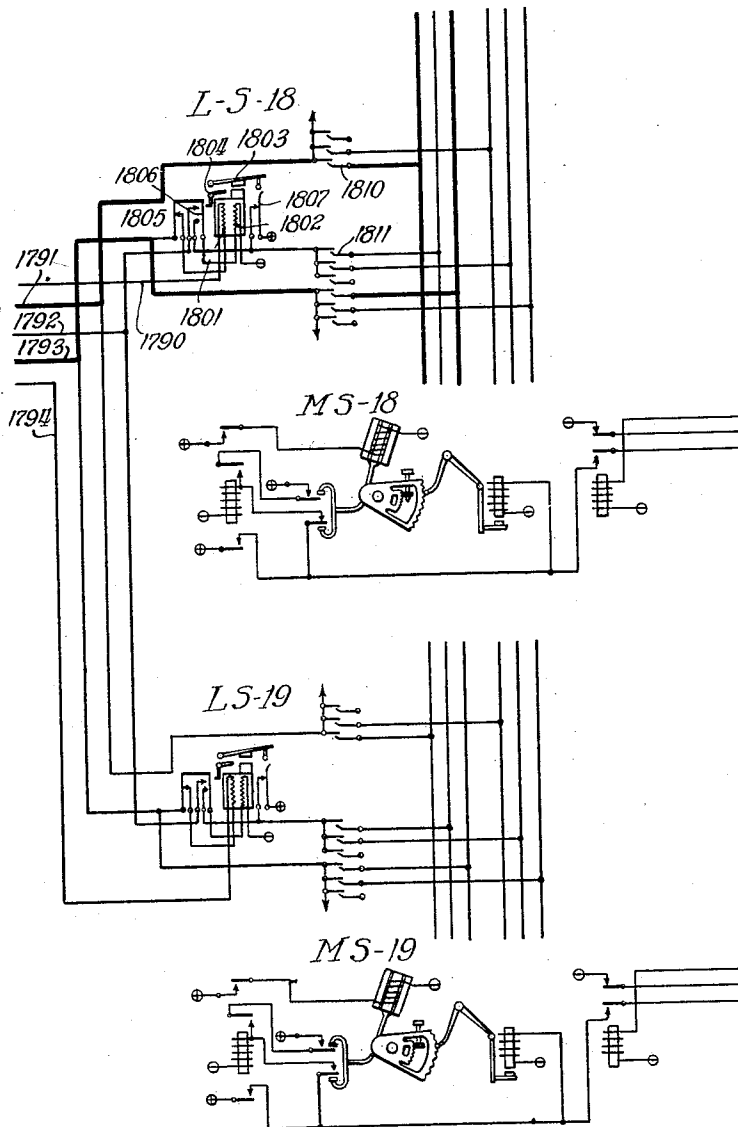
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Fig. 18.



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UNITED STATES PATENT OFFICE

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AUTOMATIC TELEPHONE SYSTEM

Application filed November 21, 1927, Serial No. 234,752. Renewed January 14, 1932.

The present invention relates in general to automatic telephone systems.

One of the objects of my invention is to provide a highly novel and efficient trunking system.

Another object is to entirely eliminate the trunk hunting time that is now required for the automatic selection of an idle trunk at the end of each digit or stage of directly controlled selection.

Another object is to pre-select idle trunks extending between the various numerical groups so that a call may be projected from a called line completely over pre-selected idle trunks.

Another object is to eliminate all the highly complex apparatus that has formerly been required to complete connections within an automatic exchange area comprising many offices and to make use of very simple equipment from a mechanical standpoint.

Another object is to use a single type of mechanism throughout the system for establishing connections between calling and called subscriber's telephone lines.

A further object is to provide a novel and highly efficient inter-office trunking system whereby connections may be completed between various offices in a multi-office area and between subscribers in the various exchanges by the use of a very small amount of equipment in a highly efficient manner.

A further object is to reduce the amount of equipment necessary to establish a connection between calling and called telephone lines to a minimum.

A further object is to render the more complex circuits and equipment common to a plurality of connections and associated with a call only during the period that the functioning of this more complex apparatus is necessary.

A further object is to simultaneously project a calling line over two paths, one of which might be termed a setting or selecting path and the other a talking path, releasing the setting path as soon as the talking path is established.

A further object is to provide selecting mechanism of the relay type in a highly effi-

cient combination to complete connections between calling and called lines.

A further object is to provide circuit and selecting mechanism whereby a connection may be completed between a calling and a called line substantially instantaneously.

A still further object is to provide improved translating and controlling mechanism whereby the foregoing results may be obtained in a highly complex metropolitan exchange area with an ultimate capacity for connections between any two of ten million lines.

Still another object is to provide improved apparatus and circuits so that the controlling mechanism thus mentioned may be properly directed from a telephone subscriber's substation.

There are other objects of my invention which, together with the foregoing will be described in the detailed specification which is to follow, taken in conjunction with the accompanying drawings.

Standard telephone practice of the present day as known to applicant divides the metropolitan area into a number of automatic exchanges, if an automatic system is installed, into ten thousand line offices. In large metropolitan areas the number of these exchanges approaches one hundred and in many instances go as high as several hundred. Of course, where there are several hundred exchanges, a considerable number of these will be smaller offices than ten thousand lines, being created as a result of the distribution of subscribers from economic studies to determine the best procedure. In other instances conditions of this nature are directly attributable to the manual telephone exchange system, which the automatic is to replace.

Wherever there are a large number of offices it is necessary in present practice to use the first three digits of the subscriber's number to locate or identify the office and to employ the remaining four digits to select the wanted subscriber's line in the office. It is theoretically possible, of course, to select as many as one hundred exchanges by two digits using the decimal system of numbering. Actually, however, the exigencies of the select-

ing apparatus cuts this down to 90. In addition it has become desirable to continue the manual practice of designating offices by names instead of numbers, it having been found that the subscribers can remember telephone numbers designated in this manner with a great deal more facility. In view of the foregoing it is entirely impossible to differentiate between the various exchanges of a metropolitan area until the third digit has been dialed or otherwise transmitted. Selections of this kind are usually handled by providing a storing device which is connected to the subscriber's line upon the initiation of a call and serves to register the digits of the wanted subscriber's number and then control the establishment of the connection.

This controlling device which goes under the name of director or translator or sender is used in all automatic metropolitan exchange areas.

Heretofore in the engineering of large multi-office areas and in designing an automatic telephone system to fit such an area, the problem has been considered as a whole. As a result of this conception sufficient selecting apparatus had to be provided for connecting any subscriber in the exchange area to any other subscriber in the exchange area; that is, this was the normal selecting route necessitating a certain number of stages of selection and each call had to go through the required number of stages. The translator, sender or director eliminated certain of these stages in certain special instances, such as local office calls through the number of stages of selection for connecting the subscribers together remained the same.

The present invention contemplates that all the selecting apparatus that is necessary and the number of selections necessary is determined by the size of the office or unit; that is, the only selecting apparatus that is necessary in any exchange is that which is required to connect any subscriber in that exchange to any other subscriber therein, in addition, of course, to being able to extend any subscriber's line in the exchange to inter-office trunks as will be explained. By this method of treatment each exchange is considered as a unit and the metropolitan exchange area is considered as an assembly of these units.

Now considering a single unit of ten thousand lines, sufficient apparatus is provided to complete a connection between any two of said lines. In addition, the selecting mechanism is capable of selecting the trunk lines that extend from it to certain other offices. The number of these inter-office trunks and the particular offices that are connected together by trunk lines depend upon the exigencies of traffic and the trunking efficiency and economy. That is to say, the inter-office trunking may be planned entirely independent of the local traffic in any office and in ac-

cordance with the best plan that may be arrived at based on traffic studies and geographical location so as to secure the maximum efficiency of inter-office trunking. The incoming trunks into any office come in on what might be termed first selectors, that is, they come in through the local trunking system in the same manner as a local call. Since they start at this point they may be handled identically the same as a local call. If the connection is to be tandemed through this office it is extended to another office in identically the same manner.

By this plan great economy is secured both in the amount of selecting apparatus required and in the number of inter-office trunks necessary. This result is obtained without sacrificing any of the features of the usual automatic metropolitan exchange system, in addition to providing many novel operating features.

Many attempts have been made heretofore to increase the speed of establishing a connection between a calling and a called line in automatic telephone systems. One of the limiting factors in former automatic telephone systems has been the speed at which impulses could be sent to directly control the central office switching equipment. Another limiting factor is the speed at which it is possible to operate and control the mechanical devices that are used to complete the selection at the central office. Another factor that limits the speed of establishing connection is the trunk hunting time required at the end of each directly controlled stage of selection.

One of the methods that has been employed heretofore to increase the speed of selection is to employ a relay selecting system. However, relay selecting systems are impractical except in exchanges of a small number of lines from 50 to 100 on account of the prohibitive cost. In addition, the controlling mechanism which controls the selecting mechanism from the subscriber's sub-station will not positively control the selecting apparatus at a speed greater than 20 impulses a second even though relay selecting apparatus is employed.

Other attempts have been made to pre-select trunks, but it has been found impractical to do this except in two or three places, namely, primary line switch pre-selection, secondary line switch pre-selection and in pre-selecting idle trunks between offices. This last effort involves considerable apparatus and can only be justified by a saving in the inter-office trunks.

The present invention employs the simplest kind of mechanical apparatus which is nothing more than relays and combines them in a highly novel trunking system so that all the trunks from the calling to the called lines are pre-selected and in order to make the se-

lection it is only necessary to operate a relay mechanism corresponding to an automatic switch at each stage of selection. In addition the controlling mechanism which brings about the proper direction of the call is common to a plurality of trunk lines and is used only at each stage of the call momentarily.

In all former automatic telephone systems the selection was set up by switching mechanisms which are usually identified by the name of selectors. Each of these selectors in response to its seizure and the dialing of a certain digit by the subscriber picked out a certain group of trunks and then proceeded to select an idle trunk in the group and extend the calling line to that trunk. Each selector thus has the power within itself to make a selection of any group out of a plurality and is a separate unitary device. The panel type of equipment manufactured by the Western Electric Company operates in comparatively the same manner with the exception that a larger number of groups are employed. The present invention contemplates the assemblage of a particular group which formerly made an element of a selecting device with all others of that group to form what might be termed a group selecting unit. Thus the connection to any device in this numerical group would have the same effect as the connection to any other device in that group. Working out a decimal basis, there would then be ten of these groups in the first stage of selection, 100 of these groups in the second stage of selections and 1,000 of these groups in the third stage of selection or ten thousand in the fourth stage.

While in the drawings I have shown my invention applied to a decimal system of selection it will be understood that any type of selection based upon any numerical system may be employed.

Referring now to the drawings comprising Figs. 1 to 18, inclusive, I have shown by means of the usual conventional diagrams sufficient apparatus and circuits to enable my invention to be readily explained and understood.

In the drawings:—

Fig. 1 is a view of a portion of the trunking system in a metropolitan area showing certain offices and inter-office trunks;

Fig. 2 is a trunking diagram of the trunking in a ten thousand line office representing also a group of outgoing trunks to another office and a group of incoming trunks;

Fig. 3 shows at the left of the sheet two subscriber's telephones T and T-1. These telephone sub-stations are of the usual type, each being provided with the usual transmitter, receiver and ringer. In addition each telephone is provided with a number of keys or push buttons. In a telephone system employing the decimal type of numbers, there are ten push buttons. These push buttons

are adapted to introduce a certain amount of resistance into the line circuit to change the conductance thereof when depressed. Each subscriber's line such as the one of the sub-station T comprises two conductors such as 312 and 313 and terminates at the central office in a line switch such as L. S.

The line switches such as L. S. are of the well known plunger type. Each line switch is provided with two armatures, a plunger armature 318 which controls the operation of the plunger arm and a line armature 319. The line armatures such as 319 are adapted to be operated when the line coil such as 316 is operated. The armature such as 318 is adapted to be operated by the plunger coil 317 and under these conditions the line armature 319 is also adapted to remain operated. In this plunger type of line switch ten trunk lines are multiplied before each switch in which they appear as bank contacts. The plunger arms of all idle line switches are maintained opposite an idle trunk line by a master switch (M. S.) of the usual type. The trunk line comprising conductors 330 and 332, inclusive, represents such a trunk line and is as shown appearing before the line switches L. S. and L. S. 1. A relay such as 452 is connected to each trunk line and is adapted to supply talking battery thereto. M. S. B. represents the bank contacts and associated wipers which are controlled by the movement of the master switch M. S. These bank contacts are thus common to one hundred subscriber's lines if a ten percent trunking system is employed. The controlling mechanism shown in Fig. 4 is common to each group of 100 lines and is adapted to be associated with the pre-selected idle trunks by the master switch wipers. This controlling mechanism comprises a group of identifying relays 403 to 412, inclusive, a group of selecting relays 440 to 450, inclusive, and controlling relays 451 to 454, inclusive. The identifying relays 403 to 412, inclusive, are differential relays that are under a graduated electrical balance. That is, the current flow in the upper windings of each of the differential relays is different from the current flow in any other of the differential relays. The lower windings of these differential relays are all connected to the line in multiple. Any single relay can be selected by operating the proper push button from a subscriber's station. These relays are usually wound with a twin winding, that is, the coils are wound at the same time, one wire of the upper winding of each coil parallel and adjacent the winding of the other coil. This construction provides a highly efficient differential relay and one in which it is very easy to secure proper neutralization with substantially no leakage in the magnetic field. These relays are preferably con-

constructed for the laminated core in order to reduce the residual magnetism and increase the speed of magnetization. The manner in which these relays are connected in the circuit and their operation has been more fully described in my co-pending application, Serial No. 211,101, filed August 6, 1927, Case 3. It will be understood that any of the instantaneous selecting circuits disclosed in that application may be employed in the present instance. In fact, it will become apparent that it is possible to use the usual impulse type of automatic telephone system with the improved talking system disclosed herein with tremendous advantages over systems that are now in use, though the present method of instantaneous selection is preferred and gives marked advantages over any other form of selection.

Each trunk line accessible to the line switches such as L. S. terminates in ten line switches such as L. S.—2 and L. S.—3 Fig. 5, each of these line switches being of the plunger type and being under the control of a separate master switch. Each of these ten line switches then has access to a different group of ten trunks. The ten line switches such as L. S.—2 and L. S.—3 make it possible to extend the trunk line to any one of ten different groups of trunks. This provides a method of selection whereby the trunk line that has been seized for call may be extended to any one of ten groups of directors, translators or senders for controlling the extension of the call.

One of these directors is shown in Figs. 6, 7 and 8. This director mechanism comprises a group of identifying relays 606 to 615, inclusive, control relays 634 and 617, and switch over control relays 601 to 605, inclusive. The identifying relays 606 to 615, inclusive, are similar to the identifying relays 403 to 412, inclusive. The switch over control relays 601 to 605, inclusive, are two-step relays and are adapted to control the operation of the various switch over relays 618 to 623, inclusive. The relays 624 to 633, inclusive, comprise the first group of registering relays. The relays 701 to 710, inclusive, comprise the second group of registering relays. The relays 624 to 633, inclusive, together with the relays 701 to 710, inclusive, gives the office selection. This is true because it requires one digit to select the particular group of directors, the second and third digits of the subscriber's number serving then to select the desired office. Substantially all the translation is thus affected in the first three stages where the office is selected. After the office has been selected four digits are required to select the desired line in substantially all instances. The relay group G comprises the third group of registering relays, relay group G—1 the fourth group, relay group G—2 the fifth group and the relay group G—3 the

sixth group. These relay groups are successively associated with the identifying relays 606 to 615, inclusive, by the operation of the switch over relay 618 to 623, inclusive. The relay groups 624 to 633, inclusive, and 701 to 710, inclusive, being associated with the identifying relay group by the operation of the switch over relays 618 and 619, respectively. The equipment shown in Fig. 8 comprises the translating equipment. The relays 801 to 810, inclusive, control the sending out of the controlling current for operating the succeeding apparatus to establish a connection. The relays 811 to 816, inclusive, being the exchange selecting relays and the relay 817 to 822, inclusive, being the control relays. The reference numerals I. D. F. designate an intermediate distributing frame which controls the translation proper, any combination of selections being formed by properly connecting the jumpers terminating in the armatures of the exchange selecting relays 811 to 816, inclusive, and proceeding to the I. D. F. The resistor 890 is used for controlling the succeeding selections, as will appear. The relays 801 to 810, inclusive, are also two step relays. These relays are so constructed that the armatures indicated by a rectangle are operated with both windings energized in series and the armatures indicated by lines are operated with only the upper winding energized.

The trunk lines accessible to the primary line switches such as L. S. and L. S.—1 also terminate in ten other line switches, such as L. S.—4 and L. S.—5, each controlled by a separate master switch, shown in Fig. 10. These trunk lines also terminate in the banks of a finder switch, shown in Fig. 9. The finder switch F.—1 is adapted to associate a controlling link comprising the identifying relays 901 to 910, inclusive, with the trunk lines. The relays 917 to 926, inclusive, are registering relays, the relays 911, 927 and 928 being control relays and the relays 915 and 916 being relays that control the operation of the motor magnet 914 governing the movement of the finder switch wipers 940 to 943, inclusive. This controlling link mechanism is adapted to operate one of the ten line switches, such as L. S.—4 and L. S.—5 in order to effect proper selection. The ten line switches such as L. S.—4 and L. S.—5 with the trunk lines accessible to the primary line switches of the subscribers terminate in what might be considered to be a first selector unit. Each of these line switches is controlled by a separate master switch. They are thus located in what might be termed different numerical groups. Since the master switches such as M. S.—4 and M. S.—5 operate to maintain the plungers of all idle line switches in that group associated with an idle trunk line the trunk lines are pre-selected. These line switches are of the type known as self-aligning, that is, they

are provided with mechanism which brings them into association with the master switch just as soon as released from a call. It will be seen that all that is necessary to project the call over the desired path is to plunge the proper one of ten line switches which it terminates in. Each one of the line switches such as L. S.—4 have access to ten trunk lines, each of which terminates in ten lines switches in ten different numerical groups, such as L. S.—6 and L. S.—7, shown in Fig. 12.

A controlling link is momentarily associated with the trunk line through the master switch bank M. S. B.—1 of each master switch, such as M. S.—4 or M. S.—5. This controlling link comprises the identifying relay 1103 to 1112, inclusive, the controlling relays 1101, 1113 and 1124, and the registering relays 1114 to 1123, inclusive. Thus this controlling link is substantially the same as the one heretofore described. This controlling link serves to bring about the operation of any one of the terminal line switches associated with the trunk line that has been seized. Line switches L. S.—6 and L. S.—7, Fig. 12 represent two of the trunk line switches that one of the trunk lines terminates in. The master switch M. S.—6 controls the positioning of the plunger arms of all idle line switches in the group in which line switch L. S.—6 is located with an idle trunk line. The master switch M. S.—7 is the same as the master switch M. S.—6 and performs a similar function. The controlling unit indicated at C—1 is similar to the controlling unit shown in Fig. 11 and serves to direct the call over one of the ten terminals that the trunk line accessible to the line switch L. S.—7 terminates in.

The controlling link shown in Figs. 13 and 14 is adapted to be associated with an idle trunk by the operation of the master switch wipers and bank contacts shown at M. S. B.—2. This controlling link is capable of selecting any one of the hundred called subscriber's lines, since this is the third and fourth stages of selection. The identifying relays 1304 to 1313, inclusive, are of the same type as before. The relays 1301 and 1302 are controlling relays. The relays 1314 and 1315 are switch over relays to associate the first group of registering relays 1316 to 1325, inclusive, with the identifying relays and the second group of registering relays 1401 to 1410, inclusive, with the identifying relays. The relays 1326, 1327 and 1328 are controlling relays. The registering relays 1316 to 1325, inclusive and 1401 to 1410, inclusive, comprise sufficient selecting apparatus to make one hundred selections.

The trunk lines accessible to the line switches such as L. S.—6 terminate before a group of one hundred line switches, represented by the line switches L. S.—9 and L. S.—10, Fig. 15. That is, these trunk lines

are also accessible to the line switches L. S.—9 and L. S.—10. These line switches are similar in type to those already described though their line windings are not connected so that the line switches such as L. S.—9 and L. S.—10 may not be operated from the telephone sub-station such as T—2 and T—3. The plungers of all idle line switches, such as L. S.—9 and L. S.—10 are maintained associated with an idle trunk line by master switches such as M. S.—9. The proper called subscriber's line switch is selected by the connector line controller shown in Figs. 13 and 14. The line switches L. S.—9 and L. S.—10 constitute the incoming terminals of the called subscriber's lines. Associated with each trunk line accessible to the incoming terminals of the called subscriber's lines is the trunk equipment comprising five relays 1411 to 1415, inclusive. These relays comprise the ringing and busy back equipment.

The foregoing apparatus represents the apparatus used on local connections in one ten thousand line exchange. The inter-office connections are handled over similar apparatus which is shown in Figs. 16, 17 and 18. The trunk lines accessible to the line switch L. S.—5, Fig. 10 extend by way of the outgoing repeater equipment O. R. by way of two trunk conductors such as 1635 and 1636 to the incoming repeater I. R. located in another exchange. While the line switch L. S.—5 is in the first stage of selection it is obvious that this trunk line might appear before line switch groups in the second stage of selection. The master switch bank M. S. B., Fig. 16 is operated by the master switch M. S.—5. The trunk lines accessible to the line switch L. S.—5 are also accessible to a finder switch such as F—4 which contains the controlling equipment for the outgoing repeater O. R. This controlling equipment comprises a group of identifying relays 1602 to 1611, inclusive, the registering relays 1615 to 1624, the controlling relays 1601, 1612, 1613, 1620 and 1625, 1628 and 1629 and the finder switch controlling relays 1626, and 1627. The finder switch F—4 is the usual type of rotary finder switch being provided with six wipers 1636 to 1641, inclusive, that are adapted to be advanced step by step by a stepping magnet such as 1635. The repeating equipment O. R. comprising the relays 1630 and 1634, inclusive, is provided for the purpose of having a two conductor trunk line between offices.

The incoming repeating equipment I. R. shown in Fig. 17 changes the control so as to properly operate the local switches. An incoming repeater controller is associated with the trunk lines incoming to the office by a finder switch comprising wipers 1740 to 1743, inclusive. This controlling equipment comprises identifying relays 1702 to 1711, inclusive, registering relays 1717 to 1726, inclusive, controlling relays 1701 to 1715, 1716 and 1727,

inclusive and the finder switch control relays 1713 and 1714. The finder switch wipers 1740 to 1743, inclusive, are adapted to be operated step by step by a motor or stepping magnet 1712.

The incoming trunk lines terminate in ten line switches such as L. S.—18 and L. S.—19 shown in Fig. 18, each under the control of a separate master switch. These incoming terminals in the office to which the call is repeated terminate in the same numerical multiple as the primary trunk lines in that exchange, so that the incoming call may now be treated exactly as a call originating in that particular office. The procedure is identically the same in the event that the call is again tandemed through this office.

Having generally described the apparatus and circuits shown in the drawings, I shall now explain the inter-office trunking system of a typical multi-office telephone exchange area with reference to Fig. 1. The drawing in Fig. 1 will serve to show the complexities that arise in most instances when an attempt is made to convert an old manual system into a modern automatic telephone system. It will be seen that a conflict occurs in the first digit between Ardmore and Armitage. However, the conflict is still present as between Armitage and Ardmore and is not cleared until the third digit is dialed. With respect to Albany, the conflict is only present to the second digit. To select the Kedzie exchange there is a conflict between Kedzie, Keystone and Kenilworth. This conflict necessitates the dialing of three digits in order to effect the office selection. Since these difficulties necessitate the storing of the first three digits in the translator or sender mechanism, it is possible to engineer the inter-office or an exchange area of this type on the most economical basis as found from traffic studies and the geographical locations of the various exchanges so that a minimum amount of trunk lines may be used to carry the load. Since in the present inter-office trunking system each exchange is considered as a unit the trunks may all be alike in that they will terminate at the first stage of selection in the exchanges to which they lead. This will be apparent by reference to Fig. 2 where the trunking in a local ten thousand line office is diagrammatically shown.

The equipment used for establishing connections between calling and called lines comprises non-numerical switches. In this instance the switches are shown as plunger type non-numerical switches sometimes called Keith switches. As is well known these switches have access to ten trunk lines and one hundred switches may be controlled from a single master switch which maintains the plunger arms of all idle line switches opposite a pre-selected idle trunk line. If the decimal system of numbering is

used in the present instance four stages of selection are necessary to select any one of ten thousand lines. In the improved trunking system disclosed herein these four stages consist each of ten thousand line switches. That is, there are four groups of ten thousand line switches each. Each subscriber's line terminates in an outgoing line switch and in an incoming line switch. The outgoing line switches are strictly non-numerical. One group of ten thousand line switches might be termed first selectors since they take the place of the usual first selectors, while the second group of line switches might be termed second selectors, since these ten thousand line switches take the place of second selectors. The incoming line switches associated with each subscriber's line might be termed the connector since they control the final stage of connection. Since Keith or plunger type non-numerical switches are used throughout all the trunk lines in the local office are pre-selected since this is an inherent function of the plunger type non-numerical switch. In order to provide numerical selection with nonnumerical switches each primary trunk line terminates in ten line switches, one switch being located in each thousand group; the first stage of selection comprising ten thousand line switches being divided into ten numerical groups of a thousand line switches each. Thus, in order to make a numerical selection it is only necessary to plunge the switch that is located in the desired numerical group. This operation can occur very rapidly since it is identical with the operation of an ordinary relay.

Each trunk line accessible to the first stage of selection terminates in ten line switches, each having access to a different numerical group. That is, the second stage of selection, which is made up with ten thousand line switches are divided into ten groups, each group being divided into ten parts, that is, by plunging one of the line switches associated with this second trunk line it is possible to make one hundred selections. The trunk lines accessible to the non-numerical switches in the second stage of selection extend and are accessible to the incoming line switches of the called line. That is, the ten trunk lines accessible to a group of one hundred line switches in the second stage of selection are accessible to one hundred subscribers' lines in that numerical group. By bringing any one of the non-numerical switches into association with that trunk a connection may be extended to the desired line.

In addition to the primary trunk line terminating in ten line switches for a numerical first stage of selection, it also terminates in ten line switches each in a different group which has access to what might be termed directors, translators or senders in order to

provide for the inter-office selection. That is, by operating one of these ten line switches the primary trunk is associated with an idle director in a particular group. The director is then operated to record, translate and control the establishment of the connection. This is true whether the connection be local or inter-office. The reason for this director selection is that the mechanism in the director for securing the translation can be greatly reduced in complexity by dividing the directors into groups and selecting a particular director.

An incoming trunk to the office, the trunking system of which is diagrammatically illustrated in Fig. 2 terminates in ten line switches, each in a different thousand group in the first stage of selection. However, these incoming trunks have no director selection since they are controlled by the director in the originating office. Thus, the incoming trunk lines have exactly the same facilities for connection in the office as a primary trunk accessible to the subscriber's line switches. The outgoing trunks from this particular office to any other office have been indicated as coming off or being accessible to one of the non-numerical switches in the first stages of selection. However, this trunk line might be accessible to some of the non-numerical switches in the second stage of selection. This depends entirely upon the exigency of the trunking equipment and the amount of apparatus available. That is, if there are a large number of trunks going to different offices from this office it will probably be advisable to make these trunks accessible to the non-numerical switches comprising the second stage of selection in order not to reduce the number of local selections that may be made. It is obvious, of course, that another stage of selection might equally well be included in this outgoing trunk so as to select any exchange in the system desired to which there are trunks going from this exchange.

Thus each incoming trunk line has the same trunking facilities as any local trunk line and thus the functions of the director are merely to extend the call to the desired office through as many other offices as may be necessary or desirable as provided by the trunking system which is controlled when determined by proper traffic study. By this method of handling inter-office calls the amount of apparatus required and the number of stages of selection is greatly reduced. In addition the trunking efficiency of the system is increased. Since non-numerical switches are used to effect the selection throughout and to make any selection it is only necessary to operate one of these switches the time increase for tandeming through various offices as dictated by the trunking system is negligible and may be ignored. Thus the trunk groups extend-

ing between various offices may be made any desired size as dictated by the trunking efficiency of the group as a whole. All this provides for a tremendous increase in the efficiency of the inter-office trunking system.

In order to explain the manner in which a connection may be projected from the calling subscriber's line T to the called subscriber's line T—1, it will be assumed that the calling subscriber T desires to connect his line with the subscriber indicated at T—1. By the removal of the receiver at the calling station the outgoing line switch L associated with the calling subscriber's line is operated to plunge in on a trunk line. The trunk line that this line switch plunges in on is, of course, idle since it has been pre-selected by the action of the master switch. The calling station is provided with ten push buttons which constitute the sending device. The calling subscriber operates the push button in accordance with the first digit of the called subscriber's number. This brings about the operation of the identifying circuit which has been associated with the preselected trunk by the master switch to plunge one of the ten line switches which the trunk line 200 terminates in so as to extend the trunk line 200 to a director switch D. This operation all occurs in response to pushing the first button at the calling station. The controlling device C is immediately released upon the call being extended to the director so as to be available for use of all other calling lines. The subscriber then goes ahead and presses six other push buttons in order to register the called subscriber's number upon the director. In accordance with the first two digits registered on the director selected and also the particular group of directors selected a particular exchange is identified. The director is then operated to cause the finder switch F. to associate the controlling link mechanism C—1 with the primary trunk line. Since it has been assumed that the subscriber at the substation T. desires to call the subscriber at the substation T—1 which is located in his own exchange and the call is already in this exchange the first three digits may be cancelled. This is accomplished in the director. By the identifying circuit employed, together with push button operation at the sub-station the selection occurs substantially instantaneously and the controlling mechanism C is immediately released upon the first digit being sent from the calling telephone. The controlling device C—1 is then operated from the director to cause the non-numerical switch associated with the trunk line 200 in the numerical group L—4 to operate. It will be assumed that the trunk line 201 is the one selected. The controlling link mechanism C—4 is associated with this trunk line and is operated in accordance with the next digit sent out from the director to

bring about the operation of the line switch in the numerical group 203 after which the controlling mechanism C—4 is immediately released and rendered available for other calls. The line switch in the group 203 operates to extend the connection to a trunk line such as 204, which has the controlling link mechanism C—5 associated with it. This controlling link mechanism is then operated from the director to register the last two digits of the called number whereupon the incoming terminal having a non-numerical switch in the group 206 is operated. This switch together with the other switches in the group having access to the ten trunk lines are maintained opposite an idle trunk line by the master switch. This idle trunk is the same idle trunk that the non-numerical switches of the group 203 are maintained associated with, so that when the incoming line switch in the group 206 is operated it is associated with the trunk line which has been seized in the group 203. The controlling mechanism C—5 is then released and available for other calls. Ringing equipment associated with the trunk line 204 is then operated to summon the called subscriber. Should the called subscriber's line be busy, a busy tone is given to the calling subscriber at the sub-station T and the controlling mechanism C—5 is released and rendered available for other calls.

It will be seen that each stage of selection requires only the plunging of a non-numerical switch. Since this non-numerical switch is always associated with an idle trunk line the only time required to make each selection is the time required to plunge one of the switches which is but a fraction of a second. The speed at which it is possible to establish the connection is determined by the rapidity with which the calling subscriber can operate the ten push buttons to designate the called subscriber's number. It will be seen that the controlling mechanism that controls the plunging of the proper switch on each stage of selection is only in use for a small fraction of a second and is then made available for use in extending other connections. That is, the projection of the call proceeds simultaneously over two paths, a setting path and a talking path; the setting path to each stage of selection being released immediately upon the completion of that stage of selection. This greatly reduces the amount of complicated apparatus necessary. It will now be assumed that the subscriber at the telephone sub-station T desires to call a subscriber whose line terminates in another exchange of the system. The procedure so far as the subscriber at sub-station T is concerned is identically the same as before, he removes his receiver and operates his push buttons in accordance with the digits constituting the called subscriber's number. The operation proceeds the same as before so far as the reg-

istering of the numbers on the selected director is concerned. The director then controls the establishment of the connection to the desired office. In order to describe this operation it will be assumed that the trunk line 210 extends to the proper office or to an intermediate office that has to be gone through in order to reach the desired exchange. The director that brings about the operation of the line switch in which the trunk line 200 terminates in the group 205. The controlling mechanism C 6 is associated with the trunk line 210, the trunk line 210 extends through an outgoing repeater O. R. which serves to reduce the trunk conductors in the trunk lines to 2 so that all inter-office trunks consist of two conductors. The controlling mechanism C 6 also assists in this transfer. The call comes in on the other exchange in a manner similar to the manner in which the trunk line 212 comes into the exchange shown in Fig. 2; that is, through an incoming repeater I. R. and the control mechanism C—7 which is associated with this trunk line. It will be seen that the trunk line 212 terminates in ten line switches and each line switch is located in one of the thousand numerical groups. The extension of the call then proceeds in identically the same manner as the establishment of a local connection. Since the incoming trunk lines terminate in non-numerical switches in the first stage of selection the call may be extended through as many offices in tandem as is necessitated by the design of the trunking system.

Since the calling sub-station is provided with push buttons instead of the usual type calling device the called number can be sent with many times the rapidity with which it can at present. Also since all automatic trunk selecting time is eliminated and since each stage of selection requires but a single operation connections may be established between calling and called lines with tremendous rapidity. This type of selection might be termed instantaneous.

It is recognized that there are certain possibilities for trouble in this type of trunking system, though it is not believed that they are at all serious. These possibilities of trouble arise from the fact that since the primary trunks such as 200 terminate in ten line switches, each line switch being controlled by a different master switch if the load should concentrate in one particular master switch group there would be a possibility of this master switch group becoming busy even though there were trunks available in other master switch groups leading to the same point. It is believed that this difficulty can be very readily taken care of by properly distributing the non-numerical switches which the primary trunks terminate in so that those lines or groups of lines in the primary line switch unit which have a tendency to call a

certain number will terminate in non-numerical switches in different groups. This possibility of trouble does not arise in the second and third stages of selection because of the distributing action of the first stage of selection. This difficulty is, of course, present in all automatic telephone systems and is cured to some extent by what is termed slip multiplying.

Having briefly described the apparatus and trunking systems employed in my invention both for inter-office and connections local to an exchange, I shall now explain in detail the manner of handling connections therein. For this purpose a local call within a single ten thousand line office will first be described. In order to do this, it will be assumed that the subscriber at the sub-station T, Fig. 3 desires to establish a connection with the subscriber at the telephone sub-station T—2, Fig. 15. In order to accomplish this result, the subscriber at sub-station T will remove his receiver and operate his calling device, which consists of ten push buttons in accordance with the digits constituting the called subscriber's number. If we assume that the line of the subscriber at sub-station T terminates in the Franklin exchange the subscriber at this sub-station will operate his push button in accordance with the letters F R A—and then the four digits of numerals such as 7690, for instance.

When the receiver is removed at sub-station A there is a circuit completed which extends from ground by of spring 322 and its resting contact, normally closed springs controlled by spring 321, resistor 313, line conductor 313, transmitter and receiver of sub-station T, normally closed springs controlled by spring 311, switch hook springs, line conductor 312, resistor 314, spring 320 and its resting contact, line winding 316 of the line switch L. S., common conductor 352, armature 432 and its back contact, armature 435 and its back contact, conductor 354 and armature 378 and its back contact to battery. The common conductor 352 corresponds with the usual open main conductor and serves to prevent any other line switch being operated when one line switch such as L. S. is operated. The operation of these other line switches is prevented until the subscriber at substation T operates one of his push buttons. He does this in response to the dial tone which is given him immediately upon removal of the receiver as will be described.

The winding 316 of the line switch L. S. is operated over a previously traced circuit and serves to attract the armature 319. The operation of the armature 319 serves to bring about the operation of the springs 320 and 321. The operation of the spring 321 completes a circuit which extends from ground by way of spring 322 and its resting contact, working contact of spring 321 and said

spring, pull down winding 317 to battery. Pull down winding 317 is energized to attract the pull down armature 318. By the operation of the pull down armature 318 the springs 323, 325 and 327 are brought into engagement with their working contacts. This is true because the master switch M. S. serves to maintain the plungers of all idle line switches opposite an idle trunk line. By the operation of the springs 323, 325 and 327 the line of the subscriber of sub-station T is extended to the trunk conductors 330 and 332, which extend to the windings of the relay 371. The relay 452 is energized over the calling line loop and serves to connect ground to the release trunk conductor 342 at armature 471. By the connection of ground to the conductor 331 there is a circuit completed by way of spring 325 and its working contact, working contact of spring 321 and said springs and pull down winding 317 to battery.

The armature 319 is maintained operated by the armature 318 being attracted. The operation of the armature 319 also serves to disconnect the calling subscriber's line from the battery and ground connection in the line switch L. S. The operation of the armature 318 serves to open a point in the circuit of the pull down winding 317. However, if the relay 452 is energized at this time as a result of the extension of the calling line loop the winding 317 is maintained energized. The deenergization of the line winding 316 is without particular function at the present time.

It will be seen that resistances 314 and 315 are incorporated into the calling line loop. This is for the purpose of bringing the conductance of all the lines in the exchange to a predetermined standard. This may be accomplished by inserting resistances as indicated, or automatically as explained in my co-pending application, Serial No. 205,677, filed July 14, 1927, Case 2.

Since the trunk line comprising conductors 330 to 332, inclusive, has been preselected by the operation of the master switch M. S. the calling line loop extends over the conductors 340 and 341 to the link controlling mechanism by way of wipers on the master switch designated 360 and 361, conductors 350 and 351, respectively to ground through the secondary of the dial tone transformer and through the lower windings of the various identifying relays 403 to 412, inclusive, in multiple to battery.

Under these conditions all the identifying relays 403 to 412, inclusive, are operated. By the operation of the armatures 425 and 435 of the identifying relays ground is connected to the various resistors 413 to 423, inclusive. This latter operation completes the circuit for the upper windings of the various identifying relays. The values of the resistances 413 to 422, inclusive, are arranged so

that the amount of current flowing in the winding of each of these identifying relays is different and successively graduated or graded. For example, there might be 10 milliamperes of current flowing in the upper winding of the identifying relay 403, 20 milliamperes of current flowing in the upper winding of the identifying relay 404, the amount of current rising in steps of 10 milliamperes with each succeeding relay.

The push button calling device at the subscriber's station T consists of ten push buttons and is arranged to change the conductance of the loop circuit so that anyone of the differential relays may be balanced. That is, if the conductance of the calling line loop is changed so that there is a current flow of 20 milliamperes in the lower winding of the identifying relay 404 there will be the same current flow in the lower winding of all relays. In only the relay 404 will a neutralization occur; the armatures of all other relays will remain attracted, while the armature of the identifying relay 404 will be retracted. Under these conditions of operation, the polarity of the magnetic field changes, however, this change occurs under the influence of opposing magnetic fields created by the differential windings of the relays, depending upon which have the most current flowing through and occurs so rapidly that the armature of the relay is not affected.

The operation of the identifying circuit has been described more fully in my co-pending application, Serial No. 211,101, filed Aug. 6, 1927, Case 3.

It will be seen that when the calling subscriber's line is extended to the link controlling equipment comprising the identifying relays that dial tone from the dial tone machine D. T. is immediately given the calling subscriber in order to inform him that he should proceed with the sending of his number. The subscriber then operates his push button calling device in accordance with the first digit of the called subscriber's number, which in this instance is the letter F. By the operation of this push button at the calling station the conductance of the calling line loop is modified so that the current flow through the lower winding of the relay 412 is the same as the current flow through the upper winding of this relay. The relay 412 is deenergized. The identifying relays 403 to 411, inclusive, remain operated, however, since the current flow through their lower windings is different in all instances than the current flow through their upper windings. The deenergization of the identifying relay 412 serves to complete a circuit which extends from ground by way of armature 425 and its front contact, armature 436 and its back contact and relay 401 to battery. There is another circuit completed in multiple with the above which extends from ground by way

of armature 425 and its front contact, armature 437 and its back contact and registering relay 449 to battery. The registering relay 449 is energized to establish a locking circuit for itself on armature 461, to open the original energizing circuit and to prepare a circuit at armature 462.

When the subscriber at the sub-station D removes his finger from the push button the identifying relay 412 is again energized to open the circuit of the relay 401 and the original energizing circuit for the registering relay 449. The deenergization of the relay 401 serves to complete a circuit which extends from ground by way of armature 424 and its back contact, low resistance relay 450, armature 462 and its front contact, conductor 488, winding 501 of the line switch L. S.—2, conductor 357, bank contact with which the master switch wiper 363 is in engagement, conductor 356, armature 464 and its front contact, conductor 494, armature 550 and its back contact through back contacts on all starting relays such as 422 of the ten master switches similar to the master switch M. S.—1 and M. S.—2 controlling the line switches or non-numerical switches that govern the director selecting, armature 553 and its back contact to battery. The coil 501 of the line switch L. S.—2 is energized over this circuit and operates its armature 506.

The conductor 488 which supplies ground to one terminal on the coil 501 of the non-numerical switch L. S.—2 is common to all the similar coils of the non-numerical switches under the control of the master switch M. S.—1 which have access to a particular group of directors. The conductor 357 might be termed a trunk conductor and is common to the ten line switches having access to the various groups of directors in which the trunk line comprising conductors 330 and 332 terminate. By this connection it is possible to operate a particular non-numerical switch of the ten under the control of the registering relays 440 to 449, inclusive, to select the particular director group that is designated by the letter F.

It is, of course, obvious that there may be considerably less than ten director groups depending upon the size and complexity of the metropolitan exchange area.

As before stated the push button calling device at the subscriber's station consists of ten push buttons, which are ordinarily denominated by numerals from 1 to 0. For a metropolitan exchange area these push buttons may also be designated by letters where the exchange names are used as part of the subscriber's number. This is in accordance with the usual automatic telephone practice and needs no explanation.

It will be recalled that each trunk line extending from the subscriber's line switches

is provided with ten non-numerical switching terminals, one appearing or having access to each of the ten groups of directors. The operation of a particular one of these line switches or non-numerical switches, therefore, selects a director in a particular group.

The coil 501 of the non-numerical switch L. S.—2 is operated over the previously traced circuit to operate its armature 506 thereby bringing the spring 503 into engagement with its working contact. A circuit is thereupon completed which extends from ground on the release trunk conductor 480, working contact and spring 503 and said springs, and pull down coil 502 of the non-numerical switch L. S.—2 to battery. The pull down coil 502 is energized to operate the pull down armature 505. The pull down armature 505 is operated to bring the springs 513, 507, 512, 508, 509, 510 and 511 into engagement with their working contacts. The plunger of the non-numerical switch L. S.—2 is, of course, standing opposite an idle trunk line leading to a director by reason of it being controlled by a master switch M. S.—1.

It will be recalled that the relay 450 in the controlling link is energized in series with the coil 501 of the non-numerical switch L. S.—2. The operation of the relay 450 serves to complete a circuit for operating the master switch M. S. The master switch start relay 377 is energized as soon as ground is connected to the release trunk conductor 331 and to remove battery from the common conductor 354. Now when the relay 450 is operated there is a circuit completed which extends from ground by way of front contacts and armature 460, conductor 355, armature 379 and its front contact and relay 376 to battery. The relay 376 is energized to attract the armature 380 thereby permitting the master switch to place the plungers of all idle line switches in association with an idle trunk line in the usual and well known manner. The movement of the master switch wipers 360 to 363, inclusive, immediately brings about the deenergization of the identifying relays in the controlling link, 403 to 412, inclusive, and also the deenergization of the registering relay 449. The circuit of the coil 501 of the switch L. S.—2 is, therefore, opened but this operation has no particular effect at this time. The link controlling equipment which is governed by the master switch is thus associated with the next idle trunk which the plungers of all idle line switches are standing opposite. The link controlling mechanism shown on Fig. 4 may, therefore, be operated by another calling subscriber.

The time that this link controlling mechanism comprising the identifying and registering relay is held up is exceedingly short since the subscriber is given dial tone immediately upon removing his receiver and the link con-

trol mechanism is released upon the operation of the first push button. The link controlling mechanism will then be available for the next call. The time that this common mechanism is tied up is so short that the other subscribers in the group will not be appreciably affected. Even though two subscribers should take off their receiver substantially simultaneously they are instructed to wait until they receive dial tone before proceeding with calling the desired number. The dial tone is only given to the calling subscriber when the link controlling mechanism is connected. During the time that one subscriber is connected to the link controlling mechanism the other subscriber's line switches are prevented from plunging since the main battery circuit is opened at armatures 432 and 435. During the time that the master switch M. S. is seeking an idle trunk this main battery circuit is also open. It will be seen that the subscriber's line upon the removal of his receiver is immediately extended to the link controlling mechanism since his line switch stands opposite an idle trunk line and since the link controlling mechanism is already associated with this pre-selected trunk line. There is thus no time lost in automatic trunk selection. The identifying relays respond to the operation of the push button sending device instantaneously so that the link controlling mechanism need only be held up for a small fraction of a second.

Returning now to the operation of the switch L. S.—2 in response to the operation of the registering relay 449 and the consequent energization of the pull down coil 502. The identifying relays 606 to 615, inclusive, in the director shown on Figs. 6 to 8, inclusive, are energized over a circuit which extends from battery through the lower winding of all the identifying relays, in multiple, conductor 524, conductor 518, spring 510 and its working contacts, conductor 481, back contact and armature 466, conductor 340, spring 323 and its working contact, calling line loop, working contact of spring 327 and said spring, conductor 341, armature 470 and its back contact, conductor 483, working contact of spring 507 and said spring, conductor 517, conductor 525, to ground. The identifying relays 606 to 615, inclusive, are energized over this circuit and attract their armatures to open points in the selecting circuit, the operation of the spring 512 on the switch L. S.—2 prepared an operating circuit for controlling the link control mechanism such as that illustrated in Fig. 9. The operation of the spring 508 prepares a certain testing circuit. The operation of the spring 513 prepares a circuit for the relay 451 in the trunk equipment T. E. The operation of the spring 509 places ground upon the conductor 518, while the operation of the spring 511 prepares a circuit for the relay 453 in the trunk equipment.

The connection of ground to conductor 518 which extends to conductor 527 completes a circuit for the starting relay 522 and the master switch M. S.—1. The master switch M. S.—1 is operated in the usual manner to align the plungers of all idle line switches opposite an idle trunk leading to another director. The operation of the armatures 651 and 652 of the identifying relays 606 and 607 serve to complete a circuit which extends from ground by way of said armatures and their front contacts in multiple, armature 647 and its back contact and switching relay 619 to battery. Switching relay 619 is energized to connect the first group of registering relays 624 to 633, inclusive, so that they may be operated under the control of the identifying relays 606 to 615, inclusive. The operation of these armatures 651 and 652 also serve to complete circuits for their upper windings. The amount of current flow through the upper windings of these identifying relays is graduated with respect to these relays so that their operation will be substantially the same as that already described with respect to the identifying relays in the link circuit shown on Fig. 4.

The foregoing operations have occurred in response to the calling subscriber at sub-station T in removing his receiver and operating his push button calling device in accordance with the first digit of the called subscriber's number.

When the calling subscriber operates his calling device in accordance with the next digit of the called subscriber's number, namely, R the relay 607 has the same current flow in both its winding and is deenergized. All the other relays remain with their armatures attracted. By the deenergization of the relay 607 there is a circuit completed which extends from ground by way of armature 651 and its front contact, armature 655 and its back contact, armature 650 and its back contact and upper winding of relay 605 to battery. The deenergization of the relay 607 also completes a circuit which extends from ground by way of armature 651 and its front contact, armature 656 and its back contact, working contact of spring 636 and said spring and relay 625 to battery. The relay 625 is energized to complete a locking circuit for itself at armature 637 and to prepare a circuit for controlling the translating equipment at armature 668. The relay 605 is a two step relay. That is, its upper winding has relatively few ampere turns and serves only to attract the armature 649. The operation of this armature serves to complete a circuit for the lower winding of the relay 605, though this circuit is ineffective so long as the original circuit is maintained, because it is shunted.

When the subscriber at the calling station releases the push button that designates R

thereof the relay 607 is again operated and the circuit for the upper winding of the relay 605 is opened. The two windings of the relays 605 are now energized in series and all the armatures 647, 648, 649 and 650 are attracted. The operation of the armature 647 opens the circuit of the switching relay 619 at the back contact of this armature and at the front contact of this armature completes circuit for the second switching relay 618, the operation of the armature 648 places ground upon conductor 526. The operation of the armature 650 opens a point in the original energizing circuit of the relay 605 and prepares a circuit for the upper winding of the relay 604. The switching relay 618 is energized to connect the second group of registering relays 701 to 710, inclusive, under the control of the identifying relay, 606 to 615, inclusive. The deenergization of the switching relay 619 disassociates the first group of registering relays 624 to 633, inclusive, from control of the identifying relays.

The connection of ground to conductor 526 completes a circuit which extends by way of this conductor, spring 511 and its working contact, conductor 486, relay 453 and armature 474 and its back contact to battery. The relay 453 in the trunk circuit is energized to connect ground to conductor 490 at armature 472, to disconnect ground from conductor 492 at armature 473 and to connect the conductor 492 to the winding of relay 454 at the front contact of this armature. The results bring about the starting of the finder switch F—1, Fig. 9 and will be explained later.

When the subscriber at the calling station T operates his push button calling device in accordance with the next character of the called subscriber's number, namely, A, the current flow through the lower winding of the identifying relay 607 is equal to the current flow through the upper winding and this relay is deenergized while all the other relays remain with their armatures attracted. The deenergization of the relay 607 serves to complete a circuit for the upper winding of the two step relay 604 at armature 655 and completes a circuit for the registering relay which extends from ground by way of armature 651 and its front contact, armature 656 and its back contact, working contact of spring 640 and said spring, conductor 677 and registering relay 702 to battery. The registering relay 702 is energized to attract its armature 710 thereby completing the translating circuit over a path which extends from ground by way of relay 634, armature 668 and its front contact, conductor 688, working contact of spring 711 and said spring, conductor 783 and relay 812 to battery. The relay 812 might be termed the exchange selection relay. Since it has been assumed that the first call made by the subscriber at the substation T is a local

one there is no translation at this time. The control circuits which are ordinarily used for interoffice trunking are rendered ineffective by reason of the connection from the relay 812 on the intermediate distributing frame I. D. F. as will be explained.

When the subscriber at the calling substation releases his push button the identifying relay 607 is again operated to open the original energizing circuit of the relay 702. However, this operation is ineffective since the relay 702 has established a locking circuit at spring 712 to ground upon grounded conductor 676.

The operation of the identifying relay 606 serves to bring about the complete energization of the two step relay 604, whereby its armatures 644 and 646 are operated. The operation of the armature 644 serves to complete a circuit for the switching relay 620 and to open the circuit of the switching relay 618. The operation of the armature 646 serves to prepare a circuit for the two step relay 603.

When the subscriber at the calling station operates his push button calling device in accordance with the next digit 7 the relay 612 is the one to be deenergized and the seventh relay in the relay group G, which is connected under control of the identifying relays by the operation of the relay 620 is energized and operates to establish a locking circuit for itself. The deenergization of the relay 712 also brings about the energization of the upper winding of the relay 603.

When the subscriber at the calling station releases his push button the relay 612 is again energized and the two step relay 603 is completely operated to bring about the deenergization of the relay 620 and the operation of the relay 621. In addition the operation of the relay 603 serves to prepare a circuit for the two step relay 602. By the operation of the switch over relay 621 the registering relay group G—1 is associated with the identifying relays.

In response to the next digit sent from the calling station T, namely 6, the relay 611 of the identifying relays is the one deenergized to complete a circuit for the sixth in the registering relay group G—1, and to complete a circuit for the upper winding of the two step relay 602. The release of the push button at the calling station brings about the operation of the identifying relay 611 so that the identifying selecting circuit is restored to its original condition.

The operation of the push button calling device at the calling station in accordance with the two digits 90 serves to select and energize the ninth and tenth registering relays in the relay group G—2 and G—3, and in addition brings about the complete operation of the relays 602 and 601. The operations occur in identically the same manner as before described.

The digits of the called subscriber's number has now been registered upon the registering equipment in the director.

It will be recalled that the relay 453 is previously operated to initiate the action of a finder switch, such as F—1 when the second digit of the called subscriber's number was registered on the director. The removal of ground from the conductor 492 serves to remove the ground potential from the test contact associated with this trunk line in the banks of finder switches such as F—1. The connecting of ground to conductor 490 serves to complete a starting circuit for finder switch such as the finder switch F over a path which extends through the armature 951 and its back contact and the upper winding at the line relay 916 to battery. The line relay 916 is energized and serves to complete a circuit for the switching relay 915 in series with its own lower winding and the winding of the motor magnet 914 and to connect the test wiper 943 to a point midway between the switching relay and the motor magnet at armature 954. The motor magnet 914 is then intermittently operated until the switch wipers 940 to 943, inclusive, are brought into engagement with the trunk line whose test terminal is ungrounded, provided, of course, that the switch wipers are not already in engagement with the bank contacts of this trunk line. In any event when the proper trunk line has been selected the short circuit is removed from the switching relay 915 and this relay is energized in series with the motor magnet. The relay 915 upon operating, at the armature 950 serves to prepare a locking circuit for itself, at armature 951 opens the circuit of the upper winding of the relay 916, opens a point in the testing circuit at armature 952, connects ground to conductor 492 at the front contact of this armature. Other results of the operation of the relay 915 are that at armature 956 a testing circuit is prepared and at armature 957 a circuit is prepared for operating the identifying relays 901 to 910 of the link controller. Since the control circuit for operating the identifying relays 901 to 910, inclusive extend back to the director it is possible to perform this operation over a single conductor.

By the operation of the finder switch the link control mechanism that is adapted to control the operation of the terminal switches such as L. S.—4 and L. S.—5 which the trunk line comprising conductors 489 to 492, inclusive, terminates in is associated with this trunk line.

Reverting now to the operation of the director equipment it will be recalled that the relay 812 is energized in response to the registering of the third digit in the director. The relay 634 is energized in series with the relay 812 and serves to complete a circuit which extends from ground by way of front

contact and armature 537, conductor 780, armature 823 and its back contact, armature 824 and its back contact, armature 825 and its back contact and upper winding of the two step relay 810 to battery. The relay 810 is energized to attract the armatures 826, 827 and 830. All the other armatures of the relay remain normal until the lower and upper windings are energized in series. The operation of the armature 827 serves to prepare a circuit for the lower winding of the relay 810. The operation of the armature 830 serves to complete a circuit for the relay 822, while the operation of the armature 826 serves to complete a circuit which extends from ground by way of armature 828 and its back contact, front contact and armature 826, armature 832 and its front contact, I. D. F. terminal 833, terminal 834 and relay 818 to battery. The relay 818 is energized to open a point in the circuit of the upper winding of the relay 810 at armature 824 and to place ground upon the conductor 551 at armature 835. The relay 822 is deenergized to remove one ground connection from the conductor 551. However, its operation is ineffective at this time since the relay 818 is operated. When the circuit of the upper winding of the relay 810 is opened both windings of this relay are energized in series and the armatures 828, 825 and 829 are operated. The operation of the armature 828 opens a circuit of the relay 818 and this relay is deenergized to complete a point in the circuit of the upper winding of the relay 809, as well as to remove one ground connection from the conductor 551. The operation of the armature 825 serves to complete a circuit for the upper winding of the relay 809. The operation of the armature 829 opens a point in the circuit of the relay 822 and this relay is deenergized to connect ground again to the conductor 551. The upper winding of the two step relay 809 serves to attract the armatures 836, 838 and 841. The operation of the armature 836 completes another circuit for the relay 818 over a path similar to the one above traced. The operation of the armature 838 prepares a circuit for the lower winding of the relay 809. The operation of the armature 841 completes a circuit for the relay 822. The relay 822 operates to remove one ground connection from the conductor 551. The operation of the relay 818 opens the circuit of the upper winding of the relay 809 and places a ground connection upon the conductor 551. The relay 809 is thereupon completely operated. In a similar manner to that already described two step relays 808, 807 and 806 are rapidly operated in succession. The operation of the relays 806 to 810, inclusive, occurs because the connection is a local one and there is no necessity for the interoffice control circuit.

Now upon the complete operation of the relay 806 there is a circuit completed for the upper winding of the relay 805. The relay 805 completes a circuit for the relay 822 at armature 849 and at armature 848 connects ground to the conductor 788.

It will be seen that the conductor 551 extends through the spring 512 of the switch L. S.—2 and its working contact to conductor 484, armature 479 and front contact, conductor 489, bank contact with which the wiper 941 is in engagement, namely, 960, wiper 941, armature 957 and its front contact and through the lower winding of the identifying relays 901 to 910, in multiple. The relays 901 to 910, inclusive, are therefore operated. As stated before, the operation of the relays 901 and 902 serves to complete at armatures 930 and 933 circuits for the upper winding of the identifying relays 901 to 910. The current flow through the various upper windings of these identifying relays is graduated. Since direct ground has been connected to the conductor 551 in the director the relays 901 to 910, inclusive, have remained operated to the present time.

Referring now to the operation of the director, the connecting of ground to conductor 788 completes a circuit through the armature of the seventh relay from the left in the relay group G, since this relay was the one operated in response to the sending of the first numerical digit from the sub-station T and then to the terminal 850 in the I. D. F. The connection from the various relay groups G, G—1, G—2, and G—3, through the I. D. S. are not shown for the sake of simplicity. However, it will be understood that the conductors shown before each relay group lead to the terminals from right to left on the upper side of the I. D. F. in order of left to right from the relay group. Ground is, therefore, connected to the resistor 890 at a point which changes the conductance of the circuit leading to the identifying relays associated with the finder switch F—1, in accordance with the numerical designation 7. This follows since the relay 822 is energized over a previously traced circuit and operates to remove the ground connection to the conductor 551 at armature 831.

It will be recalled that the relay 915 in the finder switch F—1 is energized upon the finder switch finding the proper trunk. The operation of the relay 950 in addition to the results before described completes a circuit which extends from ground by way of front contact and armature 952, wiper 943, bank contact 961, conductor 492, armature 473 and its front contact and relay 454 to battery. The relay 454 is energized to establish a locking circuit for itself to ground upon grounded conductor 491 and to open the circuit of the relay 453. The relay 453 is deenergized to open another point in the circuit

of the line relay 916 of the finder switch at armature 452 and to again connect ground to the conductor 492 at armature 473.

Returning now to the progress of the call, it will be recalled that the director modified the conductance of the control circuit which includes the lower windings of the identifying relays 901 to 910, inclusive, in accordance with the numerical designation 7. This modification in conductance so alters the current flow in the windings of the various relays comprising the identifying group that the relay 907 is deenergized since the current flow in its lower winding is equal and opposite to the current flow in its upper winding. All the other relays remain operated. The retraction of the armature 964 of the relay 907 completes a circuit for the relay 923 of the registering set. The relay 923 is energized to establish a locking circuit for itself at armature 966 and to prepare a circuit at armature 965 for the trunking or non-numerical switch L. S.—4, and to complete another point in the operating circuit of this switch at armature 967.

The relay 911 has its upper winding connected to the conductor 491 through the wiper 940 while its lower winding is connected to ground through the armatures 930 and 931 in series with the resistance 912. The relay 911 is also what might be termed an identifying relay which is used for controlling certain control functions as will appear. The relay 911 is energized to remove ground from the armature 969 of the relay 927 at armature 968. A circuit is now completed which extends from ground by way of back contact and armature 971, armature 967 and its front contact, armature 953 and its front contact, wiper 942, conductor 493, spring 1003 and its resting contact, coil 1001 of the switch L. S.—4, conductor 989, front contact and armature 965 and low resistance relay 927 to battery. The line coil 1001 of the switch L. S.—4 and the relay 928 in the link control circuit are energized in series. The relay 927 is operated to remove the shunting path to ground from the resistor 970 and armature 971. This operation alters the conductance of a circuit that extends back to the director which will be traced as follows—ground the resistor 970, armature 967 and its front contact, armature 953 and its front contact, wiper 942, bank contact 962, conductor 493, armature 469 and its back contact, conductor 482, working contact of spring 508 and said spring, conductor 550 and the lower windings of the relays 820 and 821 in multiple to battery. The relays 820 and 821 have already been energized by reason of the circuit through their upper windings, which is completed upon the grounding of conductor 790 following the seizure of the director. This modification in the conductance of the circuit extending back to the director including the lower windings of the

relays 820 and 821 so modifies the current flow through these lower windings that the current flow in the upper winding of the relay 820 is balanced and the relay 820 is deenergized while the relay 821 remains operated. The relay 820, upon deenergizing, completes a circuit for the relay 819 at armature 850. The relay 819 is energized to open the circuit of the upper winding of the relay 805 at armature 823. The relay 805 is immediately energized to attract all its armatures, thereby preparing a circuit for the relay 804 and removing the ground connection to the resistor 890 through the relay group G, as well as to open the circuit of the relay 822. The deenergization of the latter relay short circuits the resistor 890.

It will be remembered that the coil 1001 of the switch L. S.—4 is energized over a previously traced circuit to attract the armature 1006, thereby operating the spring 1004 and 1003. The operation of the spring 1004 serves to complete a circuit which extends from ground by way of spring 1005 and its resting contact, working contact of spring 1004 and said spring, pulled down winding 1002 and armature 1010 and its back contact to battery.

The pull down winding 1002 is operated to attract the pull down armature 1007, thereby extending the control circuit from the director to the link control equipment associated with the master switch through the master switch wipers 1125 to 1128, inclusive. The identifying relays 1103 to 1112, inclusive, are energized over a circuit which extends back to the director over a path that may be traced from battery through the lower windings of the identifying relays in multiple, master switch wiper 1126, which is associated with the trunk line preselected by the master switch M. S.—4 to which the call has been extended, bank contact 1136, trunk conductor 1089, spring 1015 and its working contact, trunk conductor 489, front contact and armature 479, conductor 484, working contact of spring 512 and said spring, conductor 551 to ground by way of a portion of the resistor 890 to the terminal 855 of the I. D. F. The relays 1103 to 1112, inclusive, are energized over this circuit and operate to open certain selecting circuits and to place ground through the resistor 1136 so that their upper windings are fed by different amounts of current in a manner similar to the other identifying relay circuits already described. In addition ground is supplied to the lower winding of the relay 1101 which is a test relay. One of the results of the operation of the relay 1103 is that at armature 1132 there is a circuit completed which extends from ground, resistor 1137, back contact and armature 1138, armature 1132 and its front contact, master switch wiper 1125, bank contact 1139, conductor 1090, spring 1016 and its working contact, conductor 491, bank contact 975, finder

switch wiper 940 and upper winding of identifying relay 911 to battery. This circuit serves to balance the identifying relay 911 and this relay retracts its armature to complete a circuit for the relay 928. The relay 928 is energized to open the circuit of the relay 915 of the finder switch F—1. The relay 915 is deenergized to disassociate the identifying relays from the trunk line comprising conductors 484 to 493, inclusive. All the identifying relays 901 to 910, inclusive are restored to normal as are the other relays which are operated in Fig. 9. The deenergization of the relay 915 again alters the conductance of the control circuit extending back to the identifying relays 820 and 821 in the director and the relay 820 is again operated to open the circuit of the relay 819. The relay 819 is deenergized to complete a circuit for the upper winding of the relay 804. The relay 804 is operated to connect ground to the armatures of the relays in the registering group G—1 and to complete a circuit for the relay 822. The relay 822 is operated to remove the short circuit from the resistor 890. Since the sixth relay in the registering group G—1 is operated ground is connected to the terminal 855 of the I. D. F. and the conductance of the control circuit extending to the identifying link equipment shown in Fig. 11 is altered in accordance with the numerical designation 6.

It will be seen that the link control equipment associated with the finder switch F—1 is not permitted release until the calling line has been extended to the next succeeding control link. This is done in order to prevent any possibility of trouble since the master switch M. S.—4 is searching for an idle trunk at the time the circuit was completed for operating the relay 1001, the line of the calling subscriber could not be extended until an idle trunk was found. The circuit just described assures the connection of the link circuit to the proper preselected trunk and the operation of the proper switch such as L. S.—4 which has been designated by the director.

The connection of ground through the resistor 1137 to the conductor 1090 completes a circuit which extends through the master switch wiper 1128, conductor 1093 and relay 1008 to battery. The relay 1008 is energized over this circuit but its operation is without particular function at the present time since there is no ground connected to the conductor 1094. The relay 1101 is energized as soon as the link circuit shown in Fig. 11 is seized to open the circuit of the relay 1113 and bring about its deenergization to remove the ground connection to the conductor 1094.

Returning now to the alteration in conductance of the control circuit including the lower windings of the relays 1103 to 1112, inclusive, it will be remembered that the con-

ductance was altered in accordance with the numerical designation 6. The relay 1108 in the identifying control equipment shown in Fig. 11 is, therefore, deenergized and retracts its armatures while the armatures on all the other identifying relays remain attracted. The registering relay 1119 is therefore operated to establish a locking circuit for itself at armature 1141 and to complete a circuit for the coil 1201 of the switch L. S.—6. This circuit extends from ground by way of back contact and armature 1144, front contact and armature 1143, master switch wiper 1127, bank contact 1145, conductor 1091, spring 1205 and its resting contacts, coil 1201, conductor 1194, front contact and armature 1142 and relay 1124 to battery. The relay 1124 and the coil 1201 are energized in series over this circuit. The relay 1124 is operated to prepare a circuit for the relay 820 at armature 1144 and to open one ground connection through the upper winding of the relay 1101 at armature 1138. The opening of one circuit for the upper winding of the relay 1101 prepares this relay for deenergization when the trunk line is extended to the control circuit with the identifying relays shown on Figs. 13 and 14.

The coil 1201 is energized to attract the armature 1204 thereby operating the springs 1205 and 1206. By the operation of the spring 1206 there is a circuit completed which extends from ground by way of the spring 1207 and its resting contact, working contact of spring 1206 and said spring, pull down winding 1202 and armature 1208 and its back contact to battery. This circuit extends to the open main battery on the master switch M. S.—6. The pull down winding 1202 is energized to attract the armature 1203 thereby extending the calling line by way of the master switch wipers 1330 to 1333, inclusive, to the link control identifying equipment shown on Figs. 13 and 14, and to the trunk circuit comprising conductors 1291 to 1293, inclusive. This is done through the operation of the springs 1209 to 1211, inclusive, controlled by the plunger armature 1203 of the switch L. S.—6. The trunk line comprising conductors 1291 to 1293, inclusive, having been selected by the operation of the master switch M. S.—6 in the usual manner. The trunk line comprising conductors 1291 to 1293, inclusive, appear before a multiple of 100 subscriber's lines in a Keith line switch board which constitutes the incoming terminals of this particular hundred lines. In this instance by the operation of the director the seventy six hundred line group of the local office has been selected and there are ten trunks leading to this representing ten percent trunking. The master switch M. S.—9 controlling this hundred group of incoming terminals has preselected the same trunks as the master switch M. S.—6 since

these trunks become busy simultaneously and the master switches are operated in synchronism as will appear more fully hereinafter.

By the operation of the switch L. S.—6 a circuit is completed which extends from battery, lower winding of all the identifying relays 1304 to 1313, in multiple, wiper 1331, conductor 1283, spring 1209 and its working contact, conductor 1089, spring 1015 and its working contact, conductor 489, front contact and armature 479, conductor 484, working contact of spring 512 and said spring, conductor 551 to ground in the director. The reason that there is this ground connection in the director is because when the relay 1124 in the link control circuit energized in series with the coil 1201 of the switch L. S.—6 the short circuit was removed from the resistor 1160 and this resistor was included in a circuit extending back over the conductor 1091 and conductor 493 to the relays 821 and 820 in multiple. The relay 820 is deenergized to complete the circuit of the relay 819 and this relay is energized to open the circuit of the upper winding of the relay 504. The relay 504 is operated to open the circuit of the relay 822 and to remove ground from the multiple connected armature of the relay group G—1 of the registering relays. The deenergization of the relay 822, therefore, places ground upon the conductor 551 short circuiting the resistor 890. The relay 1215 is, immediately energized but its operation is without particular function for the present.

The circuit above traced for the relays 1304 to 1313, inclusive, then extends back directly to ground in the director. The relays 1304 to 1313, inclusive, are immediately operated. The relays 1304 and 1305 upon operating complete circuits for the upper windings of the identifying relays so as to properly proportion the current flow through these windings for the instantaneous selecting functions which they are to perform. In addition there is a circuit completed which extends from ground by way of armature 1335 and its front contact, resistor 1338, wiper 1333, bank contact 1339, conductor 1285, spring 1210 and its working contact, conductor 1090, bank contact 1139, master switch wiper 1125 and upper winding of identifying relay 1101 to battery. The conductance of this circuit is such that the current flow in the upper winding of the relay is exactly equal and opposite to the current flow on the lower winding of this relay and the relay will deenergize to complete a circuit at armature 1155 for the relay 1113. The relay 1113 is energized to complete a locking circuit for itself at armature 1156 and to complete a circuit at armature 1157 which extends from ground by way of said armature and its front contact, conductor 1094, armature 1011 and its front contact. This circuit brings about the movement of

the master switch and causes the release of the identifying control equipment shown in Fig. 11. The identifying control equipment shown in Fig. 11 is thus restored to common use and associated with the next trunk pre-selected by the master switch M. S.—4. The release of the identifying control equipment shown in Fig. 11 alters the conductance of the circuit extending back to the control relays 820 and 821 in the director and brings about the energization of the relay 820.

The operation of the relay 820 opens the circuit of the relay 819 and this relay is deenergized to complete a circuit for the relay 803 which has a circuit completed for its upper winding, and this relay is energized to attract certain of its armatures thereby completing a circuit for the relay 822 and in addition connecting ground to the conductor 791 that extends to the multiplied armatures of the registering relays in the group G—2.

It will be recalled that the numerical digit registered on this group of relays is 9 and, therefore, ground is connected to the terminal 858 of the I. D. F. The operation of the relay 822 serves to remove ground from the conductor 551.

A circuit is now effective for controlling the identifying relays shown in Fig. 13, which will be described later.

Returning now to Fig. 13 it will be recalled that the operation of the armature 1335 completed a circuit for the upper windings of the identifying relays. In addition the operation of this armature serves to complete a circuit which extends by way of armature 1340 and its back contact and relay 1315 to battery. The relay 1315 is a switching relay and is operated to connect the registering relays 1316 to 1325, inclusive, under the control of the identifying relays 1304 to 1313, inclusive.

The relay 1215 of the master switch M. S.—6 is energized immediately after the extension of the call to the identifying equipment shown in Fig. 13 though its operation is without function for the present.

The operation of the relay 1304 in connecting ground to the release trunk conductor also serves to establish locking circuit for the switches L. S.—4 and L. S.—6 so that these switches are maintained operated.

Returning now to the progress of the connection under the control of the director it will be recalled that ground has been connected to the terminal 858 of the I. D. F. The conductance of the control circuit extending to the identifying relays 1304 to 1313, inclusive, is thereby altered so that the current flow through the lower winding of the relay 1312 is the same as the current flow through its upper winding and this relay retracts its armatures 1343 and 1344. The operation of the armature 1344 serves to complete a circuit which extends from ground by way of

armature 1355 and its front contact, armature 1344 and its back contact, back contact and armature 1341 and relay 1301 to battery. The relay 1301 is energized to complete a circuit for the relay 1302. However, the relay 1302 is not operated at this time since it is shunted by the original energizing circuit for the relay 1301. The retraction of the armature 1343 serves to complete a circuit which extends from ground by way of armature 1335 and its front contact, armature 1343 and its back contact, working contact of spring 1344 and said spring, and relay 1324 to battery. The relay 1324 is energized to establish a locking circuit for itself at armature 1345 and to complete a circuit at armature 1346 which extends from ground, relay 1326, armature 1346 and its front contact, conductor 1377 to the multiplied spring of the second group of registering relays 1401 to 1410, inclusive.

Another result of the operation of the armature 1347 of the relay 1301 is that a circuit is completed which extends from ground through the resistor 1348, front contact and armature 1347, master switch wiper 1330, bank contact 1349, conductor 1281, spring 1211 and its working contact, conductor 1091, spring 1017 and its working contact, conductor 493, armature 469 and its back contact, conductor 482, working contact of spring 508 and said spring, conductor 550 to the lower windings of the relays 820 and 821 in multiple to battery. The conductance of this circuit is so altered by the resistance 1348 that the relay 820 is deenergized while the relay 821 remains operated. The relay 820 is deenergized to complete a circuit for the relay 819. The relay 819 is operated to open the circuit of the upper winding of the relay 803. The relay 803 is immediately completely energized and operates to open the circuit of the relay 822 and to remove ground from the terminal 858 of the I. D. F. The deenergization of the relay 822 replaces direct ground upon the conductor 551 which ultimately extends to the identifying control relays of Fig. 13. The relay 1312 is immediately operated to attract its armatures 1343 and 1344. The operation of the armature 1343 is without particular effect. The operation of the armature 1344 opens the original circuit for the relay 1301 and this relay is maintained energized in series with the relay 1302 which is now operated. The operation of the relay 1302 serves to open the circuit of the relay 1315 at armature 1340 to complete a circuit for the relay 1314 at the front contact of this armature, to open a point in the original energizing circuit of the relay 1301 at armature 1341 and to open the circuit that extends back to the relays 820 and 821 in the director at armature 850.

The relay 1315 is deenergized to disassociate the first group of registering relays 1316 to

1325, inclusive, from control of the identifying relays 1304 to 1313, inclusive, while the relay 1314 is operated to associate the second group of registering relays 1401 to 1410, inclusive, with these identifying relays.

The operation of the armature 1350 again alters the conductance of the circuit extending back to the relay 820 and 821 in the director and the relay 820 is again operated to open the circuit of the relay 819. The relay 819 is deenergized to complete a circuit for the upper winding of the relay 802. The relay 802 is partially operated so as to complete a circuit for the relay 822 and to place ground upon the multiplied armatures connected to conductor 792 of the group G—3. Since the tenth or naught relay is operated in this group ground is connected to the terminal 859 of the I. D. F. The operation of the relay 822 removes ground from the conductor 551 while the connection of ground to the terminal 859 of the I. D. F. now alters the conductance of the control circuit extending to the identifying relays 1304 to 1313, inclusive, so that the current flow through the lower winding of the relay 1313 is equal and opposite to the current flow through its upper winding. The relay 1313 is immediately deenergized to retract its armatures 1352 and 1353 while the armatures of all the other identifying relays 1304 to 1313, inclusive, remain attracted. The operation of the armature 1352 is without particular function at the present time. The operation of the armature 1353 serves to complete a circuit which extends from ground by way of armature 1335 and its front contact, armature 1353 and its back contact, working contact of spring 1354 and said springs, and conductor 1392 and relay 1410 to battery. The relay 1410 is energized to attract its armature 1420 thereby establishing a locking circuit for itself at the spring 1421. A testing circuit is now completed which extends from ground by way of relay 1326, armature 1346 and its front contact, conductor 1377, working contact of spring 1422 and said spring, conductor 1488, pull down winding 1501 of the line switch L. S.—9 associated with the line of the subscriber at sub-station T—2 to open the battery by way of armature 1520 and its back contact.

In this discussion of our connection it will be assumed that the line of the called subscriber at sub-station T—2 is busy. The conductors 1503, 1504 and 1505 lead to the outgoing terminal line switch of the line of the subscriber at substation T. The conductors 1504 and 1505 are the usual line conductors. The manner in which the conductor 1503 is connected to the outgoing line switch of this subscriber can be seen by referring back to Fig. 3. The conductor 1503 is multiplied in the bank of the line switch associated with

the line of the subscriber at sub-station T-2 in the same manner as the conductor 370 is associated with the line switch L. S. That is, when the line switch L. S. is operated on an outgoing call the conductor 370 is grounded. Thus if the line of the subscriber at sub-station T-2 is busy because of an outgoing call from this sub-station there will be ground connected to the conductor 1503 if the line of the subscriber at sub-station T is busy from an incoming call there will be ground connected to the conductor 1506. In either event the relay 1326 in the control link circuit shown on Fig. 13 is short circuited and is not operated. A circuit is now effective which extends from ground by way of spring 1423 and its working contact, conductor 1379, armature 1362 and its back contact and relay 1327 to battery. The relay 1327 is a high impedance and is slightly slow to operate and this circuit is normally not effective since the relay 1326 is operated in the event the line of the called subscriber is idle. The relay 1327 upon operating connects ground through the resistor 1351 to master switch wiper 1332 at armature 1360 and at armature 1364 completes a circuit for the high impedance relay 1329. By the connection of ground through the resistor 1361 to the wiper 1332 the conductance of the circuit which extends by way of bank contact 1365, conductor 1380 to armature 1438 and its back contact to the upper winding of the identifying relays 1411 and 1412 in multiple. Current flow in the upper winding of the relay 1412 is now the same as the current flow in its lower winding and this relay is deenergized to complete a circuit for the relay 1413 which is energized. The relay 1413 is now energized over a circuit which extends back over the calling line loop as will be described.

Another result of the operation of the relay 1327 is that at armature 1368 there is a circuit completed which extends from ground through the resistor 1358, front contacts and armatures 1368, master switch wiper 1330, conductor 1281, spring 1211 and its working contact, conductor 1091, spring 1017 and its working contact, conductor 493, armature 469 and its back contact, conductor 482, working contact of spring 508 and said spring, conductor 550 and lower winding of relays 820 and 821 in multiple to battery. The conductance of this circuit is so modified that the relay 821 retracts its armature 860 while the relay 820 maintains its armature attracted. The deenergization of the relay 821 serves to complete a circuit for the relay 817 which is operated to connect ground to conductor 552 thereby completing a circuit which extends over this conductor, spring 513 and its working contact, conductor 485 and relay 451 to battery. The relay 451 is energized to remove ground from con-

ductor 480 and to establish a locking circuit for itself to ground upon conductor 491. The relay 451 also upon operating disconnects the calling line circuit from the director at armatures 467 and 469 and at armatures 466 and 469 connects the conductors 489 and 493 to the conductors 340 and 341. The relay 452 is now deenergized to remove one ground connection from the release trunk conductor 342 at armature 471, to open one point in the control circuit extending from the director and to open a point in the holding circuit of the director selecting switch L. S.—2. The removal of ground from the conductor 480 brings about the release of the director selecting L. S.—2 whereby the identifying relays 606 to 615, inclusive are deenergized with the result that all the various relays in the director that have been operated are now restored to their normal condition.

This operation now makes the director available so that it may be used in another call.

In the trunk equipment T. E.—1, Fig. 14, the operation of the relay 451 of Fig. 4 completes a circuit for the relay 1413 and this relay is energized to open the circuit of both windings of the relays 1411 and 1412 to open a point in the talking circuit extending from the line of the sub-station T—2. The operation of the relay 1413 also applies ground to the release trunk conductor 1292 which extends back to the various switches that have been operated to maintain them energized.

When the relay 1327 operated it also completed a circuit at armature 1364 for the relay 1328. The relay 1328 is a high impedance relay to permit sufficient time for the testing circuit extending back to the director and to the trunk equipment T. E.—1 to become effective before it completes a circuit which extends from ground by way of front contact and armature 1369, conductor 1287, armature 1221 and its front contact and relay 1216 to battery. This circuit initiates the operation of the master switch M. S.—6 in moving the plungers of all idle line switches opposite an idle trunk line. By the movement of the master switch the wipers 1330 to 1333, inclusive, are moved out of engagement with the trunk line associated with the trunk equipment T. E.—1 and brought into engagement with the bank contacts of the trunk line selected by the master switch.

The identifying relays 1304 to 1313 are thereupon deenergized with the result that all the relays and equipment of the last link control circuit are restored to their normal condition and made available to be used for another call.

The calling subscriber at sub-station T is now supplied with busy tone from the busy machine B. B. This tone informs the subscriber that the called line is busy and he

will, therefore, replace his receiver upon the switch hook and wait for an interval for attempting to make the connection again.

It will be seen that all the complex link control mechanism as well as the director are disassociated from the connection at this time and returned to common use.

Upon the replacement of the receiver at the calling telephone the circuit of the relay 1413 in the trunk equipment T. E.—1 is opened at the switch hook springs and this relay is deenergized to remove ground from the release trunk conductor 1292 at armature 1435 thereby completing a circuit for the lower windings of the relays 1411 and 1412 in multiple. The relays 1411 and 1412 are energized to open the circuit for the relay 1413. The removal of ground from the release trunk conductor 1292 brings about the release of the switch L. S.—6, Fig. 12, the removal of ground from conductor 1292 also brings about the removal of ground from conductor 1090 whereby the switch L. S.—4 is released. The removal of ground from conductor 1090 also brings about the removal of ground from ground from conductor 491 whereby the relays 454 and 451 are deenergized. The removal of ground from conductor 491 also brings about the removal of ground from conductor 342 whereby the subscriber's line switch L. S. is restored to normal. In this manner all the equipment that has been operated to establish the connection to the line of the calling subscriber's sub-station T—2 is released.

It will be understood that since the link control equipment shown on Figs. 13 and 14 is released shortly after the busy test circuit is completed that the line of the subscriber at sub-station T—2 cannot be connected with by the subscriber at sub-station T even though it becomes idle without replacing the receiver and making the call over again.

It should be mentioned at this time that the plunger type switches which are used throughout to establish the connection are of the self-aligning type, that is, when they are released they immediately place themselves under the control of the master switch. This self-aligning type of plunger switch is well known and need not be described. Because of this self-aligning feature the trunking switches may be immediately used for another call since they are placed upon their release under the control of their associated master switches.

It will now be assumed that the line of the called subscriber at sub-station T—2 is idle when the calling subscriber at sub-station T extends his connection thereto. Under these conditions there will be no ground potential present either upon the conductor 1503 or upon the conductor 1506 and there will be a circuit completed for the relay 1326 in series with the coil 1501 of the line switch L. S.—9

over the path previously traced to open main battery by way of the armature 1520. The relay 1326 upon operating completes a circuit on armature 1357 for placing ground through the resistor 1359 upon the wiper 1332, opens the circuit of the relay 1327 and armature 1362, places ground upon the wiper 1330 through the resistor 1358 and on armature 1363 completes a circuit for the relay 1328. The connection of ground to the wiper 1332 completes a circuit which extends by way of conductor 1380, armature 1438 and its back contact to the upper winding of the relays 1412 and 1411 in multiple. The conductance of this circuit has been so modified by the operation of the relay 1326 that the relay 1411 is balanced while the relay 1412 maintains its armature attracted. There is, therefore, a circuit completed which extends from ground by way of armature 1451 and its front contact, armature 1450 and its back contact and relay 1415 to battery. The relay 1415 is energized to prepare a locking circuit for itself at armature 1452 and to prepare a ringing circuit at armature 1432. The deenergization of the relay 1411 brings about the completion of a circuit for the relay 1413 over the calling subscribers line loop to the sub-station T. This occurs since the operation of the relay 1326 modified the conductance of the circuit which extends by way of the conductor 1281 back to the relays 820 and 821 of the director. The relay 821 is the one that retracts its armature to complete a circuit for the relay 817. The relay 817 is operated to complete a circuit for the relay 451 in the trunk equipment T. E. This relay is energized with the same result as before to extend the calling subscriber's line loop to the trunk equipment T. E.—1. The relay 1413 is energized over this circuit and operates to open the circuit of the relays 1411 and 1412 and to complete a locking circuit for the relay 1415 at armature 1435 in addition to placing ground upon the release trunk conductor 1292 at the same armature.

The pull down winding 1501 is energized to attract the armature 1512 thereby bringing the springs 1521 to 1523, inclusive into connection with the line of the called sub-station, that is, that the line switch L. S.—9 is plunged in on the trunk which includes the trunk equipment T. E.—1 and is the trunk equipment selected by the trunking switch L. S.—6. The line switch L. S.—9 is maintained operated by a locking circuit that extends over the conductor 1293 which is the release trunk.

The relay 1328 in the link control equipment is operated to bring about the movement of the master switches M. S.—6 and M. S.—9 to position the line switches of all the trunking switches such as L. S.—6 and all incoming line switches such as L. S.—9 controlled by each in association with an

idle trunk line, in each case. The movement of the master switch wipers 1330 to 1333, inclusive, to bring about the release of the link control equipment shown on Figs. 13 and 14 in the same manner as has been described before.

functions. When the connection is released restoration of the line switch L. S.—9 restores the battery connection to the called line so that an outgoing call may be made from that line in a manner similar to the manner in which the outgoing call was made from the line of the sub-station T.

The manner in which a call may be extended to another office in the metropolitan exchange area will now be described. For this purpose it will be assumed that the subscriber at sub-station T desires to call a subscriber whose number is Armitage 4321. In order to accomplish this result the subscriber at sub-station T will remove his receiver and operate his calling device in accordance with the alphabetical designation A. R. M. and then the numerical designation 4321.

By the removal of the receiver the line switch L. S. constituting the outgoing terminal on the subscribers line is operated to extend the line over an idle trunk. It will be assumed that the line switch L. S. operates to extend the subscriber's line in the same manner as before to the trunk line comprising conductors 341, 342 and 343. The operations in this case are identically the same as those already described. When the subscriber operates his push button calling device in accordance with the digit A. which in this instance is the same as the numerical designation 1 the first identifying relay in the link, shown on Fig. 4, namely, the relay 401 is deenergized while the remaining identifying relays remain operated. The deenergization of this relay serves to complete a circuit where a predetermined one of the ten terminal switches which serve to extend the calling line to a director unit. For the purposes of the present description it will be assumed that this line switch is the line switch or trunking switch L. S.—3, Fig. 5. This switch is operated in the same manner as before to extend the calling line to a director unit. It will be assumed that this director unit is the one shown on Figs. 6, 7 and 8. The identifying relays 606 to 615, inclusive, are now operated to bring about the operation of a registering relay in each group in substantially the same manner as before. It will be assumed that the registering relay 632 is the one operated in the first group, the relay 709 the one operated in the second group. The first relay from the left will be the one operated in the third group; the third relay from the left the one operated in the fourth group; the second relay from the left the one operated in the fifth group and the first relay the one operated in the sixth group. These are the relays that correspond to the numerical designation of the last six digits of the called subscriber's number. A circuit is now completed by the operation of the registering relays 632 in the first group and 709 in the second group which extends from

Ringing current is now applied to the line of the called subscriber over a circuit which extends from the generator G conductor 1480, armature 1432 and its front contact, back contact and armature 1439, conductor 1291, spring 1521 and its working contact, called line loop comprising conductors 1530 and 1531, including the ringer and condenser at the called station, working contact of spring 1523 and said spring, conductor 1293 and armature 1440 and its back contact and upper winding of ring cut-off relay 1414 to ground. The ring cut-off relay 1414 is not energized over this circuit since it is so constructed as not to respond to alternating current.

When the called subscriber at sub-station T—2 removes his receiver direct current is permitted to flow over the above traced ringing circuit and the relay 1414 is energized to establish a locking circuit for itself at armature 1441, to open a point in its own circuit at armature 1440 and to complete a point in the talking circuit at the front contact of this armature, and to complete another point in the talking circuit at armature 1439.

Talking battery is now supplied to the called subscriber at the sub-station T—2 from the windings of the relay 1413. Conversation may be carried on between the two subscribers over the talking circuit indicated by a heavy line extending from the sub-station T to the substation T—2.

The release of the connection occurs when both subscribers replace their receivers upon their respective switch hooks thereby bringing about the deenergization of the relay 1413. The deenergization of the relay 1413 brings about the release of the connection in the same manner as before described. There is this slight difference, however, that the line switch L. S.—9 of the called subscriber at sub-station T—2 since it is maintained operated from the ground on the release trunk conductor 1293 it is also released so as to restore the line of the sub-station T—2 to normal.

It will be seen that when the line switch L. S.—9 was operated in extending the connection to this subscriber's line that the springs 1530 and 1531 were operated to open the connection of the line which extends to the outgoing terminal of the line switch associated with the sub-station T—2. This brings about the so-called bridge cut-off, that is, the removal of the battery bridge attachment when the line is seized so as not to interfere with either the talking or ringing

ground through relay 634, armature 662 and its front contact, conductor 695, working contact of spring 750 and said spring, conductors 787 and station translating relay 816 to battery. The relay 816 is energized. The relay 634 is also operated over the above circuit and serves to complete a circuit for the upper winding of the relay 810 in the same manner as before.

10 The relay 810 is energized to attract its armatures 826, 827 and 830. By the operation of the armature 826 ground is connected to the terminal 860 of the I. D. F. in order to alter the conductance of the control circuit from the director in a manner similar to that already described. The operation of the armature 830 completes a circuit for the relay 822 and this relay is energized to remove the short circuit from the resistor 890.

20 The finder switch F—1 shown on Fig. 9 and the link control equipment illustrated therein is associated with the trunk line comprising conductors 489, 491 and 493 because of the deenergization of the relay 605 which occurs during the operation of the identifying relay 606 to 615, inclusive. In the link control circuit shown in Fig. 9 the identifying relays 901 to 910, inclusive, are operated. Now, when the control circuit from director is modified by a change of conductance in the manner described the relay 901 is deenergized while the other identifying relays 902 to 910 remain with their armatures attracted. The deenergization of the relay 901 completes a circuit for the registering relay 917.

40 The registering relay 917 is operated to establish a locking circuit for itself at armature 973 and to complete an operating circuit at armatures 974 and 975. It will be understood, of course, that the master switch M. S. is operated to select another idle trunk and to disassociate the link control equipment shown in Fig. 4 from the selected trunk line as soon as the proper trunking switch has been operated to extend the calling line to the director. These operations occur in substantially the same manner as before described.

50 By the operation of the relay 917 there is a circuit completed which extends from ground by way of back contact and armature 971, armature 975 and its front contact, armature 953 and its front contact, wiper 942, bank contact 962, conductor 493, spring 1054 and its resting contact, coil 1050 of the switch L. S.—5, conductor 990, front contact and armature 974 and relay 927 to battery. The relay 927 is energized in series with the coil 1050 of the trunking switch L. S.—5. By the operation of the relay 927 there is a circuit prepared for the relay 928 at armature 969 and at armature 971 the short circuit is removed from the resistor 970. This modifies the conductance of a circuit extending back to the director so that the relay 820 thereof is

deenergized to complete a circuit for the relay 819. The relay 819 is operated to open the circuit for the upper winding of the relay 810 and this relay is completely operated thereby bringing about the removal of ground from the terminal 860 of the I. D. F. and bringing about the deenergization of the relay 822. The latter operation again places ground so as to short circuit the resistor 890.

70 The coil 1050 of the trunking switch L. S.—5 is operated to bring about the operation of the springs 1053 and 1054. The operation of the spring 1053 serves to complete a circuit for the pull down coil 1051. The latter coil is energized to attract the pull down armature 1058. It will be assumed that the master switch M. S.—5 has brought about the selection of the trunk line, one set of whose terminals are the terminals 1055 to 1057 in the trunking switch L. S.—5. The springs 1055 to 1057, inclusive, are closed to extends the call of the conductors 1096 to 1098, inclusive. In this manner the connection is extended to the outgoing repeater O. R. The trunk line by virtue of this repeater is converted into two conductors 1690 and 1691 leading to the desired exchange, it being assumed in this instance that there is a trunk line from the exchange in which the line of the sub-station T terminates to the Armitage exchange.

95 It was stated that the master switch M. S.—5 brought about the pre-selection of the trunk line comprising conductors 1095 to 1097, inclusive. The movement of the master switch also pre-selects the repeater control link shown in Fig. 16. This is accomplished in the following manner: When the relay 1060 associated with the master switch M. S.—5 is deenergized as a result of an idle trunk line having been selected, there is a circuit completed which extends from ground by way of armature 1062 and its back contact, conductor 1088, master switch wiper 1646, bank contact 1647 associated with the pre-selected trunk and the relay 1630 to battery. The relay 1630 is energized to bring about the operation of the finder switch F.—4. The relay 1630 upon operating removes the ground connection from the test contact 1648 in the bank of the finder switch F.—4 at armature 1640 and at the front contact of this armature complete a circuit which extends from ground by way of back contact and armature 1648, armature 1640 and its front contact, armature 1652 and its back contact and upper winding of relay 1627 to battery. Relay 1627 is energized to connect the test wiper 1636 to a point midway in the circuit extending between the motor magnet and the switching relay and to complete a circuit for the switching relay 1626 at armature 1665 and its front contact. Since the test wiper 1636 is connected at a point in the above circuit midway between the switching relay and the motor magnet. The

motor magnet 1635 will be operated until the switch wipers 1636 to 1641, inclusive, are rotated into engagement with the bank contacts with which the trunk line comprising conductors 1096 to 1098, inclusive, is associated, which are the bank contacts designated as 1666 to 1672, inclusive. When this occurs the short circuits is removed from the switching relay 1626 and this relay is energized in series with the motor magnet 1635. The relay 1626 is operated over this circuit to establish a point in its locking circuit at armature 1651, to prepare a test circuit at armature 1653, to open a point in the circuit of the upper winding of the line relay 1627 and to extend the starting wire to an idle finder switch similar to the finder switch F. over conductor 1675. Another result of the operation of the relay 1626 is that at armature 1674 there is a circuit completed which extends from ground by way of armature 1657 and its back contact, front contact and armature 1674, wiper 1636, bank contact 1666, front contact and armature 1673 and relay 1676 to battery. The relay 1676 is energized over this circuit to remove ground from the armature 1640 of the relay 1630. This is done so that when the start wire is extended to the next idle finder switch ground will no longer be present upon it through the armature 1640. The relay 1627 is deenergized when its circuit is opened by the operation of the relay 1626 for the reason that a new circuit has been completed for it in series with its lower winding, the switching relay 1626 and the motor magnet 1635. All the foregoing results are brought about by the movement of the master switch wipers 1645 and 1646 in controlling the operation of the master switch M. S.—5 in its operation to select an idle trunk. The finder switch F.—4 is thus also associated with the preselected trunk.

Returning now to the progress of the connection, it will be remembered that the trunking switch L. S.—5 was operated to extend a connection to the trunk line comprising conductors 1096 to 1098, inclusive. When this occurs there is a circuit completed from the director to the identifying relays 1602 to 1611, inclusive. This circuit extends from battery to the lower windings of the identifying relays in multiple, front contact and armature 1656, wiper 1638, bank contact 1668, conductor 1096, spring 1055 and its working contact, conductor 489 and then over the same circuit as before traced to ground in the director. The identifying relays 1602 to 1611, inclusive are energized over this circuit to prepare certain selecting circuits to connect ground to their upper windings so as to properly proportion the amount of current passing through the upper windings at armatures 1676 and 1677, to complete a bridge across the trunk conductors 1690 and 1691 at armatures 1678 and 1679. The current

flow in the upper windings of the identifying relays is graduated so as to bring about the proper selecting operation of these relays upon the proper amount of current flowing in their lower windings. There is also a circuit completed which extends from ground by way of armature 1676 and its front contact, resistor 1680, finder switch wiper 1637, bank contact 1667, trunk conductor 1097, spring 1057 and its working contact to conductor 493 and thence over circuit similar to that already traced through the lower winding of the identifying relays 820 and 821 in the director. The relay 820 is deenergized under these conditions to complete a circuit for the relay 819 which is operated to bring about the complete operation of the relay 810. The relay 810 upon operating opens a circuit of the relay 822 and removes ground from the terminal 860 of the I. D. F. The deenergization of the relay 822 again short circuits the resistor 890.

There is also a circuit completed when the identifying relays 1602 to 1611 are operated which extends from ground by way of armature 1676 and its front contact, resistor 1680, wiper 1637 and its front contact, bank contact 1667, conductor 1097, spring 1056 and its working contact, conductor 489, bank contact 960, wiper 941, armature 956 and its working contact and upper winding of identifying relay 911 to battery. The relay 911 is deenergized to complete a circuit for the relay 928. The relay 928 is operated to open the locking circuit of the relay 915. The relay 915 is deenergized to bring about the release of the finder switch F.—1 and its associated link control circuits.

It will be seen that immediately upon the line switch L. S.—5 being operated ground is connected to the release trunk conductor 1097 whereby a circuit is completed for the starting relay 1060 of the master switch M. S.—5, whereby the master switch M. S.—5 is caused to select an idle trunk for the remaining trunking switches controlled by it.

There is a bridge across the trunk conductors 1690 and 1691 which can be traced from conductor 1690, bank contact 1671, wiper 1640, armature 1654 and its front contact, lower winding of electro polarize relay 1628, front contact and armature 1678, relay 1614, back contact and armature 1681, wiper 1641, bank contact 1672 and conductor 1691 to battery. The electro polarize relay 1628 is not operated at this time because there is a circuit completed for its lower winding from ground on armature 1676. The relay 1614 is energized over this circuit to prepare a circuit for the relay 1612. It will be recalled that when the line switch L. S.—5 was first operated that the relay 927 was energized to bring about the operation of the relay 820 in the director. The operation of the relay 820 brings about the complete operation of the re-

lay 810 and the deenergization of the relay 822. By the latter operation the resistor 890 is short circuited. Now when the relay 915 is deenergized the conductance of the circuit extending to the relays 820 and 821 in the director is altered and the relay 820 is again energized to open the circuit of the relay 819. The latter relay is deenergized to complete a circuit for the upper winding of the relay 809.

Since it has been assumed that there is a trunk line extending from the exchange in which the line of the subscriber at substation T terminates to the exchange in which the wanted subscriber is located at, the operation of the trunking switch L. S.—5 brought about the selection of a trunk to the wanted exchange and there is no necessity for any other exchange selection control on the part of the director. The director now proceeds to eliminate the remaining exchange selecting circuits. The operation of the relay 809 brings about the connection of ground to the terminal 834 of the I. D. F. whereby a circuit is completed for the relay 818. The relay 818 is energized to open the circuit of the lower winding in the relay 809 and to place a short circuit on the resistor 890. The relay 809 is completely operated to open the circuit of the relay 818 which is deenergized to complete a circuit for the upper winding of the relay 808. This intermittent operation continues until the relay 805 is energized. The operation of the relays 802 to 805, inclusive, bring about the numerical designation control and are necessary to control the setting of the selecting apparatus in the distant exchange so as to bring about the selection of the wanted subscriber's line. The operation of the relay 805 serves to complete a circuit for the relay 822 and to connect ground to the multiplied armatures of the relay constituting the numerical registering group G. Since the numerical designation of the wanted subscriber's line is 4321 ground is connected to the conductor 850 of the I. D. F. and the conductance of the circuit leading to the identifying relays of Fig. 16 is modified so that the relay 1605 retracts its armature while all the other relays maintain their armatures attracted. This modification of the electrical conductance of the control circuit occurs since the relay 822 is operated to remove the short circuit of the resistor 890. The deenergization of the relay 1605 brings about the operation of the relay 1618 in series with the relay 1625. The relay 1618 operates its armature 1686 whereby a certain amount of the resistor 1692 may be included in the bridge circuit extending across the trunk conductor. The operation of the relay 1625 serves to open the bridge circuit at one point, namely, armature 1681. The operation of the armature 1685 serves to complete a circuit for the relay 1612.

The trunk line comprising conductors 1690 and 1691 terminates at the Franklin exchange in an incoming repeater equipment I. R. Now, when the bridge is first completed across the trunk conductors 1690 and 1691 by the operation of the armatures the relay 1728 is energized in the incoming repeater I. R. The relay 1728 is energized to prepare a circuit for the relay 1729 at armature 1760, to remove ground from the test contact 1725 at armature 1761 and to complete a circuit at the front contact of this armature which extends from ground, armature 1761 and its front contact, armature 1779 and its back contact and upper winding of line relay 1714 to battery. The line relay 1714 is energized to complete a circuit for the relay 1713 at armature 1782, and at armature 1785 to connect the test wiper 1740 to the above circuit at a point midway between the switching relay and the motor magnet 1712. The motor magnet 1712 is intermittently operated until the switch wipers 1740 to 1743, inclusive, are brought into engagement with the bank contacts which designate the terminals of trunk line comprising conductors 1690 and 1691 in the banks of the finder switch F—5. When the wipers 1740 to 1743 are brought into engagement with this set of bank contacts switching relay 1713 is energized to open a point in the testing circuit at armature 1776, to prepare a circuit for the relay 1716 at the front contact of this armature, to complete a point in the circuit of the identifying relays 1702 to 1711, inclusive, at armature 1777, to prepare a point in the locking circuit for itself at armature 1778, to disconnect the upper winding of the line relay 1714 at armature 1779 and to extend the starter wire to the next idle finder at the front contact of this armature and to complete the circuit for the identifying relays 1702 to 1711, inclusive, at armature 1780. By the operation of the armature 1776 there is a circuit completed which extends from ground by way of armature 1781 and its front contact, front contact and armature 1776, wiper 1740 bank contact 1775, armature 1760 and its front contact and relay 1729 to battery. The relay 1729 is energized to prepare a locking circuit for itself at armature 1763, to prepare a circuit for identifying relays 1713 and 1732 at armature 1766 and to open the circuit of the relay 1728 at armature 1762 and 1765. The relays 1731 and 1732 are immediately energized. The relay 1729 is maintained energized by its armature 1764. It will be seen that the identifying relays 1702 to 1711, inclusive, are in bridge of the trunk conductors 1690 and 1691 over a path which extends from trunk conductor 1691, normally closed spring controlled by armature 1769, bank contact 1786, wiper 1743 and armature 1780 and its front contact to ground. The conductor 1690 extending by way of the normally closed spring controlled by armature 1767, bank con-

tact 1787, wiper 1742, armature 1777 and its front contact to the lower winding of the identifying relays 1702 to 1711, inclusive in multiple to battery. Since there is a bridge across the trunk conductors 1690 and 1691 in the repeater control link of Fig. 16 the identifying relays 1702 to 1711, inclusive, are immediately energized. The operation of the armature 1788 and 1789 on the relay 1702 and 1703 serves to complete a circuit for the lower winding of the identifying relays and also to complete a locking circuit for the relay 1713. This locking circuit short circuits the lower winding of the relay 1714 and this relay is deenergized to open one point in the testing circuit at armature 1785 and to open one point in the circuit of the relay 1713 at armature 1782.

Returning now to the operation of the repeater control link, the relay 1625 is energized to complete a circuit for the relay 1612 and to complete a new circuit across trunk conductors 1690 and 1691 effective. This circuit being one in which the conductance is modified in accordance with the number 4 numerical designation. This circuit may be traced from the trunk conductor 1691, bank contact 1672, wiper 1641, armature 1686 and its front contact, resistor 1692, relay 1614, armature 1678 and its front contact, lower winding of electropolarized relay 1628, front contact and armature 1654, wiper 1640, bank contact 1671 to trunk conductor 1690. It will be seen that a portion of the resistor 1692 is included in this circuit. Consequently the conductance of the trunk circuit over which the identifying relays 1702 to 1711, inclusive, are energized is modified so that the relay 1705 retracts its armature 1795, while the armatures of all the other identifying relays remain attracted. By the operation of the armature 1795 there is a circuit completed for the registering relay 1720. The operation of the registering relay 1720 completes a circuit for operating the trunking switch L. S.—18, which it will be remembered is located in the first stage of selection in the incoming office, namely, the Franklin exchange. The circuit over which the trunking switch L. S.—18 is operated may be traced to battery through relay 1727, armature 1796 and its front contact, conductor 1790, coil 1801 of the trunking switch L. S.—18, working contact of spring 1805 and said spring, conductor 1793, bank contact 1701, armature 1797 and its front contact and armature 1799 and its back contact to ground. The coil 1801 of the trunking switch L. S.—18 is energized over this circuit in series with the relay 1727. The trunking switch L. S.—18 is operated to extend the connection to the pre-selected idle trunk with which it is associated in the usual manner. The master switch M. S.—18 has, therefore, brought about the association of a control link unit

similar to the link unit of Fig. 11 with the pre-selected idle trunk.

The relay 1727 upon operating removes ground at armature 1781 from the test wiper 1740 and at armature 1799 removes a short circuit from the resistor 1798. This alters the conductance of the circuit for the lower winding of the identifying relays 1731 and 1732 and the relay 1732 retracts its armature 1772. The relay 1731 maintains its armature attracted. The deenergization of the relay 1732 serves to complete a circuit for the relay 1733. The relay 1733 is energized to connect ground to conductor 1691 thereby completing a local circuit for the identifying relays 1702 to 1711, inclusive. It will be seen that direct ground is now connected to both sides of the trunk conductors 1790 and 1791. There is no current flow over these trunk conductors for a moment and certain operations are brought about in the repeating equipment in the originating exchange.

At the originating exchange the relay 1614 is maintained energized from battery at the distant exchange. Now when this battery circuit is changed so that there is no longer current flow over the trunk conductors the relay 1614 will be deenergized and the relay 1613 is energized in series with the relay 1612. The operation of the relay 1613 opens the circuit of the registering relay 1618 at armature 1692, opens its own circuit at armature 1693 and opens a point in the circuit of the relay 1612 at armature 1694. The relays 1612 and 1613 are immediately deenergized to restore their respective circuits to normal. One of the operations resulting from the operation of the relay 1612 when it was energized was that the conductance of the circuit extending back and including the testing relays 820 and 821 in the director was altered so as to bring about the deenergization of the relay 820 whereby a circuit was completed for the relay 819 which operated to open the circuit of the lower winding of the relay 805. The relay 805 was completely operated to open the circuit of the relay 822 which short circuits the resistor 890 and removes ground from the multiplied armatures of the registering relays of group G in the director. Now when the relay 1612 is deenergized the conductance of the circuit extending back to the relay 820 is again modified and the relay 820 is energized to open the circuit of the relay 819. The relay 819 is deenergized to complete a circuit for the upper winding of the relay 804. The relay 804 is operated to connect ground to the multiplied armatures of the registering relay group G—1 and to complete a circuit for the relay 822. The former operation brings about the connection of ground to the terminal 891 of the I. D. F. The latter operation removes the short circuit from the resistor 890. By these operations the conductance of the control cir-

cuit which includes the identifying relays 1602 to 1611, inclusive, is again modified and the relay 1604 retracts its armature to complete a circuit for the registering relay 1617.

8 The registering relay 1617 is energized to complete a new circuit in bridge of the trunk conductors at armature 1695. The relay 1625 is operated to prepare a new circuit for the relay 1612.

10 When the relay 1733 is energized at the distant exchange there is a circuit completed for the relay 1734 which is operated to establish a locking circuit for itself at armature 1736, to open a point in its original energizing circuit at the normally closed springs controlled by this armature and to connect ground by way of armature 1770 and its back contact and armature 1737 and its front contact to the conductor 1691. This operation permanently grounds the conductor 1691 so that the link controlling apparatus that is used for local exchange calls may also be used for incoming calls. This modification is necessary because the local exchange link controller circuits are operated over one conductor, while the repeater is operated over the two conductors.

In the distant exchange the operation of the trunking switch L. S.—18 serves to connect or extend the call to a control link which has been associated with the pre-selected trunk by the operation of the master switch M. S.—18. When the connection is extended to this identifying control link, the identifying relays therein are energized and the conductance of the circuit which supplies ground to the release trunk in this trunk is modified so as to bring about the deenergization of an identifying relay 1716 in the identifying control link of Fig. 17. The relay 1716 is deenergized to complete a circuit for the relay 1715. The latter relay is energized to open the circuit of the relay 1713 whereby the finder switch F—5 and the controlling link equipment is disassociated from the trunk line comprising conductors 1690 and 1691. The link control equipment is thus restored to normal and rendered available for use in another call. The release of the relay 1713 brings about an alteration in the conductance of the circuit including the identifying relays 1731, 1732 and the identifying relay 1732 is again operated to open the circuit of the relay 1733 and the relay 1733 is operated to remove the ground connection from the conductor 1791. This operation again establishes the usual battery connection to the trunk conductors 1690 and 1691, whereby the relay 1614 is again energized to complete a circuit for the relay 1612. The latter relay is operated to alter the conductance of the test circuit extending back to the director whereby the relay 820 is deenergized to complete a circuit for the relay 819, which is operated to open the circuit of the relay 804.

The relay 804 brings about the removal of ground potential from the terminal 891 of the I. D. F. and the opening of the circuit of the relay 822 which is deenergized to short circuit the resistor 890.

Ground is supplied to the release trunk conductor 1792 in the control link that is associated with the extended call by the master switch M. S.—18. This maintains the relay 1729 energized in the incoming repeater equipment I. R.

By the modification of the conductance of the bridge across the trunk conductors in the originating exchange one of the identifying relays of the next control link is deenergized to complete a circuit for its associated registering relay. This control equipment is identically similar to that shown in Fig. 11. Since it has been assumed that there is a trunk line extending from the originating exchange directly to the wanted exchange the further extension of the call is identically similar to the extension of the call in the local exchange, which was completed between the subscribers at substation T and T-1. It is thought that these operations will be apparent without further description. After the completion of each stage of selection the conductance of the circuit including the identifying relays is altered so as to bring about the deenergization of the relay 1732 to complete a circuit for the relay 1733. The relay 1733 is deenergized to bring about the deenergization of the relay 1614 in the distant exchange. The deenergization of the relay 1614 in controlling the operation of the director has already been described. This operation occurs repeatedly until the connection is finally extended to the wanted telephone line. When this connection is made a test is made to determine whether the wanted telephone line is busy or idle. In either event, however, the conductance of the test circuit extending back and including the identifying relays 1731 and 1732 is modified so that the relay 1731 is deenergized while the relay 1732 maintains its armature attracted. The relay 1730 is energized to establish a locking circuit for itself to ground upon the release trunk conductor 1792 at armature 1768, to disconnect the identifying relays 1731 and 1732 from a portion of the test circuit at armature 1738 and to reverse the connections of the trunk conductors 1791 and 1793 with respect to the trunk conductors 1690 and 1691. By this operation there is a reversal of current flow through the lower winding of the electropolarized relay 1628 and this relay is energized to connect a certain amount of resistance to ground in series with the conductor 1098 which extends back to the test circuit in the director including the identifying relays 820 and 821. The relay 821 is now deenergized to complete a circuit for the relay 817. The latter relay is operated to connect

ground to conductor 552. The connection of ground to the conductor 552 brings about the functioning of relays in the trunk equipment T. E. to bring about the release of the director and its associated apparatus, thus rendering it available for another call.

In the Armitage exchange the link control equipment that brings about the connection of the wanted subscriber's line is also released and if the called line is busy the subscriber at the calling sub-station is informed of the fact or, if the called line is idle, ringing current is automatically and intermittently applied thereto until the called subscriber removes his receiver from the switch hook. Conversation may be carried on between the two subscribers over the usual talking circuit indicated by the heavy conductors. The selecting apparatus in the Armitage exchange is maintained operated by a holding circuit which is supplied with ground from a relay in the trunk equipment associated with the trunk to which the called subscriber is connected similar to the relay 1413 in the trunk equipment T. E.—1 of Fig. 14.

Prior to this time the operation of the electropolarized relay also brings about the deenergization of the relay 1631 in the outgoing repeater O. R. The relay 1631 is deenergized to complete a circuit for the relay 1632. The relay 1632 is operated to complete the talking circuit at armatures 1661 and 1662 and establish a locking circuit for itself at armature 1660. The operation of the relay 1628 in the repeater control link equipment completes a circuit for the relay 1629. The relay 1629 is energized to open the locking circuit of the relay 1626. The relay 1626 is deenergized to disassociate the repeater control link from the connection and render it available for other calls. The deenergization of the relay 1626 restores all the relays and apparatus of the repeater control link to normal.

The line relay 1633 is now energized over the calling line loop, the director having been disconnected by the operation of the trunk equipment T. E. The calling telephone is supplied with battery from the windings of this relay.

When the conversation is through, the replacement of the receiver at the calling telephone brings about the deenergization of the relay 1633 which removes ground from the release trunk conductor 1097. By this operation the holding circuit of all the relays in the proceeding switches are opened and these relays are deenergized to bring about the release of the connection in the same manner as before. That is, by the removal of ground from the release trunk conductor the operated relays in the trunk equipment T. E. are released as are the trunking switches and the calling subscriber's line switch. Because the trunking switches and the calling subscriber's

line switch are self-aligning they are immediately aligned with the other switches in their respective groups and are ready to be used for another call. In addition the deenergization of the relay 1633 opens the bridge across the trunk conductors through the high impedance relay 1634. The relay which supplies talking battery to the called subscriber is deenergized when the called subscriber replaces his receiver upon the switch hook. This relay also maintains a holding circuit for the various trunking switches in the distant exchange so that when it is deenergized the holding circuit is opened and these various switches are released. This occurs in substantially the same manner as has already been described. In this manner the connection is released when the conversation between the two subscribers is terminated.

When the subscriber in an exchange which is the subscriber at sub-station T desires to establish a connection with a subscriber located in another exchange where it is necessary to tandem through an intermediate exchange the operation is substantially the same as that already described with the exception that the connections on the I. D. F. are so arranged that the proper control is exercised by the director for these intermediate tandem exchanges to enable the call to progress to the proper point. This is accomplished by proper jumpers in the intermediate distributing frame in an obvious manner. By this arrangement it is possible for a subscriber in one exchange to set up connection substantially instantaneously with the subscriber in any other exchange in the system.

In the description thus far the functioning of the director has been described with the subscriber at the calling sub-station first registering the digits of the called number on the various registering relays, and then the control of the director in establishing the connection has been described. It will be understood, of course, that these operations proceed simultaneously, that is, while the digits of the called number are being registered on the director, the director is simultaneously controlling the extension of the connection. Under some conditions it may be desirable to prevent the director functioning until all the digits have been registered. This, of course, can very readily be accomplished. It may be found, for instance, that the subscribers are not able to set up the digits of the called number as fast as the director can function and consequently it may be desirable to hold the connection until all the digits have been registered to insure that the connection is established at maximum speed through the various trunking switches. To accomplish this result it is only necessary to connect ground to the conductor 697 by the operation of the switch over relay which is the last in the chain, namely, number 601. Under these conditions it is

probably desirable to delay the operation of the finder switch F until the last digit has been registered. This can be accomplished by the connection of ground to conductor 526 by the operation of the relay 601 instead of by the operation of the relay 605 as at present.

The manner in which certain special conditions are taken care of notably in the releasing of the connection at any time under the control of the calling subscriber will now be described. In the release of the connection when the call is in the same exchange as the original subscriber it will be seen that the identifying relays are always under the control of the director and the identifying relays in the director are under the control of the calling line. Should the subscriber at the calling sub-station hang up at any time the identifying relays 606 to 615 are deenergized and ground is connected at armatures 698 and 699 to the conductor 552 which brings about the release of the director equipment in the same manner as before. Since the control loop to the calling station is opened there is no circuit for the identifying relays to which the call has been extended and these relays are immediately deenergized to remove ground from the release trunk conductor whereby the holding circuit of all the trunking switches are opened as well as the line switch of the calling line and the connection is immediately released. The conductor 552 is not grounded during the normal operation of the relays 609 and 610 because only one of them can be deenergized at the same time unless the subscriber hangs up his receiver. The director also controls the release of the equipment in the distant exchange or exchanges in what is thought to be an obvious matter.

It will be noted that a slow acting electrically operated device 617 is shown associated with the director. This device may be provided so a calling subscriber cannot tie up one of the directive mechanisms which is common to a plurality of calls for an indefinite length of time. Since instantaneous controlling circuits are at the disposal of the subscriber it is possible for him to register the wanted number as fast as he can operate his push buttons to designate them. In order to obtain the maximum advantage of this kind of operation it is desirable that the subscribers be educated so that they will operate their push button calling devices very rapidly. A certain interval might be definitely assigned in which all the subscriber's number must be registered or the director will be released. This can be very easily accomplished by the operation of the timing device 617 which is set to operate within the interval permitted. If the subscriber registers all his number before this device is operated, as he should do, this circuit may be opened by the operation of any relay that is

operated in the last group of registering relays G 3. Unless the wanted subscriber's number has been registered during this interval the operation of the slow acting device 617 may connect ground to the conductor 552 thereby releasing the director mechanism by operating a relay in the trunk equipment T. E. The operation of the trunk equipment T. E. at this time may give the subscriber a busy signal or signal him that he is slow in operating his push button calling device. It is thought that the manner in which this might be accomplished is obvious from the foregoing description.

It will be seen that I have devised a highly novel inter-office trunking system in which the inter-office trunks may be allotted and grouped in accordance with the maximum trunking efficiency as indicated by traffic studies. It will also be seen that by treating each office as a unit that the number of stages of selection in any one office are limited to four irrespective of the size of the system. This greatly reduces the cost of the exchange of the metropolitan exchange system. In addition all the trunking throughout the system is standardized. It will also be seen that a call may be extended substantially instantaneously from one calling line to the called line. Further that the extension of the call in any connection is controlled by apparatus at each stage which is common to a plurality of connections and is only used for a short instant of time while controlling a particular connection and then is restored to common use. In this manner the cost of the exchange equipment is greatly reduced. When the connection is finally established it will be seen that the apparatus included in the connection is of very simple character; all the complicated common apparatus having been released and made available for other calls. The cost of the metropolitan exchange system of this type is also greatly reduced by the fact that only one type of switching mechanism is used throughout, namely, switches on the non-numerical type. Since the mechanical construction of the apparatus is greatly simplified and the mechanical construction of the various stages is the same the system is very readily adapted to quantity production. Attention is also called to the manner in which all the trunks in any given connection between a calling and called subscriber are pre-selected so that no time is consumed for the usual trunk hunting operation. Attention is also called to the fact that the instantaneous control circuit has been applied to the subscriber's sub-stations so that they may instantaneously bring about selection in a large metropolitan exchange system. However, many of the advantages of this trunking system and apparatus disclosed herein may be obtained with the use of ordinary two wire telephone control circuits.

While I have shown a particular embodiment of my invention, it will be understood that many modifications, deviations and departures may be made and that I do not wish to be limited to the specific embodiment illustrated and described herein, but desire to protect by Letters Patent all such changes, modifications, departures and deviations as come within the scope of the appended claims.

10 I claim:—

1. In an automatic telephone system, a line terminating in a switch, a plurality of trunks, switch control mechanism, means for maintaining said switch associated with an idle one of said trunks and for maintaining said switch control mechanism associated with the same idle trunk, a separate group of switches terminating each of said trunks, means for operating said first switch responsive to the initiation of a call over said line to connect with the trunk associated therewith at the time the call is initiated, said control mechanism being operable over said line to initiate the operation of a particular one of the switches terminating the connected trunk line, the switch operated depending on the digit for which the calling device at the station on the line is operated.

2. In an automatic telephone system, a plurality of trunks over any one of which a call may be extended from a calling station, a separate group of switches terminating each of said trunks, and control mechanism common to all said switches for operating a certain one of said switches independently of the rest, the switch being operated depending on the trunk over which the call is extended and the digit for which the calling device at the calling station is operated.

3. In an automatic telephone system, a plurality of trunks, a separate group of switches terminating each of said trunks, and digit responsive control mechanism common to all of said switches for controlling any one of said switches independently of the rest.

4. In an automatic telephone system, a group of plunger line switches, a group of trunks accessible to said switches, a master switch for maintaining the idle ones of said plunger line switches associated with an idle one of said trunks, a switch terminating each of said trunks, control mechanism for controlling the operation of the switches terminating said trunks, and means controlled by said master switch for maintaining said control mechanism associated with the same trunk with which the plunger line switches are associated.

5. In an automatic telephone system, a group of plunger line switches, a group of trunks accessible to said switches, a master switch for maintaining the idle ones of said plunger line switches associated with an idle one of said trunks, a switch terminating each of said trunks, control mechanism for con-

trolling the operation of the switches terminating said trunks, and means controlled by said master switch for maintaining said control mechanism associated with the same trunk with which the plunger line switches are associated and means responsive to the operation of one of said switches terminating said trunks for causing said master switch and the means controlled thereby to associate the idle ones of said plunger line switch and said controlling mechanism with another idle trunk.

6. In an automatic telephone system, a trunk terminating in a switch, a director and means for associating it with said trunk line, switch controlling mechanism and means for associating it with said trunk line, means in said controlling mechanism responsive to the association of said director with said trunk line for altering the conductance of a circuit including one conductor of said trunk line, means in said director responsive to said alteration for altering the conductance of a circuit including another conductor of said trunk line and means in said controlling mechanism responsive to said last alteration for controlling said switch.

7. In an automatic telephone system, a trunk line terminating in a plurality of switches, a director for registering digits, means for associating said director with said trunk line, switch controlling mechanism and means for associating it with said trunk line, means in said controlling mechanism responsive to the association of said director with said trunk line for altering the conductance of a circuit including one conductor of said trunk line, means in said director responsive to said alteration for altering the conductance of a circuit including another conductor of said trunk line, the degree of alteration depending on the magnitude of one of the digits registered, and means in said controlling mechanism responsive to said last alteration for controlling one of said switches, the switch controlled depending on the degree of said last alteration.

8. In an automatic telephone system, a plurality of groups of switches, a control mechanism, positioning means for maintaining said control mechanism, associated with a group of switches in which all the switches are idle, means in said control mechanism for selectively operating any one of the switches in the group with which it is associated at any particular time, and means responsive to the operation of a switch for initiating the operation of said positioning means.

9. In a telephone system, a trunk line, a plurality of similar switches connected in parallel to said trunk line, and a separate group of trunk lines accessible to each switch, and means common to the switches for selectively operating any of the switches independently of the others.

10. In a telephone system, a group of trunks, a plurality of groups of switches, each group of switches containing one switch for each trunk, and a plurality of different lines accessible to the switches of the different groups, all the switches of each trunk being connected in parallel.

11. In a telephone system, a group of trunks, a plurality of groups of switches, each group of switches containing one switch for each trunk, a plurality of different lines accessible to the switches of the different groups, all the switches of each trunk being connected in parallel, and means common to each group of switches for controlling the switches in the group.

12. In a telephone system, a trunk line terminating in a plurality of switches connected in parallel, a director for registering digits, means for associating said director with said trunk line, switch controlling mechanism and means for associating it with said trunk line, said controlling mechanism including means for selectively operating any one of said switches independently of the others, and means in said director for controlling said controlling mechanism in accordance with the magnitude of a digit registered.

13. In an automatic telephone system, a plurality of exchanges, telephone lines terminating in each exchange, trunk lines connecting said exchanges, automatic switches for establishing a connection between a calling and called one of said lines in one of said exchanges, automatic switches for establishing a connection between a calling line in one exchange and a called line in another exchange over one of said trunk lines and means for pre-selecting the trunk lines employed in each of said connections.

In witness whereof, I hereunto subscribe my name this 19th day of November, 1927.

JOHN E. GARDNER.