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F. J. SCUDDER

2,034,883

TELEPHONE SYSTEM

Filed Oct. 12, 1933

3 Sheets-Sheet 2

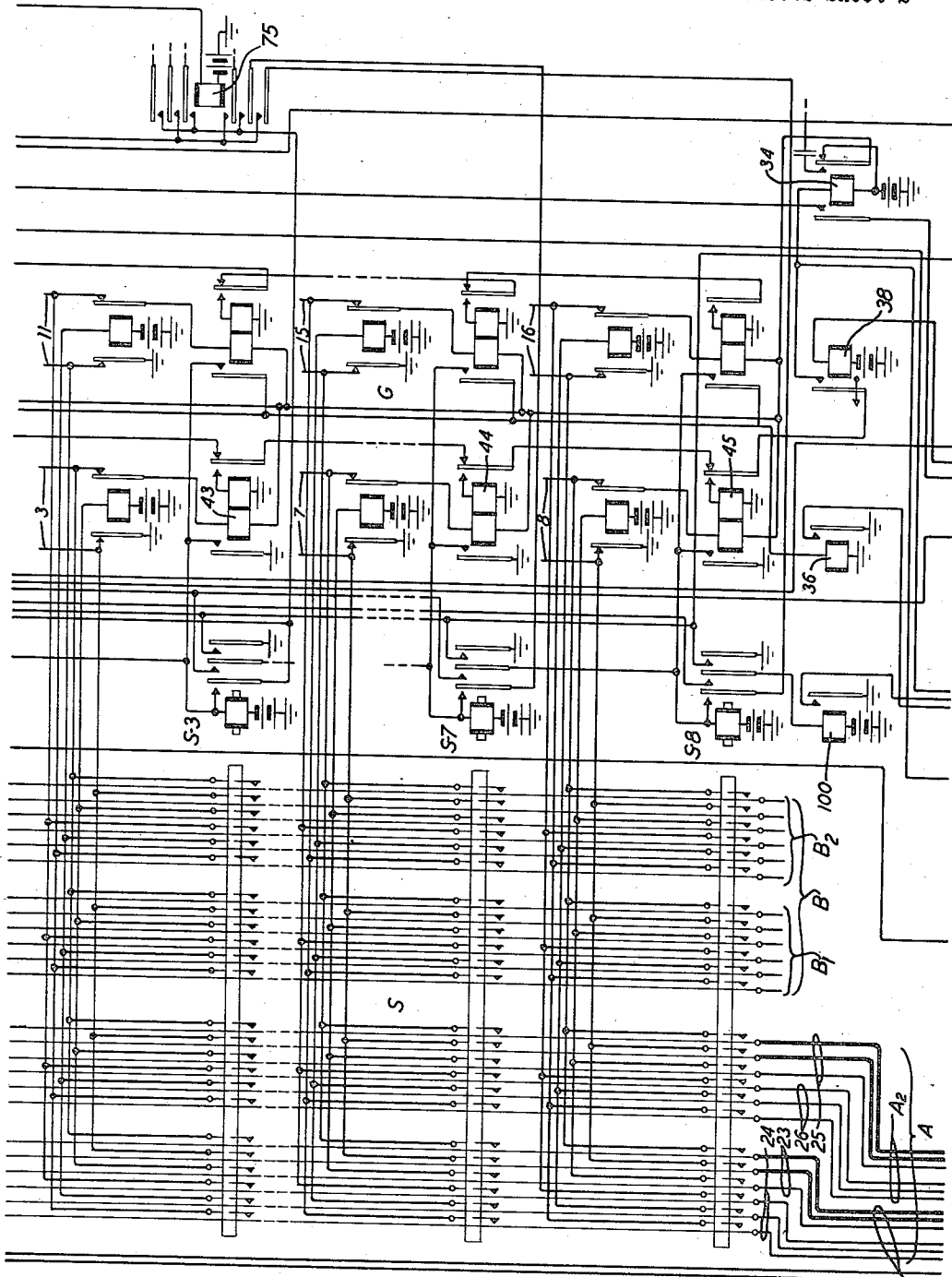


FIG. 2

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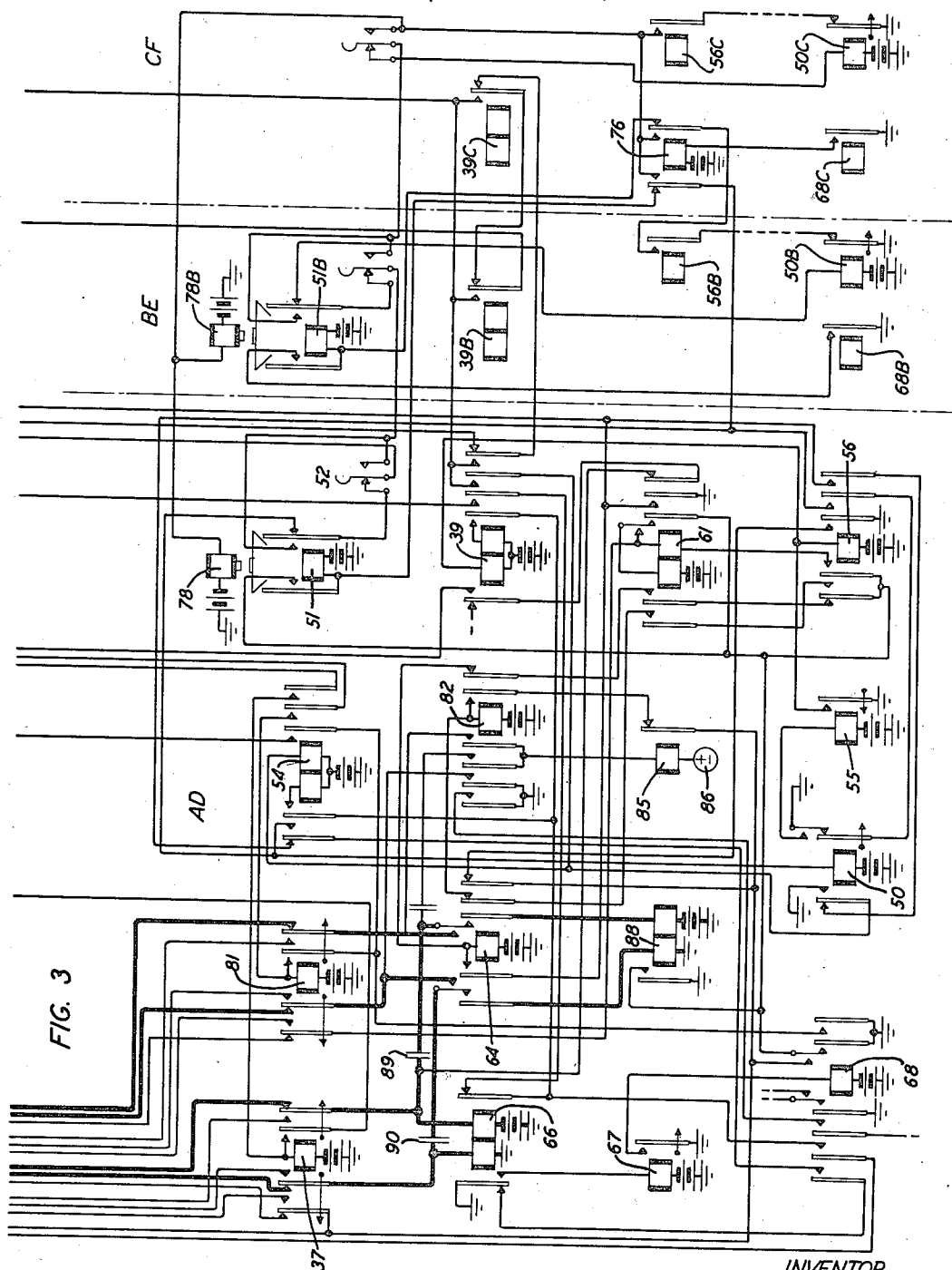
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3 Sheets-Sheet 3



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TELEPHONE SYSTEM

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Application October 12, 1933, Serial No. 693,265

18 Claims. (Cl. 179—22)

This invention relates to telephone systems and particularly to small capacity automatic telephone systems.

5 An object of the invention is to provide improved and economically arranged systems for automatically establishing connections between telephone lines by means of a single switching unit of the cross-bar type.

10 Another object of the invention is to increase the capacity of such switching units.

15 Heretofore systems have been provided in which a single cross-bar switch has been employed for establishing connections from one line to another in a single switch. A system of this kind is shown in a patent to L. R. Waller 1,567,309 of December 29, 1925. The copending application of Carpenter and Clark, Serial No. 693,287, filed on even date with the present application, now Patent No. 1,991,193, granted Feb. 12, 1935, 20 also shows an arrangement of this kind in which links are used, each comprising a line finder branch and a connector branch with means whereby the lines terminate at the cross-points of separate horizontal rows and the link branches 25 terminate in individual vertical rows of cross-connecting points. A calling line is connectable with the line finder branch of an idle link and the called line with the connector branch of this link.

30 A feature of the present invention is a system of this general type in which the calling or called lines terminating in the switch may be called horizontal lines and be arranged in pairs, each pair terminating at the cross-connecting points 35 in an individual horizontal row; and in which connecting branches or lines may be called vertical lines and be arranged in pairs, each pair terminating at the cross-connecting points in an individual vertical row, and in which two 40 pairs of such vertical lines are connectable to a single link. The arrangement is such that a calling horizontal line may be connected to the called horizontal line through a vertical line of an idle pair, the associated link and another vertical line of the associated pair. One embodiment 45 of this invention, therefore, contemplates the use of two groups of contact sets at each cross-connecting point for the connection of two horizontal lines with two vertical lines so that a call incoming on one of a pair of horizontal lines may 50 be extended through vertical lines of a line finder pair through the associated link and one vertical line of a connector pair to the called horizontal line of any pair.

55 A modified form of this system contemplates

groups of vertical lines arranged with one line finder vertical line and two connector vertical lines in each of a plurality of groups and a plurality of other groups arranged with two line finder vertical lines and two connector vertical lines in each group. The horizontal lines may in this case be arranged so that one horizontal line of each pair normally has access at cross-connecting points to the single line finder vertical line in one group and the other horizontal line 10 of each pair normally has access at cross-connecting points to the single line finder vertical lines of another group, and so that if a calling line of any pair of horizontal lines finds the associated single line finder vertical line busy, the call is 15 transferred to the groups having two line finder vertical lines where a connection may be established through the associated link through one of said line finder vertical lines.

This invention has been illustrated in the accompanying drawings in which Figs. 1, 2 and 3 20 arranged according to Fig. 4 show one embodiment of the invention, and in which Fig. 5 shows diagrammatically a modified form of the invention. An ordinary cross-bar switch of the type 25 disclosed in Patent 1,168,419 to J. N. Reynolds of January 18, 1916, may be employed and has been illustrated in diagrammatic form at S. This switch may be arranged for a number of lines 30 1 to 8 and 9 to 16 terminating in the switch at cross-points in contact sets arranged in horizontal rows. Lines 1, 2, 3, 7 and 8 and 9, 10, 11, 15 and 16 only have been shown and may be termed horizontal lines. At each cross-point in a horizontal row the contact sets of two lines are 35 shown, for example, lines 1 and 9 are shown terminating at contact sets 20 at one cross-point and at 21 at another cross-point in a horizontal row and so on. The contact sets of these lines have access at various cross-points to contact 40 sets associated with links such as A and B, each comprising four lines each of which may be termed vertical lines. The calling lines have access to the branch or vertical lines A1 of link A or B1 of link B and the called lines have access 45 to the branch A2 of link A or B2 of link B. For example, lines 1 and 9 have access through the contact set 20 to branch A1 if they are calling lines and if they are called lines they have access through contact set 21 to branch A2. If line 50 1 is calling a connection is made, for example at contact set 20 of branch A1 and then through these contacts through the group of conductors 23, while if line 9 had been a calling line this line would have access through contact set 20, 55

and the group of conductors 24 to a common equipment AD. Similarly, if line 1 is the desired line, it would be connected through the group of conductors 25 of branch A2 and the contact set 21, while if line 9 had been the called line, the connection would have extended through contact set 21 and the conductors 25 of branch A2 from the common equipment AD. Similarly any other line may be a calling or a called line and may establish a connection to branch A1 for calling lines through either set of conductors 23 or 24 and for called lines through the set of conductors 25 or 26 and corresponding contact sets of the cross-bar switch. In case, however, this link is in use, the connections will extend through the other link B or even through other links if link B is busy. In the cross-bar switch, no such link has been shown but certain relays individual to one such link have been shown at CF. Similarly, certain relays individual to link B have been shown at BE while the complete circuit arrangement and relays for the link A has been shown at AD. The relay and circuit equipment common to all links has been shown at G. The horizontal operating magnets for connecting the lines to the links have been shown as follows. The magnets for lines 1 and 9 at S1, for lines 2 and 10 at S2, for lines 3 and 11 at S3, for lines 7 and 15 at S7 and for lines 8 and 16 at S8. The vertical operating magnets have been shown at 28 for branch A1, at 29 for branch A2, at 30 for branch B1, and at 31 for branch B2, while the remaining vertical operating magnets for other links have been omitted.

It should be understood that the operation of one horizontal magnet and the operation of one vertical magnet and the release of the operated horizontal magnet causes a connection to be established between a line and a branch of an idle link at the corresponding cross-point and from thereon over either set or branch 23 or 24 for calling lines and over either set or branch 25 or 26 for called lines if a connection is made over the link A.

A description will now be made of the operation of the above mentioned system while establishing a connection from a calling line 1 to a called line 2 over the link A.

When the calling subscriber of line 1 lifts his receiver from the switchhook a connection is established through the subscriber's loop in the usual manner from ground at contacts of cut-off relay 32 over the subscriber's loop and back over contacts of the same relay 32 through a winding of line relay 33 to battery at the contacts of relay 34. Relay 33 operates and closes an obvious circuit for the operation of the horizontal magnet S1 for the subsequent operation of the set of contacts 20 and 21 or other contact sets in the same horizontal row. If line 9 had called line relay 35 would have operated and in that case in addition to the operation of the horizontal magnet S1, relay 36 would have operated over a circuit from battery through the winding of magnet S1, contacts of line relay 35, winding of relay 36 to ground. This relay 36 in operating would eventually cause the operation of relay 37 to switch from the group of conductors 23 to the group of conductors 24 to establish a connection from line 9 through the conductors 24 to the common equipment AD. In the present case, however, these relays 36 and 37 are not operated and when the connection is established from line 1, it will extend through conductors 23. Now, as it is assumed that the link A is idle, a circuit will be

completed for the operation of relay 38 from battery through the winding of this relay, contacts of relay 39 contacts of relays 39—B and 39—C in links BE and CF, respectively, to ground at contacts of magnet S1. The operation of relay 38 provides a locking circuit for line relay 33 and an operating circuit for relay 34 from battery through the winding of this relay, contacts of relay 38, contacts of the intermediate line relays such as 42, 43, 44 and 45, a winding of relay 33 to ground. Relay 34 in operating opens original energizing circuit for relay 33 and closes a circuit for the operation of relay 50 in the equipment AD from battery through the winding of this relay, contacts of relay 51, key 52, contacts of relay 34, contacts of relay 53, to ground at contacts of the vertical magnet 29.

Relay 50 causes the operation of relay 54 from battery through a winding of this relay, contacts of relay 50 to ground. Relay 54 would now close a circuit for the operation of relay 37 due to the operation of relay 35 in case line 9 had called. In this case, of course, this circuit is not closed as line 1 is the one calling. Relay 54 closes a holding circuit for itself to ground at relay 40. Relay 50 also closes a holding circuit for relay 34 independent of relay 38 to ground at relay 68. This relay 50 further closes an obvious circuit for relay 55 and this latter relay in operating closes obvious circuits for relays 56 and 39. Due to the operation of relays 56 and 39, a circuit is completed from the dial tone source at 59 (not shown) through contacts of relays 53, 39 and 61. To one of the conductors of the group 23 for transmission to the calling subscriber's line when the vertical magnet 28 is operated to close the connection through contact sets 20. It will be noted that the operation of relay 58 closes a circuit for this vertical magnet 28 from battery through the winding of this magnet, contacts of relay 64 to ground at contacts of relay 56. Magnet 28 in operating now closes the connection from conductors 23 to line 1 through the contact set 20 of the cross-bar switch in the usual manner. The operation of magnet 28 closes a holding circuit for relay 37 but as this relay is not operated, this circuit is not functioning. On the closing of the connection through the contact set 20, a circuit is completed for the cut-off relay 32 from battery through the winding of this relay, contacts of the set 20, the sleeve conductors of the group 23, contacts of relays 37 and 64 to ground at contacts of relay 56. The connection from the calling line 1 now extends through the contact set 20, over the tip and ring conductors of the group 23, contacts of relay 37, the two windings of the pulsing relay 66 to battery and ground. Dial tone is now also transmitted through the contact set 20 to the calling subscriber's line and relay 66 is operated through the calling subscriber's loop over the circuit hereinafter mentioned. Relay 66 closes an obvious circuit for the operation of relay 67 and this relay in turn an obvious circuit for the operation of relay 68. Relay 68 in operating closes a circuit for maintaining relay 34 operated from battery through the winding of this relay, contacts of relay 54, contacts of relay 68 to ground so as to maintain the original energizing circuits for all line relays open and thereby prevent other lines from calling until the common relay and circuit equipment is freed from use in connection with link A. It should be noted that on the energization of relay 39, the circuit for relay 38 was opened so that the original energizing circuit for relay 34 was opened, but

this will not take place until after relay 68 has operated as relay 55 is slow in operating and relay 38 is slow in releasing. Relay 38 in releasing opens the locking circuit for the line relay 33 which in releasing causes the release of the horizontal magnet S1. The vertical magnet 28 holds the connection through the switch S. It should also be noted that on the operation of relay 39, a circuit was completed for the slow to operate relay 70 which may be of the dash-pot type from battery through the winding of this relay, contacts of relay 39, to ground at contacts of relay 50. The purpose of the operation of this relay is to free link A from the calling subscriber's line if the calling subscriber fails to dial within a certain period. The circuits are now in condition for dialing.

When the calling subscriber now dials he will on the first impulse cause the release and re-operation of the pulsing relay 66. On the release of relay 66 a circuit is completed for the operation of relay 72 from battery through a resistance, winding and make-before-break contacts of relay 72, contacts of relays 39, 66 and 68, contacts of the vertical magnet 29, and contacts of relay 70 to ground. Relay 72 in operating closes the locking circuit for itself to ground at relay 50 and causes the operation of the first horizontal magnet S1 as follows: from battery through the winding of magnet S1, contacts of relay 53, contacts of relay 72 to ground. Relay 67 remains operated during the pulsing due to its slow to release characteristics. When now the pulsing relay 66 is again operated at the end of the first impulse, the shunt circuit for relay 73 is opened at contacts of relay 66 so that a circuit completed for the operation of relay 73 by the relay 72 becomes effective. This circuit may be traced as follows: battery, a resistance, winding of relay 73, contacts of relay 72, contacts of relay 39 to ground at contacts of relay 50. The operation of relay 73 closes an obvious circuit for the operation of relay 53 and an obvious locking circuit for the horizontal magnet S1. It should be noted that the original energizing circuit for magnet S1 is opened by the operation of relay 53. Relay 53 also closes a locking circuit for itself and a circuit for the operation of relay 75. The locking circuit extends from battery through a winding of relay 53, contacts of relay 53, contacts of relay 39 to ground at relay 50, and the circuit for relay 75 extends from battery, winding of relay 75, contacts of relays 53, 39 and 50 to ground. Relay 53 also opens the circuit from the dialing tone source 59. When now the pulsing magnet 66 releases in response to a second impulse, relay 72 is released due to a shunt circuit established at the right-hand armature and back contact of relay 66, from battery, a resistance, contacts of relays 73, 39 and 66, and 68, contacts of magnet 29, and contacts of relay 70 to ground. The release of relay 72 closes a circuit for the second horizontal magnet S2 from battery, winding of this magnet, contacts of magnet S1, contacts of relay 53, contacts of relay 72 to ground. When relay 66 is again actuated at the end of the second impulse, relay 73 is released as the original energizing circuit for relay 73 was opened on the release of relay 72 and the holding circuit established for relay 73 through the make-before-break contacts of relay 72 to ground supplied through the right-hand armature and back contact of the impulsing relay 66 is opened by the release of this relay. Magnet S2 provides a

locking circuit for itself on the release of relays 72 and 73 through contacts of these relays, contacts of relays 53, 39 and 50 to ground, while the locking circuit for magnet S1 is opened on the release of relay 73 so this magnet will now release. As no further impulses are transmitted, the circuits now remain in this condition. It is evident therefore that relays 72 and 73 will be operated and released by alternate impulses in such a manner that on the third, fifth and seventh impulses, relay 72 will operate to close the circuits for S3, S5 and S7 magnets and on the fourth, sixth and eighth impulses relay 72 will release to operate magnets S4, S6 and S8. The original energizing circuit for relay 50 was opened on the energization of relay 53, but this relay 50 was maintained operated during the pulsing over the circuit from battery through the winding of relay 50, contacts of relays 54 and 68 and the ground supplied during pulsing at a back contact of relay 66 as relay 50 is slow in releasing, as the pulsing ceases, relay 50 is allowed to release. Relay 50 now causes the operation of the vertical magnet 29 from battery, winding of this magnet, contacts of relay 56, which is still maintained operated due to the slow to release characteristics of relay 55, contacts of relay 50, contacts of relays 39, 40 and 41 and the contacts of magnet S2 to ground. Another relay operated by the release of relay 50 is the relay 51 from battery, winding of relay 5, contacts of relay 76, of the link CF, contacts of relay 56 to ground at contacts of relay 50. Relay 51 is locked in operated position mechanically by the armature of relay 78, as indicated in schematic form. Relay 50 being released to open the original energizing circuit for relay 54 and magnet 23 being operated causes relay 54 to release and this relay in releasing causes the release of relay 34. After an interval relays 55 and 56 are released. The release of relay 55 also causes the release of relay 39 and this relay in turn causes the release of relays 53, magnet S2 and relay 75. The common equipment S is therefore now returned to common use for other cells over the other links BE and CF.

Returning now to the operation of the magnet 29, this magnet in operating closes a connection between the called subscriber's line 2 at contact 80 of the cross-bar switch and the set of conductors 25 to contacts of relay 81. It should be noted that on the closing of the connection through contact set 80 relays 61 and cut-off relay 84 are operated over a circuit from battery, winding of the cut-off relay 84, contacts 80, the sleeve conductor of the group 25, a winding of relay 61, contacts of relay 56 to ground at contacts of relay 68. This takes place of course before relay 56 has time to release. Relay 84 in operating disconnects the called subscriber's line from ground on one lead and from the connection to the line relay 42 for the other lead. Relay 61 in operating closes a holding circuit for itself to ground at contacts of relay 68. Relay 61 in operating also closes a circuit for holding vertical magnet 29 operated and another circuit for the operation of relay 82 from battery to the winding of this relay, contacts of relay 64, contacts of relay 61, contacts of relay 56 to ground at contacts of relay 68. This also takes place before relay 56 has time to release. Relay 82 in operating establishes a locking circuit for itself to ground at relay 69 over contacts of relay 85. The operation of relay 82 establishes a connection

tion between the tip and ring conductors of the called subscriber's line, the tip and ring conductors of group 25, contacts of relay 82, the ringing trip relay 85 to the ringing source at 86 for one lead and to ground at contacts of relay 82 for the other lead. This rings the called subscriber. When the called subscriber answers trip relay 85 is operated and opens the holding circuit for relay 82. When relay 82 now releases it permits the operation of relay 64 from battery, winding of this relay, contacts of relay 82, contacts of relays 61 and 56 to ground at the contacts of relay 68. Relay 64 now extends the tip and ring conductors through its contacts to battery and ground through the winding of relay 88. Tip and ring conductors from the called line are now also extended by the operation of relay 8 through condensers 89 and 90 through the tip and ring conductors, contacts of relay 37 and contacts 20 to the calling subscriber's line 1 so that conversation can now take place. Talking battery for the calling line is furnished through the windings of impulse relay 66 and talking battery for the called line through the windings of relay 88.

When the calling subscriber replaces his receiver on the switchhook after the conversation is finished, relays 66, 67 and 68 are released. Relay 68 causes the release of magnet 28 and relays 61, 64 and 88 and opens the original energizing circuit for relay 51. Relay 61 releases magnet 29. The connection between the two subscribers is therefore now released. Relay 51 is not released as it is being mechanically locked by relay 78.

In regard to the allotting of the links A, B and C for use in establishing connections the following explanation may suffice. The link A is allotted first, link B second and link C third. If link C is engaged and links A and B are idle link A is allotted first. It should be noted that when a connection has been established for example through link A relay 51 is operated. A second connection may now be established through link B as relay 39 is released. Therefore, if the calling line operates its corresponding horizontal magnet a circuit may be completed for the operation of relay 38 from battery through the winding of this relay, contacts of relay 39, contacts of relays 39—B and 39—C to ground at the contacts of the operated horizontal magnet. From this point on the operations of the circuits are exactly the same as heretofore described except that the operation of the relay 50—B in link B is operated from battery through the winding of this relay, contacts of relay 51—B, contacts of the operated relay 51, contacts of relays 34 and 53 to ground at the vertical magnet of link B corresponding to vertical magnet 31 of link B.

After a connection has been established through link B a circuit connection may be established through link C as the relays 50 and 50—B in links A and B are released and the operations of the circuits in link C are exactly the same as heretofore described in connection with link A, except that in this case the relay 50—C of link C is operated through contacts of the operated relays 51 and 51—B.

If now link C should be engaged and links A and B released it should be noted that the special relay 76 in link C has operated due to the operation of relay 68—C and that when the connection through link C was established and the relay 50—C was released before relay 56—C was re-

leased a circuit was completed for the operation of relays 78 and 78—B so that now relays 51 and 51—B may be unlocked to return links A and B for seizure. If another call now comes in the link A will be the one to be first used as its relay 50 will operate due to the released condition of its relay 51. As soon as the connection through this link A has been completed the release of relay 50 and before relay 56 is released will complete a circuit for the momentary operation of relays 78 and 78—B as follows: From battery, windings of these relays in parallel, contacts of the operated relay 76, contacts of relay 56 to ground at relay 50. The purpose of this momentary operation of relays 78 and 78—B is in this case to permit the release of relay 51—B in case link B has been engaged and released in the meantime. The operation of relay 78 will, of course, in this case have no effect as relay 51 will be held operated by relay 68. Therefore, if link B is now idle and links A and C are engaged, link B will be seized as its relay 50—C will operate through contacts of relay 51—B and 51. Relay 51 is in this case operated.

Referring now in more detail to calls between lines over link A and the conductors 24 and 26 which represent connections from lines 9 to 16. In case line 9 is the one calling then relay 36 operates in series with magnet S1 over contacts of line relay 35. Relay 36 in this case causes the operation of relay 37 to switch the connection from the contact group 23 to the contact group 24 thus establishing a connection from line 9 to the contact set 20. Relay 37 is locked by magnet 28. If now the called line is one of the group of lines 9 to 16 the connection is switched from the conductors 25 to 26 through a contact set, such as 80. In this case the calling subscriber must dial two digits. The first digit must always be nine and the second digit any one of the digits one to eight depending on which of the lines 9 to 16 is wanted. Consequently, the first digit will operate in succession all of the magnets S1 to S8, and on the ninth digit relay 100 is operated from battery, winding of this relay, contacts of magnet S8, contacts of relay 72 to ground. Relay 100 in operating then closes a connection from the operation of relay 81 from battery, winding of this relay, contacts of relay 54, contacts of relay 100 to ground. Relay 81 locks to ground at contacts of relay 68. This accomplishes the switching of the connection for the called line to conductors 26. At the end of the ninth impulse relay 72 releases causing the release of relay 100 and relay 50 being held during pulsing releases in the normal manner. Ordinarily if any of the magnets S1 to S8 had been operated the vertical magnet 27 would have operated as a result of the release of relay C from a ground at contacts of any one of these magnets. As this does not take place the net result of dialing nine is that relay 81 only is operated. The second digit may, therefore, now be dialed and in the same manner as hereinbefore described a desired horizontal magnet may be selected. For example, if digit two is dialed, magnet S2 will be operated and the connection from the tip and ring conductors 26 will be extended through contact set 80 to line 12. Otherwise, the operations are the same as hereinbefore described.

Referring now to the operation of relay 70, this is a slow-acting relay of the dash-pot type which only operates a considerable interval after it is energized. The purpose of this relay is to release the common equipment D for the use of other

calls if the calling subscriber that has appropriated link A does not dial within this interval of time. If this is the case relay 70 will operate and thereby attract its armature and remove the ground connection for the pulsing circuit controlled by relay 66. Relay 70 will also close an obvious circuit for the operation of relay 53. This relay in turn opens the circuit for relay 50 which in releasing releases relays 55 and 56. It should be noted, however, that the vertical magnet 28 is maintained operated by a ground connection established through contacts of relay 68 which remains operated. The original energizing circuit for this magnet is opened on the release of relay 56. As long as the calling subscriber has his receiver off the hook the link A will be held occupied, but the calling subscriber cannot dial while the common equipment G may be used by other calling subscribers in establishing connections through links B or C if idle.

A modified form of this system has been shown in Fig. 5 in diagrammatic form. In this arrangement three links have been shown terminating in the contacts in the cross-bar switch S for lines 1 and 9, and 8 and 16. The link A in this case is only provided with one line finder branch so that at the cross points where contacts of this branch terminate lines 1 to 8 only have access to this branch. Similarly, the link B is shown with a single line finder branch. To this line finder branch lines 9 to 16 only have access at the cross point while link C is equipped in the same manner as the regular link shown in Figs. 1 to 3. The arrangement, therefore, in this case is such that lines 1 to 8 will normally use link A and lines 9 to 16 link B and if these links are busy link C will be used by either group of lines.

What is claimed is:

1. In a telephone system, a cross-bar switch having a plurality of cross-connecting points, horizontal lines arranged in pairs, each pair terminating at cross-points of an individual horizontal row, vertical lines arranged in groups, a link for each group of vertical lines, and means for establishing a connection from any horizontal line to any other horizontal line through a link and two of the vertical lines associated with said link.

2. In a telephone system, a cross-bar switch having a plurality of cross-connecting points, horizontal lines arranged in pairs, each pair terminating at cross-points of a separate horizontal row, vertical lines arranged in groups, each group terminating at cross-points of two vertical rows, links, each link capable of connecting two vertical lines of a certain group with one vertical line terminating in each of the two vertical rows of cross-points of said group, and means for establishing a connection from a line of a pair of horizontal lines through a link and two of the group of associated vertical lines to either one of any pair of horizontal lines.

3. In a telephone system, a cross-bar switch having a plurality of cross-connecting points, horizontal lines arranged in pairs, each pair terminating at all cross-connecting points of an individual horizontal row, vertical lines arranged in pairs, each pair terminating at all cross-points of an individual horizontal row, links each connectible to two pairs of vertical lines and means for establishing a connection from either line of a pair of horizontal lines through a corresponding line of a pair of vertical lines over the link connectible to said pair of vertical lines

and over either of the other associated pair of vertical lines to a corresponding line of a pair of horizontal lines.

4. In a telephone system, a cross-bar switch having a plurality of cross-connecting points, horizontal lines, vertical lines, means at each cross-connecting point for connecting either of two sets of lines together each set comprising a vertical and a horizontal line, links, and means for connecting either of two vertical lines terminating at one row of cross-connecting points through a certain link to either of two vertical lines terminating at another cross-connecting point.

5. In a telephone system, a cross-bar switch having a plurality of cross-connecting points, horizontal lines, vertical lines arranged in pairs, links each associated with two pairs of vertical lines, and means for establishing a connection from any horizontal line to any other horizontal line through any link and over one vertical line of each of the two pairs associated with said link.

6. In a telephone system, a cross-bar switch having a plurality of cross-connecting points, horizontal lines, two groups of vertical lines, links, means for connecting any horizontal line to any other horizontal line through a link and two vertical lines one from each group and at two cross-connecting points one for each group of vertical lines.

7. In a telephone system, a cross-bar switch having a plurality of cross-connecting points, horizontal lines arranged in pairs, two pairs of vertical lines, a link associated with said two pairs of vertical lines, means for establishing a connection at each cross-connecting point between either horizontal line of a pair and a corresponding vertical line of one pair and between either horizontal line of a pair and a corresponding vertical line in the other pair of vertical lines, and means for establishing a connection over said link between either vertical line of one pair and either vertical line of the other pair.

8. In a telephone system, a cross-bar switch having a plurality of cross-connecting points, horizontal lines, vertical lines, links and means for establishing a connection from any calling horizontal line to any other called horizontal line through a link in one direction only and through one vertical line in one direction and another vertical line in the other direction including a connection at a cross-connecting point between the calling horizontal line and the first mentioned vertical line, and a connection at another cross-connecting point between the second mentioned vertical line and the called horizontal line, and means at each cross-connecting point for establishing either of two such connections between a calling horizontal line and a called horizontal line.

9. In a telephone system, a cross-bar switch having two sets of contacts at each cross-connecting point, a group of horizontal lines, a group of vertical lines terminating in the contacts of one set at the cross-connecting points, another group of horizontal lines, and another group of vertical lines terminating in the contacts of the other set at the cross-connecting points, links and means for establishing a connection from a horizontal line of either group through a contact set and a vertical line of the corresponding group through a link and to another contact set and another vertical line in another group to another horizontal line in the corresponding group.

10. In a telephone system, a cross-bar switch

- having two sets of contacts at each cross-connecting point, horizontal lines, vertical lines for establishing connections at the contact sets between horizontal calling lines, vertical lines for establishing connections at contact sets to horizontal called lines, links, means for connecting a calling horizontal line through one contact set and associated vertical line and a link through another contact set and a vertical line to an associated called horizontal line.
11. In a telephone system, a cross-bar switch having two groups of contact sets at each cross-connecting point arranged in horizontal and vertical rows, a pair of horizontal lines for each horizontal row of contact sets, a pair of vertical lines for each vertical row of contact sets, each horizontal line in a pair terminating in different group of contact sets at each cross-connecting point and each vertical line in a pair terminating in a different group of contact sets of each cross-connecting point, a link for each two vertical rows of vertical lines, and means for establishing a connection from any horizontal line to another horizontal line at the corresponding contact groups at the two cross-connecting points of two vertical rows of vertical lines and the corresponding link.
12. In a telephone system, a cross-bar switch having two groups of contacts at each cross-connecting point for the establishing of two independent cross-connections of intersecting lines, horizontal lines divided into pairs, vertical lines divided into pairs, horizontal magnets one for each pair of horizontal lines, vertical magnets, one for each pair of vertical lines, a link for each two pairs of vertical lines, means including the actuation of a horizontal magnet and a vertical magnet for establishing a connection between a pair of horizontal lines one of which is a calling line and a pair of vertical lines and for establishing a connection from said calling line and one of said pair of vertical lines to one end of the associated link, and means including the actuation of another horizontal magnet and another vertical magnet for establishing a connection between a pair of horizontal lines one of which is the called line and another pair of vertical lines, and for establishing a connection from said called line to the opposite end of said link.
13. In a telephone system, a cross-bar switch having two groups of contacts at each cross-connecting point for the establishing of two independent cross-connections of intersecting lines, horizontal lines divided into pairs, vertical lines divided into pairs, horizontal magnets one for each pair of horizontal lines, vertical magnets, one for each pair of vertical lines, a link for each two pairs of vertical lines, means including the actuation of a horizontal magnet and a vertical magnet for establishing a connection between a pair of horizontal lines one of which is a calling line and a pair of vertical lines and for establishing a connection from said calling line and one of said pair of vertical lines to one end of the link, and means responsive to impulses received from said calling line over said connection to a link including the selection and operation of a horizontal magnet and the operation of a vertical magnet for establishing independent connection between another pair of horizontal lines one of which is the called line and the two lines of another pair of vertical lines, and for establishing a connection through said called line over one of said vertical lines from the other end of said link.
14. In a telephone system, a cross-bar switch having a plurality of cross-connecting points, horizontal lines arranged in pairs, two pairs of vertical lines, a link associated with said two pairs of vertical lines, means for establishing a connection at each cross-connecting point between either horizontal line of a pair and a corresponding vertical line of one pair and between either horizontal line of a pair and a corresponding vertical line of the other pair of vertical lines, a relay for each pair of vertical lines, and means responsive to the connection of a particular vertical line of either pair of vertical lines to a horizontal line for operating the associated relay to connect said vertical line to the link.
15. In a telephone system, a cross-bar switch having a plurality of cross-connecting points, horizontal lines arranged in pairs, two pairs of vertical lines, a link normally connected to one vertical line of each pair, means for establishing a connection at each cross-connecting point between either horizontal line of a pair and a corresponding vertical line of one pair and between either horizontal line of a pair and a corresponding vertical line of the other pair of vertical lines, a relay for each pair of vertical lines, and means responsive to the connection to a horizontal line of the vertical line of either pair normally disconnected from the link for operating the associated relay to disconnect the normally connected vertical line from the link and connect the normally disconnected vertical line to the link.
16. In a telephone system a cross-bar switch having a plurality of cross-connecting points, horizontal lines arranged in pairs, each pair terminating at cross-points of an individual horizontal row, vertical lines, some arranged in groups of four lines and others arranged in groups of three lines, a link for each group of vertical lines, and means for establishing a connection from any horizontal line to any other horizontal line through a link, and two of the vertical lines associated with said link.
17. In a telephone system a cross-bar switch having a plurality of cross-connecting points, horizontal lines arranged in pairs, each pair terminating at cross-points of an individual horizontal row, vertical lines, some arranged in groups of four lines and others arranged in groups of three lines, a link for each group of vertical lines, means for establishing a connection from any one of certain horizontal lines to any other horizontal line through certain of the links associated with groups of three vertical lines, the connection being established over two of the vertical lines associated with the link used and for establishing a connection from any one of certain other horizontal lines to any other horizontal line through certain other of the links associated with the groups of three vertical lines, the connection being established over two of the vertical lines associated with the link used, and means for establishing a connection from any horizontal line to any other horizontal line through any of the links associated with groups of four vertical lines, the connection being established over two of the vertical lines associated with the link used.
18. In a telephone system a cross-bar switch having a plurality of cross-connecting points, horizontal lines arranged in pairs, each pair terminating at cross-points of an individual horizontal row, vertical lines arranged in groups, some groups comprising three vertical lines with one line terminating at cross-points of one vertical row and the other two lines terminating at cross-

points of another vertical row and some groups comprising four vertical lines with two lines terminating at each of two vertical rows of cross-points, a link for each group of vertical lines, the
5 links for the three line groups being capable of connecting the single vertical line of one vertical row with either of the two lines of the other vertical row of the associated groups and the links for the four line groups being capable of connect-
10 ing either vertical line of one vertical row with either vertical line of the other vertical row of the associated groups, means for establishing a connection from one of the lines in each pair of horizontal lines to a link associated with certain
15 three line groups of vertical lines from the single vertical line in a group to either one of any pair

of horizontal lines over an associated vertical line of the other two lines in a group, means for establishing a connection from the other of the horizontal lines in each group in each pair to links associated with certain other three line
5 groups of vertical lines from the single vertical line in the group to either one of any pair of horizontal lines over an associated vertical line in the other two lines in the group, and means for establishing a connection from a line of any pair
10 of horizontal lines through a link associated with the four line groups of vertical lines over two of the group of associated vertical lines to either one of any pair of horizontal lines.

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