June 30, 1942. W. H. T. HOLDEN 2,287,881

TELEPHONE SYSTEM

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FIG. 2

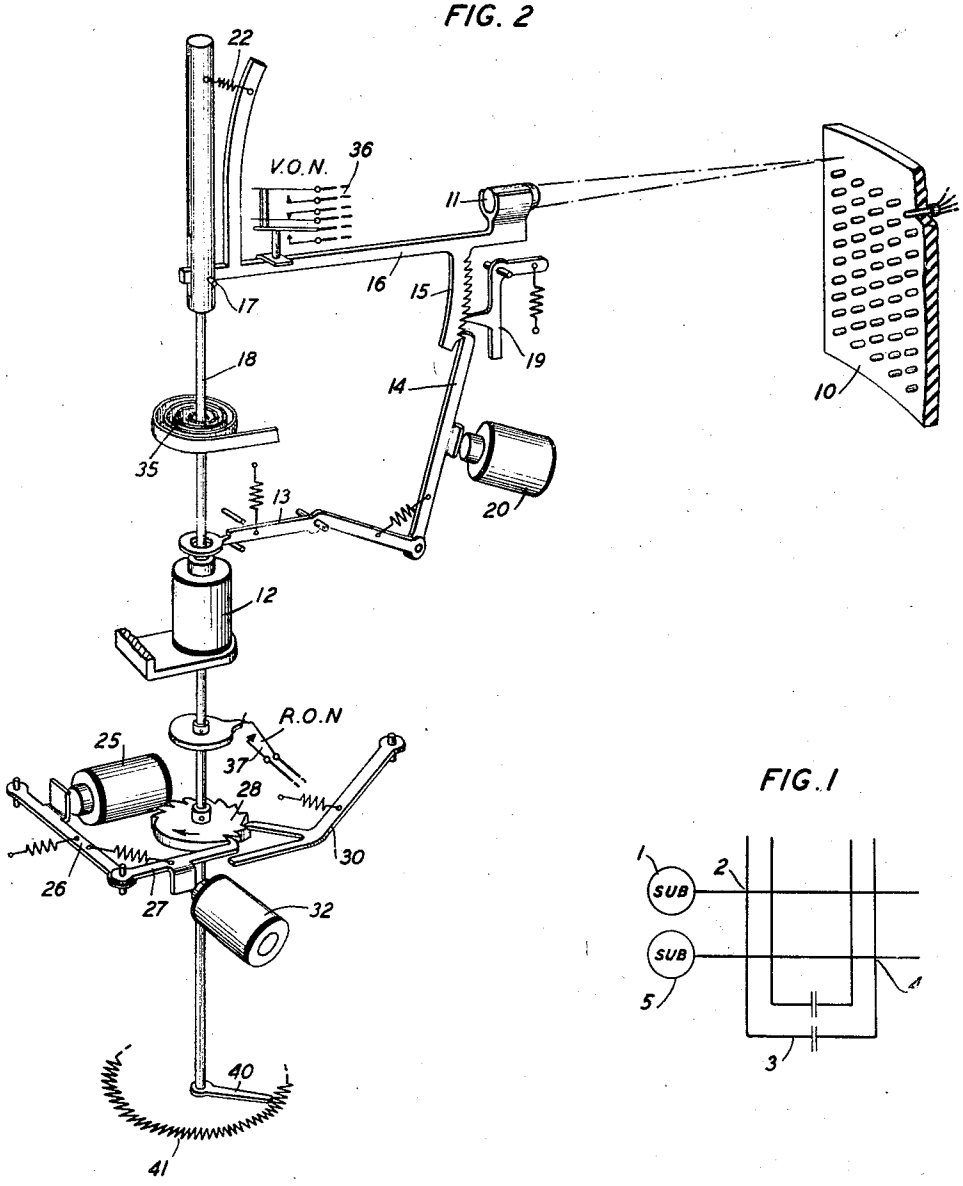

FIG. 1

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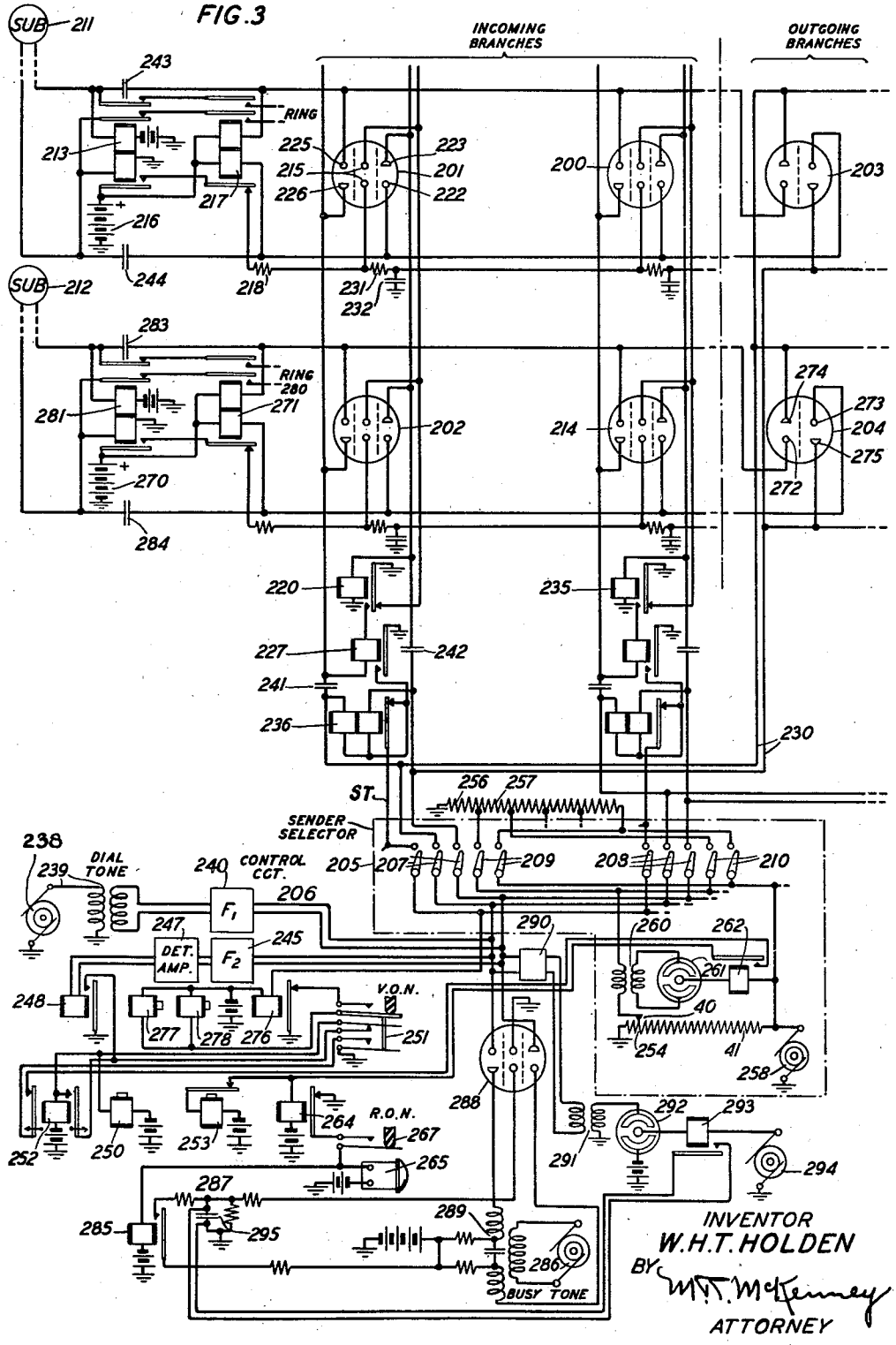
FIG. 3



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TELEPHONE SYSTEM

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8 Claims. (Cl. 179—27.52)

This invention relates to telephone systems and particularly to automatic selective switching mechanisms for interconnecting electrical circuits such as telephone lines.

An object of the invention is to simplify the apparatus used in establishing such connections and to increase the speed of operation of such apparatus.

Heretofore systems have been provided in which cathode ray beams were used as part of the talking path between subscribers' lines and in which the beam was deflected by selecting mechanism to establish such connection.

Coordinative selecting systems in which lines intersect each other have also been employed in the past of the type in which cold cathode tubes have been used to operate a relay for establishing connections between the lines at intersecting points.

This invention relates to coordinate line connecting systems of this general type in which lines intersect each other and a feature thereof is an arrangement whereby a cold cathode tube or tubes are provided at each intersecting point with means for momentarily flashing an energy carrying beam on the tubes at each intersecting point to cause said tubes to break down and establish a connection between the associated lines. The tubes may be so adjusted that they exhibit a high breakdown starting voltage when in the dark and exhibit a high drop in the breakdown voltage when illuminated. The energy carrying beam may be a beam of light or of any other form of energy capable of being transmitted substantial distances through the air. Partitions may be employed in the tubes between each set of elements comprising the various circuit paths.

Another feature is an arrangement whereby cold cathode tubes may be provided at the intersecting points which are equipped with control electrodes for causing the tubes to break down.

Another feature is a switching arrangement associated with said arrangement of tubes in a coordinate switching system whereby a source for producing an energy carrying beam is directed to any tube and caused to emit an energy carrying beam to break down the tube to which the source is directed.

The invention has been illustrated in the accompanying drawings in which:

Fig. 1 illustrates in diagrammatic form the general arrangement in a coordinate system of the lines and links employed to carry out the applicant's invention;

Fig. 2 shows a mechanism in diagrammatic form for selectively directing a light beam on cold cathode tubes arranged in accordance with the applicant's invention; and

Fig. 3 shows a circuit arrangement for establishing a connection between a calling subscriber's line and a called subscriber's line by means of cold cathode tubes arranged in a coordinate manner as illustrated in Fig. 1.

Referring now to the drawings and in particular to Fig. 1, subscribers' lines may be arranged in horizontal rows and intersected with incoming branches and outgoing branches of links; for example, a calling subscriber at 1 may establish a connection at the cross-connecting point 2 for his line to an incoming branch of a link 3 and through an outgoing branch of this link at the cross-point 4 to a called subscriber at 5. This figure, therefore, shows in general the scheme of establishing connections between subscribers' lines. In Fig. 2 a mechanism has been shown for directing a light beam onto a coordinate arrangement of cold cathode tubes arranged as shown at 10 in horizontal and vertical rows. This mechanism may consist of a light source 11 which may be normally directed to point at some point outside of the field of cold cathode tubes as arranged at 10. To direct a beam from this source to a particular tube in this field, a vertical magnet 12 may be actuated in a step-by-step manner to cause armature 13 and pawl 14 to operate on the ratchet 15 to lower the light source 11. This light source is mounted on an arm 16 integral with the ratchet 15. The arm is pivoted at 17 on a supporting shaft 18 with the armature 13 and pawl 14 in such a manner that the light source may be lowered or raised, but at the same time rotated with the shaft 18. A holding pawl 19 is provided to retain the ratchet 15 in whatever position it is put by the operation of the magnet 12. When this ratchet is to be released the magnet 20 may operate to withdraw the actuating pawl 14 and the holding pawl 19 from the ratchet 15 and the source of light 11 and arm 16 and associated parts will return to the normal position under tension of the spring 22, attached to an extension of arm 16 at one end and to the shaft 18 at the other end. When the source of light has been lowered to the desired horizontal level of the tubes, it may be shifted towards the right to direct a light beam onto a particular tube in the selected horizontal row. This is accomplished by operating the rotary magnet 25 in a step-by-step manner which then, through its armature 26 and operating pawl

27, rotates the ratchet wheel 28 to rotate the arm 16 and point the source of light 11 onto the desired tube so that a light beam from this source will strike this tube. A holding pawl 30 is provided to hold the shaft 18 in the selected position. When it is desired to return the shaft 18 to the normal position, the release magnet 32 will be operated to disengage the operating pawl 27 and the holding pawl 30 from the ratchet wheel 28. Thus the shaft 18 will return to normal in a rotary direction under tension of spring 35. The vertical off-normal contacts 36 and the rotary off-normal contacts 37 may be provided to operate on the first step of the vertical magnet 12 and the rotary magnet 25. Circuit arrangements may be provided whereby the light source is first operated in a vertical direction and then in a horizontal direction whereupon the light source is momentarily energized to cause a beam of light to strike the selected tube in the field 10 to make it discharge. To the lower end of shaft 18 is attached an arm 40 that rides over a rheostat 41 when the shaft is rotated. The purpose of this rheostat will be explained hereinafter.

In Fig. 3 a circuit system has been shown for establishing a connection from one subscriber to another over an idle link and through tubes arranged in accordance with the applicant's invention. Tubes 201 and 202 are provided for establishing connections from calling subscribers to the incoming end of a link and tubes 203 and 204 are provided to establish connections to called subscribers over the outgoing branch of this link, whereas tubes 200 and 214 are provided for establishing connections from calling subscribers to the incoming branch of another link. It should be understood that this merely illustrates a fraction of a tube arrangement. For example, if the system is designed for a ten-line exchange, ten rows of horizontally arranged tubes would be provided for the establishing of connections between any two of ten subscribers' lines, and there may be as many vertical rows of tubes as are required to provide for the maximum number of links required. If five links are required, there would be five incoming branches and five outgoing branches which would require five vertical rows of tubes like tubes 201, 202, 200, 214 for the incoming branches and five vertical rows of tubes like 203 and 204 for the outgoing branches. Ordinarily perhaps only two or three links may be required for taking care of the maximum traffic connections between any two of the ten subscribers. Any suitable sender selector arrangement, marked in general by the box designated 205, may be used as is well known in the art for selecting a common control circuit arrangement, designated by the numeral 206, from any idle link seized by a calling subscriber for establishing a connection. This sender selector arrangement 205 may include, besides the usual tip, ring and sleeve brushes for each link as shown at 207 for the first link, and at 208 for the second link, two additional brushes 209 associated with brushes 207 and 210 associated with brushes 208. The purpose of these additional brushes will become apparent as the designation proceeds. The common control circuit 206 is provided to operate the mechanism disclosed in Fig. 1 for directing the light source 11 on a desired tube of a called subscriber's line and momentarily flashing a light beam from this source on a tube for the establishing of a connection between the outgoing branch of the selected link to the called subscriber's line.

The operation of this system will now be described. If it is assumed that the subscriber at 211 desires to establish a connection through the coordinate switching system to a called subscriber 212, he will remove his receiver from the switchhook. This closes a connection over the tip and ring conductors of his line and thus causes the operation of relay 213 by a circuit from battery and ground and the windings of this relay over the line through a connection at his station. The operation of this relay causes a potential difference to be established between the control electrodes 215 of tube 201 from the positive pole of the battery 216, contacts of relays 213 and 217, resistance 218, control electrodes 215 to ground at contacts of relay 220. This fires the tube 201, and causes a discharge to take place through this tube between the anode 222 and cathode 223 from the positive pole of battery 216, lower winding of relay 217, the ring conductor, anode 222, cathode 223, winding of relay 220 to ground. Relay 220 is thereby operated and closes a circuit for the tip conductor through tube 201 over the anode 225 and cathode 226 from the positive pole of battery 216, upper winding of relay 217, the tip conductors, anode 225, cathode 226, winding of relay 227, to ground at contacts of relay 220. Relay 227 now operates and the discharge across the control electrodes 215 ceases as the ground is removed at the armature and back contact of relay 220 for the discharge path through these control electrodes. These operations therefore have now caused the calling subscriber's line to be connected to the incoming branch of the first link marked 230. It should be understood, of course, that this link was idle and the reason why it was seized is that the current that flows from the positive pole of battery 216, through the resistance 218, through the control electrodes 215 also flows through the resistance 231 and charges the condenser 232. However, before this condenser 232 is fully charged, the connection from the positive pole of battery 216 to the condenser 232 is opened by the operation of relay 217 by the current flowing through its winding over the above-mentioned circuits. Hence further current is prevented from flowing along to the control electrodes of the next tube 203, which would have taken place had the condenser 232 been fully charged. Therefore, tube 201 is fired to establish a connection before tube 203 has had time to fire. However, if the first link had been in use, the next link would have been seized when the subscriber 211 called, as in that case the relay 220 in the first link would have been operated and there would not have been any ground connection for the return path from the positive pole of battery 216 through the control electrodes 215, but, if it is assumed that the second link is idle, ground would be found on the corresponding relay 235 of this link.

On the operation of relay 227 a connection is established from ground through the contacts of this relay, contacts of relay 236 to the start lead ST. This ground now causes the sender selector equipment 205 to operate in any well-known manner to connect this link to the common control circuit shown at 206. When this control circuit is seized, a certain alternating current frequency is transmitted from the source 238 as modified by the dial tone equipment 239 and filter 240 over the tip and ring brushes of the group 207 in equipment 205, condensers 241 and 242, through the anode and cathodes 222, 223, 225 and 226, condensers 243 and 244, over the subscriber's loop at the station 211 to supply a dial tone to the calling

subscriber. This frequency from source 238 may cause certain harmonics to be produced on the line, when the calling subscriber starts to operate his dial, by any suitable harmonic impulse producing means well known in the art, so that each impulse in a digit transmitted will consist of an impulse of said certain harmonics. These impulses may be received through the filter 245 and amplifier-detector equipment 247 to cause the operation of relay 248 each time such an impulse is received. The first impulse received at relay 248 closes a circuit for the operation of the vertical magnet 250 from battery through the winding of this magnet, vertical off-normal contacts 251 to ground at contacts of relay 248. This circuit is also closed from battery through the winding of relay 252 which operates and is slow in releasing and therefore remains operated during the pulsing of the digit. On the first operation of the vertical magnet 250, the vertical off-normal contacts 251 are opened by the mechanism as shown in Fig. 1 and a circuit for the succeeding impulses will then be established through contacts of relay 252, directly to the ground at contacts of relay 248. When all the impulses of the digit have been received, relay 252 releases.

It now becomes apparent that as the first link 230 has been selected the vertical magnet has been operated to select the horizontal row in which the called line is located, that is, the second row as illustrated, and consequently a connection must be made to the called line from the outgoing branch of the first link in order to establish a connection through this link between the subscribers 211 and 212. Hence as the first link is connected through the first vertical row of tubes of which the tubes 203 and 204 have been shown, the source of light must be advanced in a horizontal direction to point to the tube 204 which, as noted, is the first tube in the second row of horizontal tubes. It therefore follows that the rotary magnet 253 must be operated only once in order to cause said tube 204 to establish a connection between the subscriber 212 and the outgoing branch of link 230. To accomplish this, equipment, practically all of which is shown in the sender connector 205, is provided. The arm 40 and the rheostat 41 of the selector have been shown connected in this circuit in the sender selector and it should be observed that the arm 40 on the shaft 18 is normally located so as to connect with the rheostat 41 through a portion 254 thereof to ground. It should also be noted that the left-hand brush of the group 209 is connected through a connection leading through a portion 256 of the resistance 257 to ground. The opposite end of the resistance 257 is connected through the right-hand brush of the group 209 to an alternating current source 258, while the opposite end of the rheostat 41 is connected directly to the source 258. Hence when the connections through the contacts of the group 209 are made, the alternating current from source 258 will flow through the two circuit branches, one leading to ground through resistance 41 and the other leading to ground through the right-hand brush of the group 209 and the resistance 257 to ground, but as the resistance of the portion 256 is greater than the resistance of the portion 254, part of the alternating current from source 258 will also flow through the right-hand brush of the group 209, a part of resistance 257, the left-hand primary winding of the repeating coil 260, arm 40 and resistance 254 to ground. This current causes an alternating current to be produced in the right-hand secondary winding of repeating coil 260 and through the elements of the tube 261 which causes the tube 261 to break down and a direct current to flow through the circuit connected through the winding of relay 262. This relay therefore now operates and closes one point in a circuit for the rotary magnet 253 and when, as stated above, relay 252 releases, a second point in this circuit will be closed so that the rotary magnet 253 will operate from battery through the winding of this magnet and its self-interrupting contacts, contacts of relays 262 and 252, vertically off-normal contacts 251 to ground. This causes the magnet 253 to operate and release and thus advance the switch in a rotary direction so that the arm 40 advances on the rheostat 41 towards the right, as indicated by the arrow, a certain distance and as only one step of the rotary magnet is required, the arm 40 will advance on the rheostat 41 to a position where the resistance of the portion 254 plus the added resistance due to the movement of the arm 40 is equal to the resistance 256. When this occurs it is evident that the alternating current from source 258 will flow through the two branches, as hereinbefore mentioned, of equal value and therefore the current through the primary winding of repeating coil 260 will cease to flow. Hence the tube 261 will cease operating and relay 262 releases and thus opens the circuit for the rotary magnet 253 so that the lamp 11 (marked 265 in Fig. 3) will be pointed on tube 204. The circuit for the rotary magnet 253 is also closed through the winding of relay 264 to battery so that this relay is operated during the pulsing. When this pulsing circuit is opened relay 264 releases. This closes a circuit for the lighting of lamp 265 from battery, through the filament of this lamp, the rotary off-normal contacts 267 to ground at the contact of relay 264. As tube 204 now becomes active due to this beam of light, it establishes a connection for the outgoing end of the selected link 230 to the called subscriber 212 over his line. This established circuit between the elements in this tube may be traced as follows: from the positive pole of battery 270, windings of relay 271, tip and ring conductors, anodes 272 and 273, and cathodes 274 and 275, windings of relay 236 to ground at contacts of relay 227. Relay 236 now operates and opens the connection to ground for the start lead ST, causing the release of relay 276 which was operated when the sender selector was seized by the above-mentioned ground applied at the contacts of relay 227. Hence a circuit will now be closed for the release magnets 277 and 278 which corresponds to release magnets 20 and 25 of Fig. 2. This causes the release of the selector switch and the sender selector is returned to normal also due to the absence of the ground on the start lead. These circuits through the windings of relay 236 as above mentioned also cause the operation of relay 271. Relay 271 in operating closes a circuit from the ringing source at 280 through contacts of this relay and contacts of relay 281 to the tip and ring conductors and the subscriber's station 212 to ring this subscriber. When the subscriber at 212 answers, relay 281 is operated to disconnect the ringing. A talking circuit is now completed from the subscriber at 211 to the subscriber at 212 over the tube 201, the link 230 and tube 204. The talking battery for the calling subscriber is supplied from the battery 216 and the talking battery for subscriber 212 is supplied at battery 270 and talking may now begin over the connection mentioned

through condensers 241, 242, 243, 245, 283 and 284. When the subscribers hang up, tubes 201 and 204 become inactive and the link 230 is released.

Provision is made for giving a busy tone to the calling subscriber 211 in case the called subscriber 212 is busy. In this case, of course, his relay 281 is operated so that when relay 271 operates to apply ringing it cannot be applied as there is no path for the ringing current from the source 280. It should be noted that the circuits to light the lamp 265 also extend to battery through the winding of relay 285 so that this relay operates at the same time as lamp 265 is lighted. If a calling subscriber does not receive an answer within a certain time interval, the operation of this relay will apply busy tone from the source 286 to the calling line, as a circuit is closed by relay 285 over a delay circuit network 287 to cause the firing of the tube 288 at the end of this time interval. When this tube fires, it discharges through its anode and cathode circuits to complete a circuit through the left-hand windings of the repeating coil 289 for the tip and ring conductors of the engaged link. It should, however, be observed that this busy signal arrangement will not function in case the called subscriber is slow in answering. In this case when ringing current is applied over the tip and ring conductors the filtering device indicated by the box 290 will transmit certain selected frequency components only of the applied ringing current to the repeating coil 291 which will cause the tube 292 to operate. This tube then closes an output circuit from battery through the tube 292 over the winding of relay 293 and generator 294 to ground. Relay 293 is thereby operated and closes a short circuit around condenser 295 of the network 287 to prevent the busy tone through repeating coil 289 from source 286 from being transmitted to the calling line as the circuit for firing tube 288 is disabled by said short circuit closed by relay 293.

What is claimed is:

1. In a coordinate system, subscribers' lines arranged in horizontal rows, links arranged in vertical rows across said subscribers' lines, a cold cathode tube at each intersecting point of a subscriber's line and a link, each tube having electrodes connected to a subscriber's line and electrodes connected to a link, means for establishing connections from a calling line over the electrodes in a tube to one end of a link, means for establishing a light beam, means for momentarily flashing said beam on a tube having electrodes of a called line and another end of said link causing said last-mentioned tube to break down and establish a connection between said called line and said other end of said link over the associated electrodes, and means for signaling the calling line in case the called line is busy.

2. In a coordinate system, lines arranged in horizontal rows, links having an incoming branch and an outgoing branch arranged in vertical rows across said lines, a cold cathode tube at each intersecting point of a line and a branch of said links, one-half of the number of tubes in a horizontal row having each electrodes connected to one line and corresponding electrodes connected to the incoming branch of a different link and also auxiliary control electrodes, and the other half of the number of tubes in said horizontal row having each electrodes connected to the same line and corresponding electrodes connected to the outgoing branch of a different link, means for establishing a connection from any line through one of the tubes in the first-mentioned group to the incoming branch of any link including means for causing said tube to break down by the aid of the associated control electrodes, means for establishing an energy-carrying beam and means for momentarily flashing said beam on the tube of the second-mentioned group at any intersecting point of any other line and the outgoing branch of the link to which the first line is connected through the incoming branch to cause said last-mentioned tube to break down to establish a conductive path between said other line and said outgoing branch to complete a connection between said lines.

3. In a coordinate system, lines each having two conductors and arranged in horizontal rows, a link having an incoming branch and an outgoing branch, each branch having two conductors and arranged in vertical rows across said first lines, a cold cathode tube at each intersecting point of a line and a branch in said links, each tube in a horizontal row having electrodes connected to the two conductors of one line and corresponding electrodes connected to the two conductors of a branch of said link, each of said tubes at the cross-point of the line and an incoming branch of a link having auxiliary electrodes, a partition in each of the tubes at the cross-point of a line and an outgoing branch of a link separating the electrode of one of the two conductors of a line and its associated electrode of one of the two conductors of the outgoing branch from the other two electrodes in said tube, means for establishing a connection from any line to the incoming branch of any link over the electrodes of the associated tube including means for causing said tube to break down by the aid of the associated control electrodes, means for establishing an energy-carrying beam, and means for momentarily flashing said beam on the tube at any intersecting point of any other line and the outgoing branch of the link to which the first line is connected to the incoming branch to cause said last-mentioned tube to break down to establish a conductive path between the conductors of said other line and the associated conductors of said outgoing branch to complete a connection between said lines over said link.

4. In a coordinate system, lines arranged in horizontal rows, links having an incoming branch and an outgoing branch, arranged in vertical rows across said lines, a cold cathode tube at each intersecting point of a line and a branch of said links, one half of the number of tubes in a horizontal row each having electrodes connected to one line and corresponding electrodes connected to the incoming branch of a different link and also auxiliary control electrodes and the other half of the number of tubes in said horizontal row each having electrodes connected to the same line and corresponding electrodes connected to the outgoing branch of a different link, means for establishing connections from any calling line through any one of the tubes in the first-mentioned group to the incoming branch of any link including means for causing said tube to break down by the aid of the associated control electrodes, a step-by-step switch, a source for producing an energy carrying beam, means for operating said switch in response to impulses from the calling line to

direct said source to point towards the horizontal row of the second-mentioned group of tubes associated with a desired line, and means for thereafter automatically directing said source to point towards the tube at the cross-point of the outgoing branch, of the link to which the calling line is connected to the incoming branch, and the desired line and for then causing said source to emit an energy carrying beam to flash on this tube at the said selected cross-point to cause said tube to break down to establish a conductive path between said desired line and said outgoing branch to complete the connection between said desired line and the calling line.

5. In a coordinate system, lines arranged in horizontal rows, links having an incoming branch and an outgoing branch arranged in vertical rows across said lines, a cold cathode tube at each intersecting point of a line and a branch of said links, one half of the number of tubes in a horizontal row each having electrodes connected to one line and corresponding electrodes connected to the incoming branch of a different link and also auxiliary control electrodes, and the other half of the number of tubes in said horizontal row each having electrodes connected to the same line and corresponding electrodes connected to the outgoing branch of a different link, means for establishing a connection from any calling line through one of said tubes in the first-mentioned group to the incoming branch of any link including means for causing said tube to break down by the aid of the associated control electrode, means for establishing an energy carrying beam and means for momentarily flashing said beam on the tube of the second-mentioned group at any intersecting point of any desired line and the outgoing branch of the link to which the calling line is connected through the incoming branch to cause said last-mentioned tube to break down to establish a conductive path between said desired line and said outgoing branch to complete a connection between the desired line and the called line, and means operative in case the desired line is busy for transmitting a busy tone to the calling line, a certain interval after the connection has been established through to the desired line.

6. In a coordinate system, lines arranged in horizontal rows, links having an incoming branch and an outgoing branch arranged in vertical rows across said lines, a cold cathode tube at each intersecting point of a line and a branch of said links, one half of the number of tubes in a horizontal row each having electrodes connected to one line and corresponding electrodes connected to the incoming branch of a different link and also auxiliary control electrodes, and the other half of the number of tubes in said horizontal row each having electrodes connected to the same line and corresponding electrodes connected to the outgoing branch of a different link, means for establishing a connection from any calling line through one of the tubes in the first-mentioned group to the incoming branch of any link, including means for causing said tube to break down by the aid of the associated control electrodes, a control means connected to a plurality of links, means for connecting said control means to the seized link operative in response to the establishing of the connection between the calling line and the incoming branch of the seized link, said control means operative in response to the transmission of signals from said calling line to cause an energy carrying beam to momentarily flash on the tube of the second-mentioned group at any intersecting point of any other desired line and the outgoing branch of the link to which the first called line is connected through the incoming branch to cause said last-mentioned tube to break down to establish a conductive path between said desired line and said outgoing branch to complete the connection between said desired line and the called line.

7. In a coordinate system, lines arranged in horizontal rows, links having an incoming branch and an outgoing branch arranged in vertical rows across said lines, a cold cathode tube at each intersecting point of a line and a branch of said links, one half of the number of tubes in a horizontal row each having electrodes connected to one line and corresponding electrodes connected to the incoming branch of a different link and also auxiliary control electrodes, and the other half of the number of tubes in said horizontal row each having electrodes connected to the same line and corresponding electrodes connected to the outgoing branch of a different link, means for establishing a connection from any calling line to one of the tubes in the first-mentioned group to the incoming branch of any link including means for causing said tube to break down by the aid of the associated control electrodes, a step-by-step switch, a source for producing an energy carrying beam associated with said switch, means for actuating said switch in response to dial pulses from the calling line to cause said source to be directed on the tube of the second-mentioned group at any intersecting point of any desired line and the outgoing branch of a link to which the called line is connected to the incoming branch and to emit an energy carrying beam to momentarily flash on the selected tube to cause said tube to break down to establish a conductive path between said desired line and said outgoing branch to complete a connection between said desired line and the calling line.

8. In a coordinate system, a group of lines, each line comprising a plurality of conductors arranged in horizontal rows, another group of lines, each line comprising a plurality of conductors arranged in vertical rows across said first-mentioned lines, a cold cathode tube at each intersecting point of the lines in said two groups, each of said tubes being divided into chambers, each chamber containing two electrodes, one connected to a conductor of a line in a horizontal row and the other connected to a conductor of a line in a vertical row, a source of light independent of said tubes and means for momentarily flashing a beam of light from said source on the electrodes in the chambers of a tube at any intersecting point to break down said tube to establish a conducting path between the electrodes in each chamber and the connected conductors said paths remaining conductive after the beam of light is removed from the electrodes of said tube.

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