Dec. 1, 1942. W. H. T. HOLDEN 2,303,356

SELECTING SYSTEM

Filed Dec. 30, 1941 2 Sheets-Sheet 1

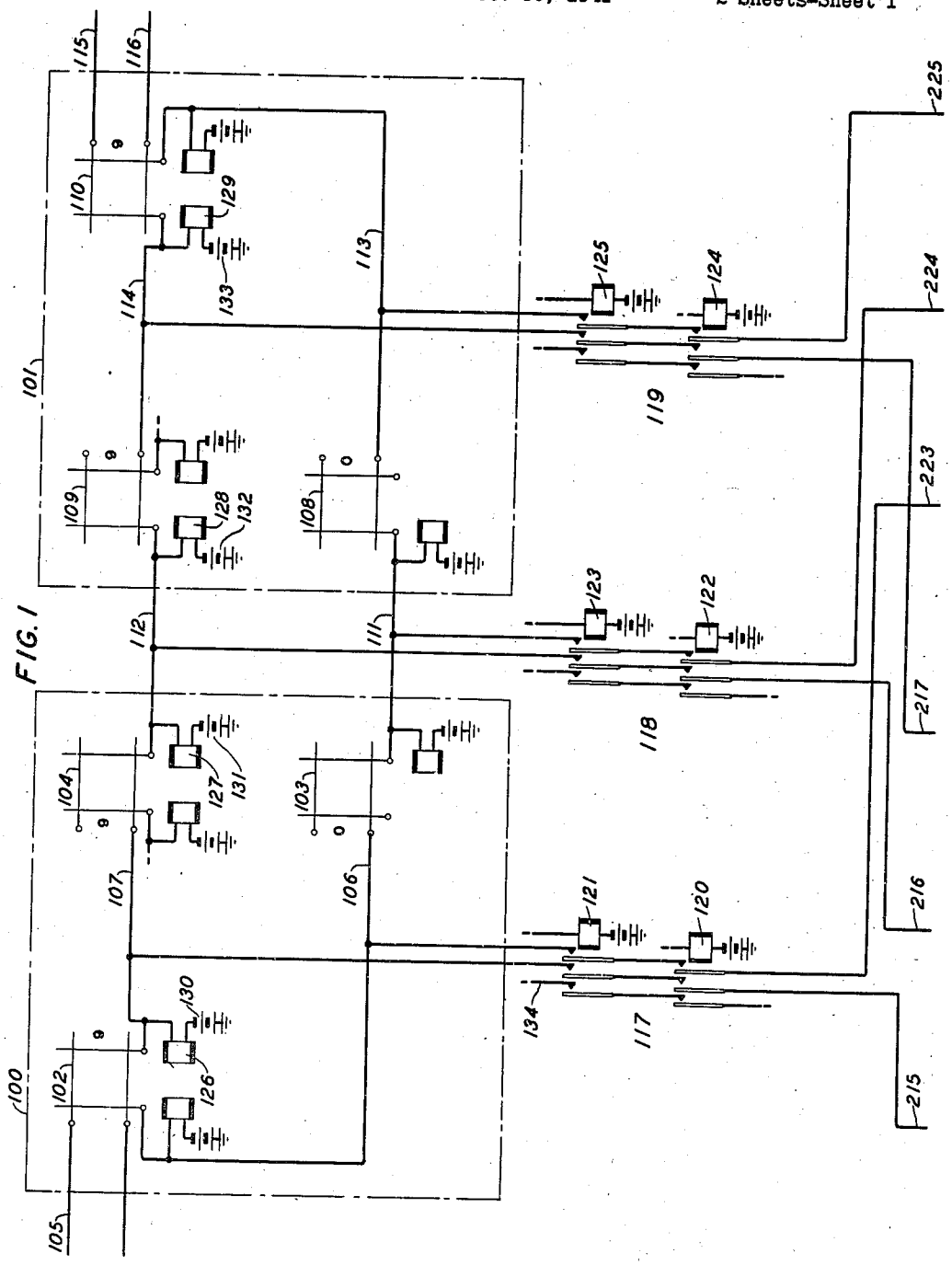

FIG. 1

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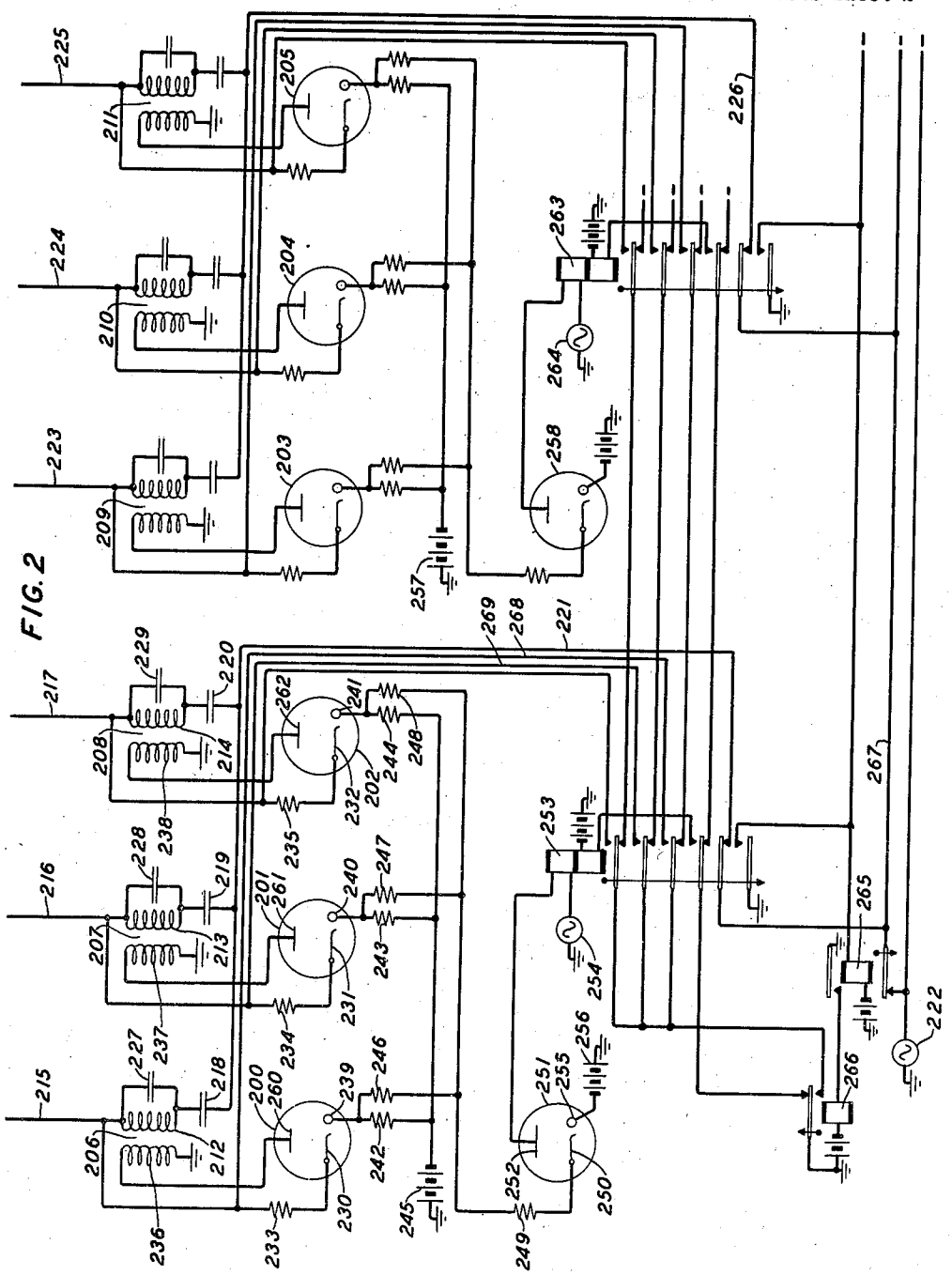

FIG. 2

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UNITED STATES PATENT OFFICE

2,303,356

SELECTING SYSTEM

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Application December 30, 1941, Serial No. 424,866

6 Claims. (Cl. 179—18)

This invention relates to selecting systems and particularly to those used in the establishment of automatic telephone or other communication connections.

The objects of the invention are to minimize the number of false operations and double connections incident to the testing of links, trunks, or other circuits used in automatic switching systems; to obtain a more positive test of these circuits; to enable the ready detection of an unstandard condition on the conductors over which these circuits are tested; to enable both the testing and switch-operating functions to be performed over the same conductors without danger of false operations; and to obtain other improvements and advantages in systems of this character.

In systems of the well-known crossbar type where connections between incoming and outgoing circuits are performed at switching stages comprising a plurality of interconnecting channels, each of which includes a number of serially related links, it has been the common practice to use relays for testing the several channels provided for interconnecting any incoming trunk to any outgoing trunk. These relays are usually common to the switching stages and serve to determine the busy or idle condition of each of the individual links involved in each of the interconnecting channels.

In accordance with the present invention the testing relays of these prior systems are replaced by space-discharge tubes which are capable of distinguishing between links that have an idle condition on their test conductors and links that have their test conductors in a busy or an open condition or inadvertently crossed with other conductors. More specifically, an alternating voltage source is applied to the test conductors of the component links of each switching channel through the windings of transformers which are associated individually with the respective links; and the resulting potentials developed on these test conductors, the magnitude of which depends on the electrical conditions found on said conductors, are applied to space-discharge tubes, which are also individually associated with the links temporarily for the purpose of the test. If the link thus undergoing test is idle and in proper condition for use, the alternating potential applied to the corresponding tube is sufficient to operate it; whereas if the test conductor of the link has a busy condition thereon, or is open, or is crossed with some other conductor, the potential applied to the tube is insufficient to operate it. Thus only if all links of a channel are idle, the corresponding tubes all operate and cause the operation of a single testing tube which is individually associated with the channel. This tube in turn causes the application of battery potention directly to the test conductors of all component links of the idle channel, and the resultant current flow in these test conductors operates the switch magnets to seize the channel for use.

By using an alternating voltage and by properly selecting the impedances of the transformers with respect to that of the switch magnets, it is possible to test the condition of the links, without falsely operating the switch magnets, by applying this alternating voltage to the same link conductors over which the magnets are subsequently operated if the test indicates that the channel is idle. The advantage of this feature will be obvious; it reduces the number of conductors extending between the switch links and the common markers which perform the tests and apply the operating currents for energizing the switch magnets. Also a more positive test is obtained than is possible where relays are used to test the links over the same conductors that serve as the operating circuits for the switch magnets.

These and other features of the invention will be described more fully in the following specification:

Fig. 1 illustrates two frames of automatic switches through which connections are established. This figure also shows the frame connectors which serve to connect to these frames one of a number of common switch-controlling markers; and

Fig. 2 illustrates portions of one of these switch-controlling markers.

Although the invention is applicable to testing arrangements for testing links, trunks or other circuits in various types of communication systems, it has been disclosed herein for the purpose of illustration in a telephone system of the crossbar type. In such a system connections are established through successive frames of crossbar switches, such as the district frame and the office frame, by way of connecting channels, each of which comprises as many as three separate link circuits arranged in serial relation. Since these links are capable of being used in a plurality of different channels, it is necessary to test the component links of each channel capable of serving the particular call to determine which channels are idle, in other words, to determine which chan-

nels have all of their component links in an idle condition.

In the system illustrated herein these matching tests are performed by electronic devices, such as space-discharge tubes, in the common marker, these tubes being associated respectively through the frame connectors with the connecting channels over which the call may be extended. The condition of the component links of each channel determines the potentials to be applied to the electrodes of the associated tube. These potentials are derived from a source of alternating voltage which is applied to the test conductors through the primary windings of transformers. Each transformer and the corresponding switch-operating magnet, both of which are connected to the link testing conductor, have impedances which are so chosen that the resulting potential produced on the test conductor is sufficient to operate the associated discharge tube if the link is idle and is insufficient to operate the tube if the link is busy, if the test conductor is open, or if the test conductor is inadvertently connected to another test conductor. If all links of a particular channel are idle simultaneously, the corresponding tubes in the marker all operate and cause the application of a direct current source to the test conductors of these links to operate the associated magnets on the switch frames.

Referring particularly to the drawings, two frames of crossbar switches are illustrated, a district frame **100** and an office frame **101**. It will be assumed that each of these frames comprises ten primary and ten secondary crossbar switches. One district primary switch, the No. 9 switch **102**, and two district secondary switches, the No. 0 switch **103** and the No. 9 switch **104**, are shown. The incoming trunks, such as trunk **105**, appear in the horizontal rows of contacts of the primary switches, and the primary switches have access to the secondary switches by way of district links **106**, **107**. There are ten links appearing in the ten vertical rows of contacts of each primary switch, and these ten links are distributed to the ten secondary switches, appearing in the horizontal rows of contacts of said secondary switches.

Two of the ten primary office switches, the No. 0 switch **108** and the No. 9 switch **109**, and one secondary office switch, the No. 9 switch **110**, are illustrated.

The one hundred office junctors appearing in the vertical contacts of the ten secondary district switches are divided into ten groups, each group leading to one of ten office frames. Only one of these office frames **101** is shown in the drawings, and the ten office junctors **111**, **112** extending from the district frame **100** appear in the vertical rows of contacts of the ten primary office switches **108**, **109**. Similar junctor groups from other district frames also appear in these primary office switches. The one hundred office links which appear in the horizontal rows of contacts of the ten primary office switches **108**, **109** are divided into ten equal groups, and each group is distributed to the ten secondary office switches. For example, the office link **113** outgoing from the primary switch **108** and the office link **114** outgoing from the primary switch **109** appear in the secondary switch **110**. The ten secondary office switches have access to outgoing trunks, such as trunks **115**, **116**.

From the foregoing description it will be seen that there are ten possible channels between any trunk incoming to a district primary switch and any trunk outgoing from an office secondary switch. Each one of these channels comprises a district link, an office junctor, and an office link in serial relation. For example, one channel extending from the district primary switch **102** to the secondary office switch **110** comprises the district link **107**, office junctor **112**, and the office link **114**. Another channel between these switches comprises the district link **106**, office junctor **111**, and the office link **113**.

The common marker disclosed in Fig. 2 includes the testing mechanism whereby the component links of the several channels are tested simultaneously to determine which channels are available for use. This testing mechanism includes a plurality of groups of discharge tubes, one for each of the channels to be tested simultaneously, each group including three tubes which correspond respectively to the three links of the channel. Two of these groups are shown in the drawings, one of which includes the tubes **200**, **201**, **202** and the other of which includes tubes **203**, **204**, **205**. There may be as many of these groups as required. If, for example, it is desired to make a simultaneous test of ten different channels through the district and office frames **100** and **101**, ten groups of testing tubes would be provided in the marker. The testing mechanism also includes a plurality of groups of transformers, each group corresponding to one of the channels and including a transformer for each of the links in the channel. Transformers **206**, **207** and **208** comprise the group corresponding to tubes **200**, **201** and **202**; and transformers **209**, **210** and **211** comprise a second group corresponding to tubes **203**, **204** and **205**. The primary winding of these transformers serves to connect a source of alternating voltage to the several test conductors, which are connectable individually to the test conductors of the links of the several channels to be tested simultaneously. For example, the primary windings **212**, **213** and **214** of transformers **206**, **207** and **208** interconnect the respective test conductors **215**, **216** and **217** through suitable condensers **218**, **219** and **220** with the common supply conductor **221** to which the source of alternating voltage **222** is connected when the test is to be made. Similarly the primary windings of the transformers **209**, **210** and **211** interconnect the test conductors **223**, **224** and **225** with the common supply conductor **226** to which the source **222** is connectable. And the same is true of the other groups of transformers not shown on the drawings. The primary windings of the several transformers are shunted by condensers of suitable capacity, such as the condensers **227**, **228** and **229** for the purpose of obtaining the desired impedance relation between the supply conductors **221** and the individual test conductors.

The several test conductors are connected through resistance elements to the starting electrodes of the respective tubes in order that the tubes may determine from the potential on these test conductors whether the corresponding links in the switch frames **100** and **101** are idle and in proper condition for use. To illustrate, it will be noted that the test conductors **215**, **216** and **217** are joined respectively to the starting electrodes **230**, **231** and **232** of the tubes **200**, **201** and **202** through individual resistors **233**, **234**, **235**. The main anodes **260**, **261** and **262** of these tubes are connected respectively to the secondary windings **236**, **237** and **238** of the corresponding transformers. The cathodes **239**, **240** and **241** of these tubes

are connected through resistances 242, 243 and 244 to the negative pole of battery 245. Also these cathodes are connected through resistances 246, 247 and 248 and through the common resistance 249 to the starting electrode 250 of the tube 251, which is common to the group containing tubes 200, 201 and 202. The anode 252 of the common tube 251 is connected through the winding of relay 253 to the alternating current source 254. The cathode 255 of tube 251 is connected to the negative pole of battery 256. In a similar manner the anodes of tubes 203, 204 and 205 are connected to the secondary windings of the corresponding transformers, and the cathodes are connected through resistors to the negative pole of battery 257 and through other resistances to the starting electrode of the common tube 258.

In order that the links of the frames 100 and 101 may be tested by the marker shown in Fig. 2, the marker is connected at the appropriate time to these frames and to the particular switches on these frames on which the desired links appear. These connections are made by the frame connectors 117, 118 and 119. The connector 117 comprises a multicontact relay 120 for the marker illustrated, a similar relay for each other marker having access to the frame, a relay 121 for the primary switch 102 and nine other similar relays for the nine remaining primary switches on the district frame. The connector 118 comprises a multicontact relay 122 for the marker, corresponding relays for other markers, and ten relays, including the relay 123, one for each of the ten groups of office junctors. The connector 119 includes the marker relay 124, corresponding relays for other markers, and ten relays including relay 125, one for each of the office secondary switches.

The test of the three links comprising a channel, such as links 107, 112 and 114, is made by connecting the alternating voltage source 222 over conductor 221 through the primary circuits of the transformers 206, 207 and 208 to the test conductors 215, 216 and 217, which in turn are connected respectively through the connectors 117, 118 and 119 to the test conductors of the links 107, 112 and 114. It will be noted that the test conductor of the link 107 is also connected through the winding of the associated operating magnet 126 to the negative pole of battery 130, that the test conductor of the link 112 is connected through the windings of operating magnets 127 and 128 in parallel to the negative poles of batteries 131 and 132, and that the test conductor of link 114 is connected through the winding of the operating magnet 129 to the negative pole of battery 133. If the link 107 is idle and the test conductor leading into the marker is continuous, the voltage of the alternating source 222 adds to the voltage of battery 130, when the alternating source is in its positive half cycle, and causes current to flow in the test conductor 215. The potential on the conductor 215 depends upon the relative impedances of the primary circuit of transformer 206 and the winding of the operating magnet 126. These impedances are so chosen, preferably at about equal values, that the potential appearing on the conductor 215 is sufficient to ionize the operating gap of the tube 200 when the link 107 is idle and the test conductor is continuous and free from inadvertent connections with other test conductors. This potential on conductor 215 is applied through the resistor 233 to the start electrode 230 and adds to the potential of the battery 245 applied to the cathode 239. Hence the starting gap 230—239 ionizes if the link 107 is idle and the test conductor is closed and is free from cross connections. If, however, the link 107 is busy, a ground potential exists on the test conductor, and no potential is applied to the starting electrode 230 of the tube 200. Similarly if the link 107 is idle and an open condition exists in the test conductor extending into the marker, no potential is applied to the electrode 230 from the link. Again if the link 107 is idle and the test conductor is continuous but is inadvertently crossed with some other conductor, such as the test conductor 134, the parallel connections through the impedances of the two operating magnets serves to lower the resultant potential on conductor 215 and on the electrode 230 below the value necessary to ionize the control gap 230—239 of the tube 200. Therefore, the test tube 200 will operate its control gap only if the link 107 is idle and its test conductor is free from all unstandard conditions. In a similar manner the tubes 201 and 202 test the condition of the links 112 and 114.

If the tube 200 operates its control gap to indicate that the link 107 is idle and in proper condition to be selected for use, the main gap of the tube immediately discharges. The source of current for the main discharge gap of the tube is supplied by the voltage induced in the secondary winding 236 of the transformer 206 on each positive half cycle and by the battery 245 connected to the cathode 239. The circuit for this current flow may be traced from the upper terminal of the secondary winding 236, anode 260, cathode 239, resistor 242 to the negative pole of battery 245. If the link 112 is idle and tube 201 ionizes its control gap, the main discharge gap is immediately ionized, and current flows from the upper terminal of winding 237 on each positive half cycle, anode 261, cathode 240, resistor 243 to the negative pole of battery 245. Similarly if the third link 114 is idle, the tube 202 ionizes, and current flows in the main discharge gap including the anode 262, cathode 241, resistor 244 to the negative pole of battery 245. Thus if all three tubes are operated, the voltages developed across the resistors 242, 243 and 244 are equal and no current flows in resistors 246, 247 and 248. Accordingly the full positive potential on the cathodes 239, 240 and 241 is applied through resistors 246, 247 and 248 in parallel through the common resistor 249 to the starting electrode 250 of the tube 251. This positive potential adds to the negative potential of battery 256, and the control gap 250—255 ionizes. At the time the control gap of the tube 251 ionizes, the source 254 is in its positive half cycle, and current flows from said source through the upper winding of relay 253, anode 252, cathode 255 to the negative pole of battery 256. The relay 253 operates in this circuit and performs the functions to be explained hereinafter.

Thus if all three of the tubes 200, 201 and 202 operate, indicating that the corresponding links 107, 112 and 114 of the channel are all idle, the common tube 251 receives sufficient potential on its starting electrode 250 to operate. However, if only two of the links are idle and the third one, say the link 114, is busy, the tube 251 fails to operate. Since the link 114 is busy, the tube 202 remains deionized, and no voltage is developed across the resistor 244. Therefore, the voltage across resistors 242 and 243 cause current to flow in obvious circuits through the re-

sistors 246 and 247 and resistors 248 and 244. This current flow in resistors 246 and 247 lowers the potential applied to the electrode 250 below the point where it is sufficient to ionize the tube 251. Similarly if only one link, link 107, is idle, the tubes 201 and 202 remain deenergized, and no voltages are developed across resistors 243 and 244. Consequently the voltage across the resistor 242, resulting from the operation of tube 200, causes current to flow through resistor 246 and thence in parallel through the resistors 247, 243 and 248, 244. This flow of current in the resistor 246 lowers the potential applied to electrode 250 below the ionizing value, and the tube 251 fails to operate.

In a similar manner simultaneous tests are made of all other channels to which the marker is connected, and the common tubes 251, 258, etc., corresponding to all idle channels are ionized, whereas the common tubes relating to all channels having one or more busy links or one or more links in an unstandard condition fail to ionize. If at the time this test is made the other channel illustrated is idle, namely the channel comprising links 106, 111 and 113, the associated tubes 203, 204 and 205 are operated, and the common tube 258 operates to cause the energization of relay 263 in a circuit including the source 264.

Since only one idle channel is needed for setting up the desired connection, means is provided for choosing the first idle channel and excluding all other channels that may be found idle at the time. This means includes the common slow-releasing relays 265 and 266. As soon as relay 253 operates, a holding circuit is closed therefor traceable from battery through the lower winding of the relay, front contacts of said relay to ground at the back contacts of relay 266. Relay 253 in operating opens the holding circuit of relay 263 and of all other succeeding relays. Therefore, relay 253 is the preferred one, and the channel it represents will always be chosen in preference to other channels. Also when relay 253 operates, it opens the original circuit from the source 222 to the conductor 221. Before this circuit is opened, however, the relay 253 locks itself in the holding circuit above described. Relay 253 operates relay 265, which in turn operates relay 266. Relay 265 disconnects the source 222 from conductor 267 to cause the release of all tubes that may have been operated in connection with other idle channels. When relay 266 operates it opens the holding circuit of relay 253. During the interval that relay 253 is maintaining its armature in a closed condition circuits are closed for operating the magnets associated with the links 107, 112 and 114 of the third idle channel. The circuit for magnet 126 may be traced from ground through the front contact of relay 266, armature and front contact of relay 253, conductor 268, conductor 215, contacts of relays 120 and 121, test conductor 107 through the winding of magnet 126 to the negative pole of battery 130. The circuit for magnets 127 and 128 may be traced from ground through the front contact of relay 266, armature and front contact of relay 253, conductor 269, conductor 216 thence through the contacts of relays 122 and 123, conductor 112 and in parallel through the windings of magnets 127 and 128 to battery and ground. Similarly the operating circuit for magnet 129 is closed through the contacts of relay 266 and relay 253. After an interval relay 253 releases and causes the release in turn of relays 265 and 266. The common control circuit is now restored so that tests may be made of the channels.

It will be noted that the test circuit for the district link 107 includes the primary winding of the transformer 206 and the winding of the operating magnet 126. As mentioned hereinbefore the impedances of the transformer and the magnet are proportioned so as to provide the necessary potential on the conductor 215 for identifying the condition of the district link. For example, the impedance of the primary transformer winding may be substantially equal to the impedance of the magnet 126, in which case the voltage is divided equally across these impedances. The same is true of the test circuit for the office link 114, which includes the primary winding of transformer 208 and the winding of the operating magnet 129. Since however the intermediate link 112 is connected to both magnets 127 and 128 in parallel, it is necessary, of course, to select the impedances of these magnets and the impedance of the transformer 207 to provide the same potential on conductor 216 that exists on conductors 215 and 217 for the same condition. This may be done by making the impedance of the primary of transformer 207 one-half as great as that of the primary windings of the other transformers.

For a more complete understanding of the details of the crossbar system and the operation of the switches and markers, reference may be had to the patent to Carpenter, 2,235,803 of March 18, 1941. The discharge tubes disclosed herein may be of any well-known type, such as those having gas-filled envelopes and cold cathodes.

What is claimed is:

1. In combination, a plurality of connecting channels each comprising a number of serially related links, operating magnets for said links for connecting the links of any channel in series, test conductors, means for connecting the test conductors individually to the separate links of a channel and to the operating magnets of said links, impedance devices connected individually in said test conductors, a group of discharge tubes for each channel including a tube for each link of the channel, circuits for connecting said tubes to the corresponding test conductors, a source of test voltage and means for applying the same through said impedance devices to the several test conductors, the impedance of said devices being so proportioned with respect to the impedance of said magnets that the resulting potential on each of said test conductors is sufficient to operate the associated tube if the corresponding link is idle and insufficient to operate the tube if the link is busy, and means responsive to the operation of all tubes of a group representing the idle links of a channel for operating the corresponding magnets to establish a connection over the links of said channel in series.

2. In combination, a plurality of connecting channels each comprising a number of serially related links, operating magnets for said links for connecting the links of any channel in series, test conductors, means for connecting the test conductors individually to the separate links of a channel and to the operating magnets of said links, transformers each having one winding connected individually in one of said test conductors, a group of discharge tubes for each channel including a tube for each link thereof, circuits for connecting each of said tubes to

the corresponding test conductor and to the other winding of the corresponding transformer, a source of test voltage, and means for applying the same through one of the windings of each of said transformers to the several test conductors, the impedance of said transformers and the impedance of said operating magnets being chosen to produce a resulting potential on each of said test conductors sufficient to operate the associated tube if the link is busy, and means responsive to the operation of all tubes of a group representing the idle links of a channel for operating the corresponding magnets to establish a connection over the links of said channel.

3. In combination, a plurality of connecting channels each comprising a number of serially related links, operating magnets for said links for connecting the links of any channel in series, test conductors, means for connecting the test conductors individually to the separate links of a channel and to the operating magnets of said links, impedance devices connected individually in said test conductors, a group of discharge tubes for each channel including a tube for each link of the channel, circuits for connecting said tubes to the corresponding test conductors, a source of alternating voltage, and means for applying the same through said impedance devices to the several test conductors, the impedance of said devices being so related to the impedance of said magnets that the potential produced on each of said test conductors in response to the application of said alternating voltage is sufficient to operate the associated tube if the corresponding link is idle and insufficient to operate the tube if the link is busy, and means responsive to the operation of the tubes of a group representing the idle links of a channel for operating the corresponding magnets to establish a connection.

4. In combination, a plurality of connecting channels each comprising a number of serially related links, operating magnets for said links for connecting the links of any channel in series, test conductors, means for connecting the test conductors individually to the separate links of a channel and to the operating magnets of said links, impedance devices connected individually in said test conductors, a group of discharge tubes for each channel including a tube for each link of the channel, circuits for connecting said tubes to the corresponding test conductors, a source of test voltage and means for applying the same through said impedance devices to the several test conductors, the impedance of said devices and the impedance of said magnets serving to divide the applied test voltage to produce on each of said test conductors a resulting potential sufficient to operate the associated tube if the corresponding link is idle and insufficient to operate the tube if the link is busy, if the test conductor is open, or if the test conductor is inadvertently connected to some other test conductor, and means responsive to the operation of the tubes representing the idle links of a channel for operating the corresponding magnets to establish a connection.

5. In combination, a plurality of connecting channels each comprising a number of serially related links, operating magnets for said links for connecting the links in any channel in series, each of said links having a test conductor connected to the corresponding operating magnet, a plurality of impedance devices, means for connecting said impedance devices individually to the test conductors of said links, discharge tubes, one for each of said impedance devices, circuits for connecting said tubes respectively to the corresponding impedance devices and to the corresponding test conductors, a source of alternating voltage, means for applying the same through said impedance devices to the several test conductors, said impedance devices and said operating magnet serving to divide the applied voltage to produce a resulting potential on each of said test conductors sufficient to operate the associated tube if the corresponding link is idle and insufficient to operate the tube if the link is busy, a source of direct current, and means responsive to the operation of the tubes corresponding to the idle links of a channel for connecting said source of direct current to the test conductors of said idle links for operating the associated magnets to establish a connection.

6. The combination in a telephone system of a trunk circuit for extending telephone connections, a test conductor for said trunk circuit, means for varying the impedance of said test conductor in accordance with the busy or idle condition of said trunk, a testing mechanism including a source of alternating current, means for connecting said source of alternating current to said test conductor, means in said mechanism for measuring the impedance of said test conductor when said source is connected thereto, an electronic device in said mechanism operative in response to the impedance measurement when said trunk is in an idle condition, and means controlled by said electronic device for establishing a connection over said trunk.

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