Oct. 26, 1943. E. VROOM 2,332,878

DIAL OPERATED CROSSBAR SELECTOR

Filed June 19, 1942 6 Sheets-Sheet 1

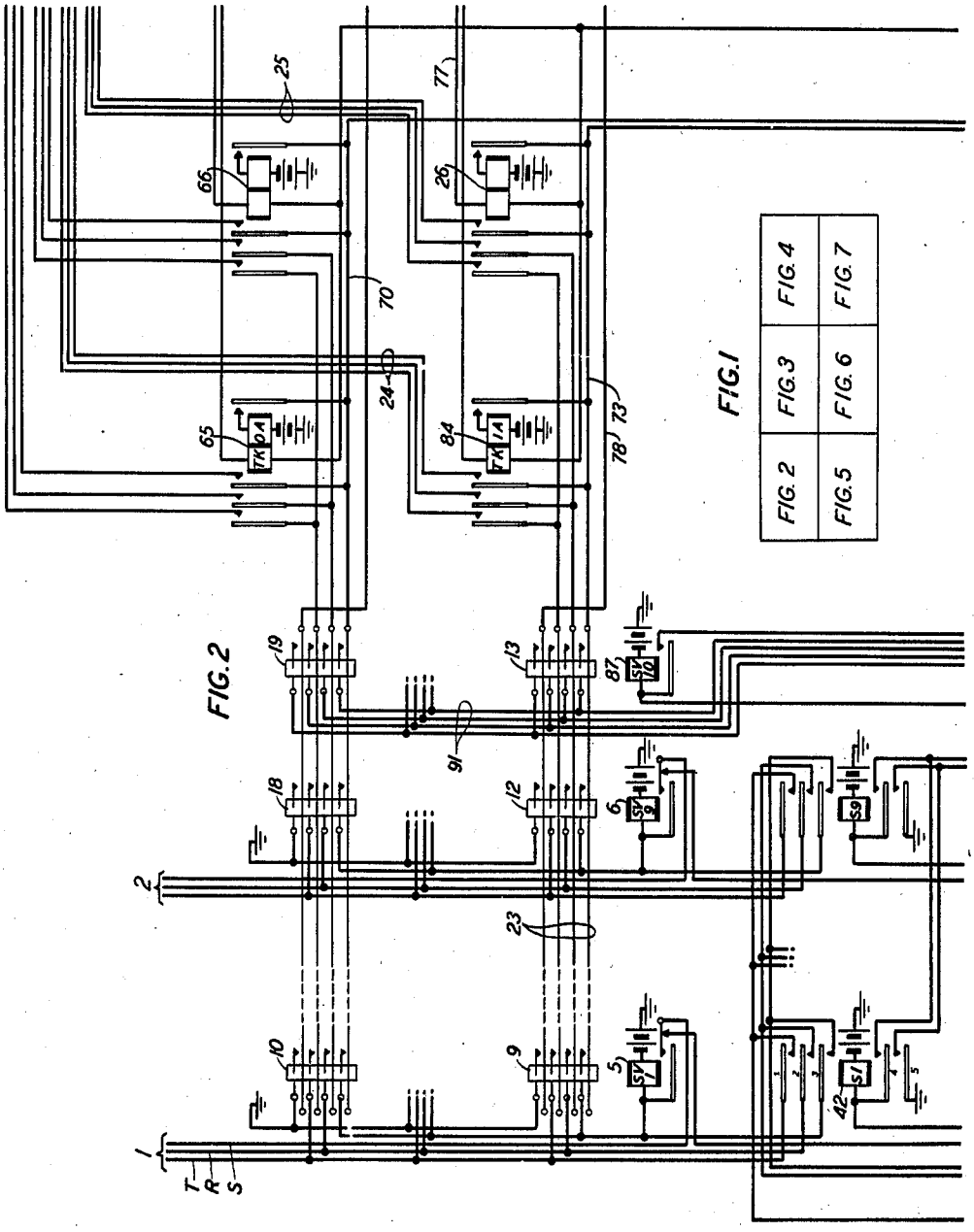

FIG. 1

FIG. 2	FIG. 4
FIG. 3	FIG. 6
FIG. 5	FIG. 7

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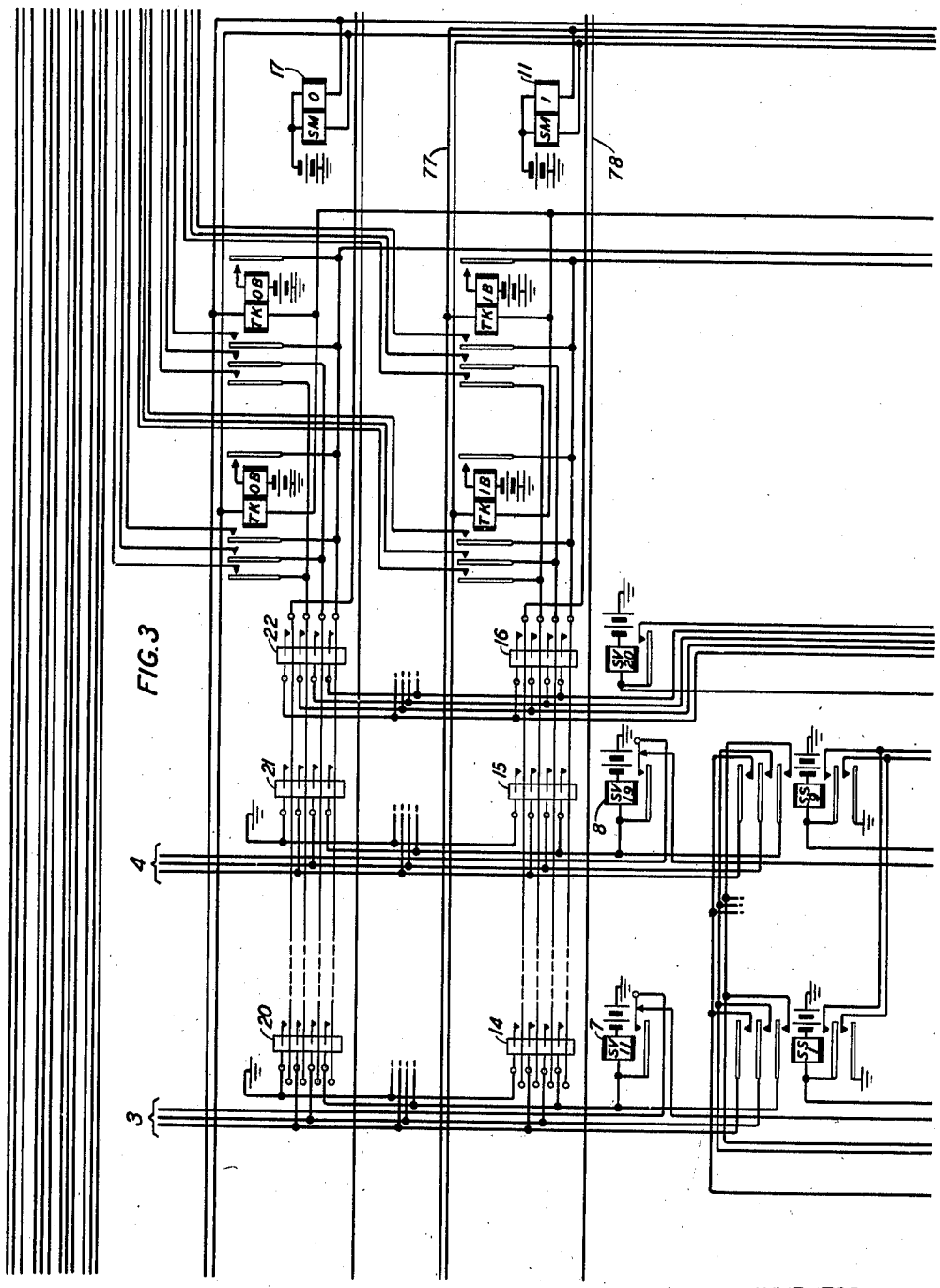

FIG. 3

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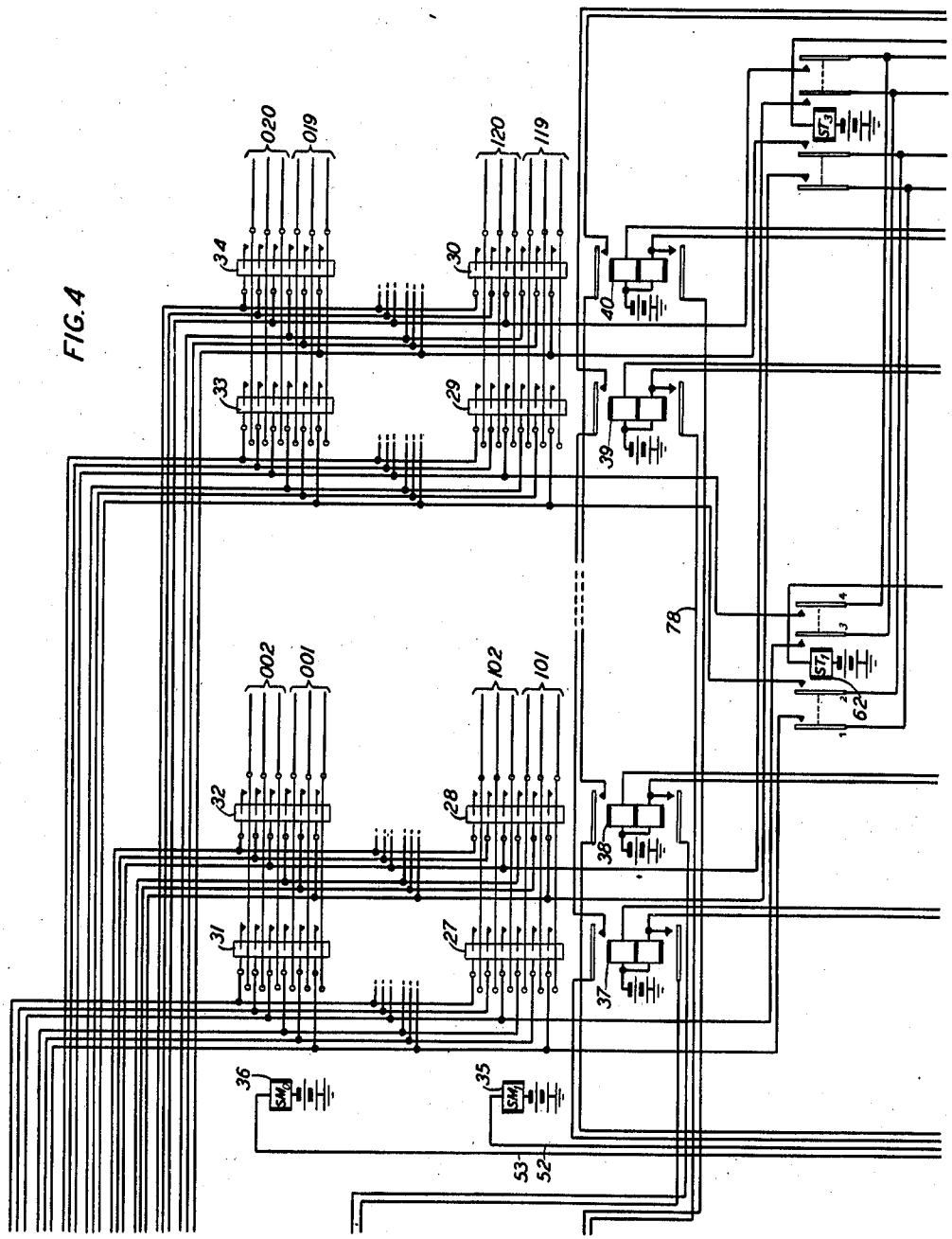
FIG. 4



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DIAL OPERATED CROSSBAR SELECTOR

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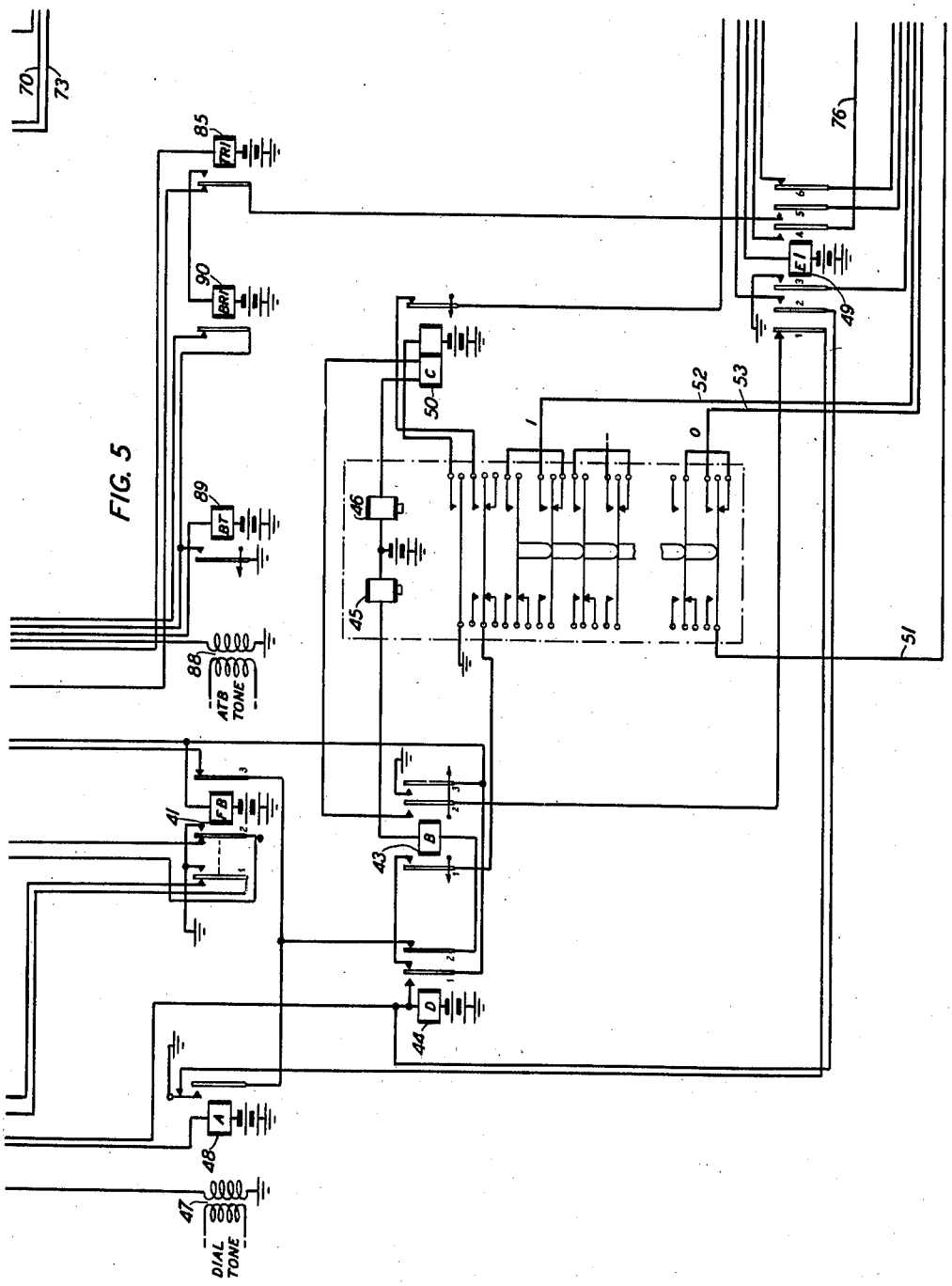

FIG. 5

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DIAL OPERATED CROSSBAR SELECTOR

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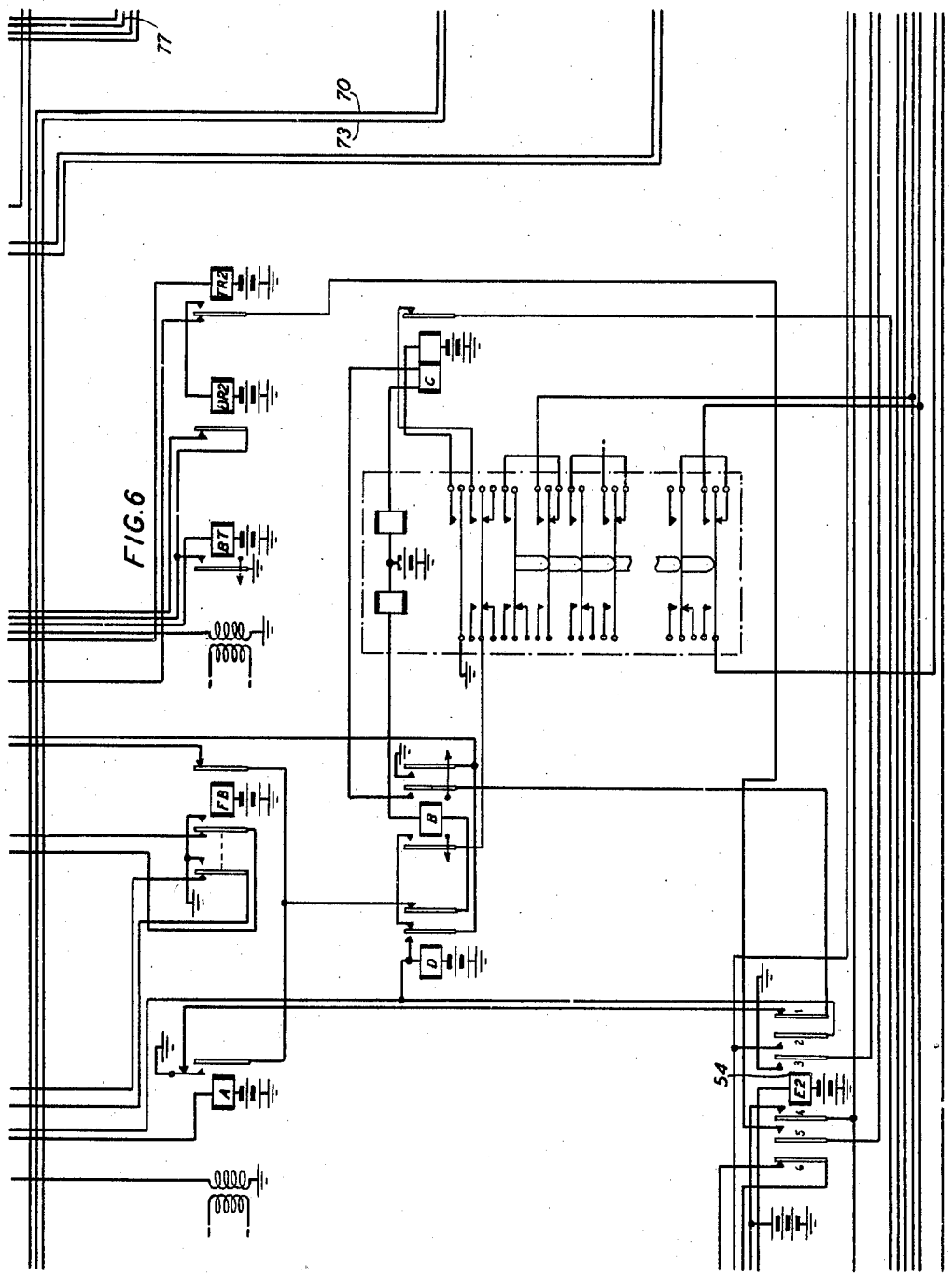

FIG. 6

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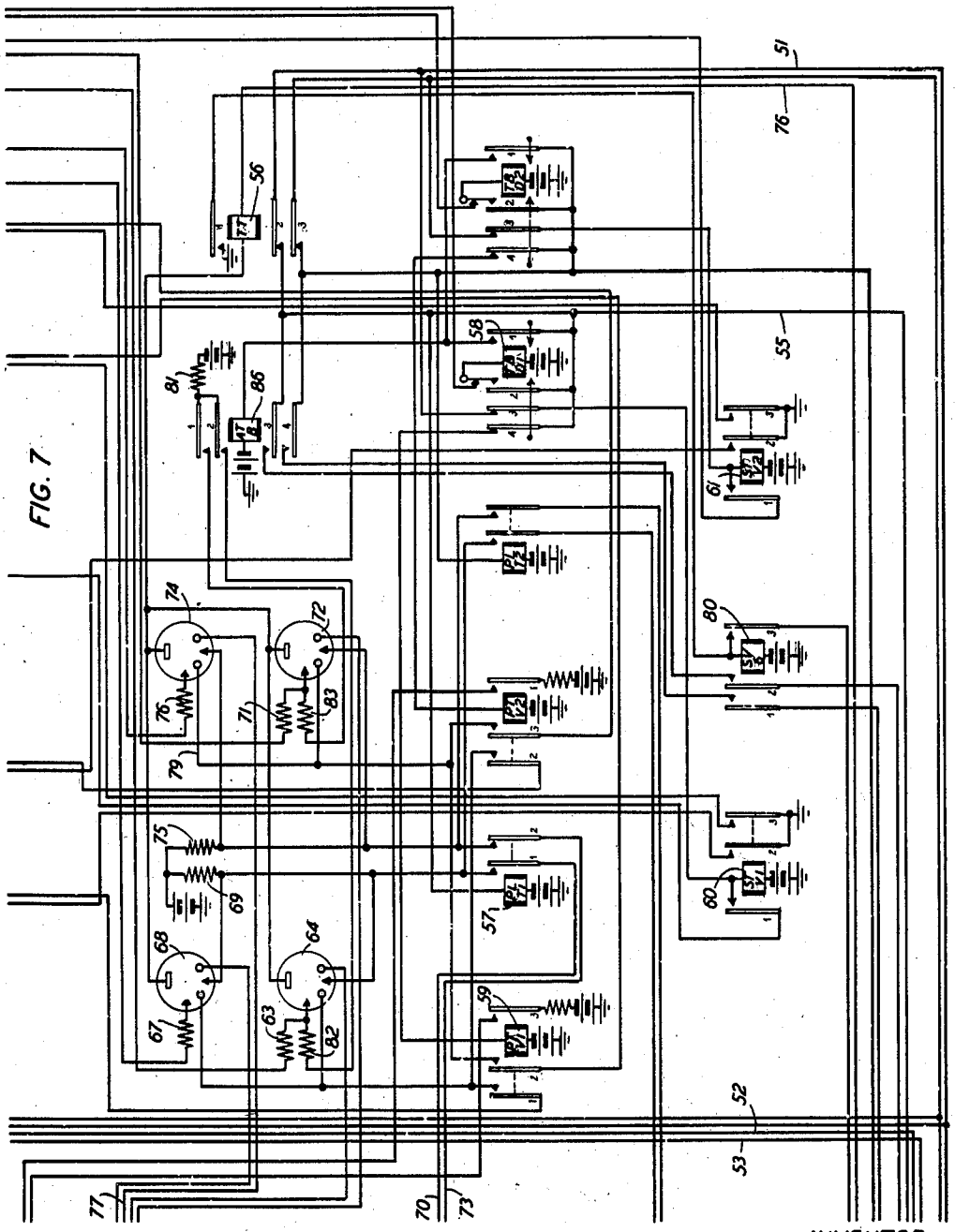

FIG. 7

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Patented Oct. 26, 1943

2,332,878

UNITED STATES PATENT OFFICE

2,332,878

DIAL OPERATED CROSSBAR SELECTOR

Edward Vroom, Ossining, N. Y., assignor to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

Application June 19, 1942, Serial No. 447,677

6 Claims. (Cl. 179—22)

This invention relates to switching systems and particularly to dial controlled switches for use in communication systems.

The object of the invention is to operate a crossbar switch in the manner of a step-by-step switch so that it will properly select an idle outgoing line from a group designated by a train of dial pulses. This broad object has been accomplished heretofore and particularly in a manner disclosed in the application of S. B. Williams, Serial No. 420,445, filed November 26, 1941. The present invention is an improvement of the Williams' system.

On an incoming call, an incoming train of pulses will set a register which designates a particular group of outgoing lines. Thereupon a select magnet having control over all the outgoing lines of that group will be operated and a train of circuit operations for testing such outgoing lines will be started. There is provided a group of cold cathode tubes equal in number to the number of outgoing lines in a group. Each of these tubes is inserted in a circuit between the sleeve of an outgoing line and the sleeve of the link circuit to which it would be connected. If either the sleeve of the outgoing line or the sleeve of the link indicates a busy condition the tube will remain inert. If only a single tube in this mass circuit connection is connected between an idle link and an idle outgoing line the tube will ignite and control the making of a permanent connection between such link and such line. If a plurality of tubes are included in possible circuits only one will ignite and the others will be inductively locked out. In general, this inductive lock out system is disclosed in the application of M. E. Mohr, Serial No. 377,998, filed February 8, 1941.

A feature of the invention is the means for making a mass circuit connection of the test tubes between the outgoing lines of the selected group and the links to which they might be connected. Accordingly, after the select magnet of the designated group is operated the operating circuits for all the hold magnets are closed. If any link which might be used is busy, then the hold magnet will already have been operated and no further connection will be established. If, however, the hold magnet is unoperated at the time, then the operation thereof will cause the corresponding contact set of the crossbar switch to operate so that the sleeve of the corresponding outgoing line will be extended to a test tube. When the junction of an idle link and an idle outgoing line is thus determined the operated hold magnet controlling this point will be maintained and all others will be released.

Another feature of the invention is the means for simultaneously extending all idle links to corresponding outgoing lines of the selected group and then releasing all such established connections excepting the one chosen for service.

In case an all-trunks-busy condition is encountered an idle link will be temporarily employed for connecting a proper signal to the incoming line. Since the arrangement is such that there are more outgoing lines in a group than there are incoming lines there will always be an idle link even though an idle outgoing line cannot be found and hence this idle link is employed for the purpose stated of sending back an all-trunks-busy signal.

Other features will appear hereinafter.

The drawings consist of six sheets having six figures which arranged as indicated in Fig. 1 form a complete circuit diagram of a step-by-step selecting stage accommodating eighteen incoming lines and two hundred outgoing trunks.

The eighteen incoming lines are arranged in two groups, the first nine lines indicated in Fig. 2 and the second nine lines indicated in Fig. 3. Thus line 1 is the first and line 2 is the last of the first group and line 3 is the first and line 4 is the last of the second group. All of these lines appear in a single crossbar switch of well-known construction and each line appears in a vertical row of sets of permanently paired contacts and each has individual to it a hold magnet. Thus hold magnets 5, 6, 7 and 8 correspond to lines 1, 2, 3 and 4, respectively. The contact sets 9 representing the first and the contact set 10 representing the last are individual to the line 1.

Each horizontal row of contact sets is controlled by a select magnet such as the magnet 11 controlling the contact sets 9, 12, 13, 14, 15 and 16 and the magnet 17 controlling the contact sets 18, 18, 19, 20, 21 and 22.

The contact sets 9, 12 and 13 by way of example serve to connect any of the incoming lines of the first group to a link 23 which may be divided for appearance in the switch of Fig. 4 into the two branches 24 and 25.

This switch is known as a twenty by ten four-wire switch since there are twenty verticals and ten horizontals and since each contact set has four pairs of permanently paired contacts.

The outgoing switch is a twenty by ten six-wire switch. Each contact set has six pairs of permanently paired contacts and accommodates two

hundred outgoing three-wire trunks, each of which is multipled to contacts of two sets.

In this switch the first, second, nineteenth and twentieth verticals are represented by the contact sets 27, 28, 29 and 30, respectively, in the first horizontal row and by contact sets 31, 32, 33 and 34, respectively, in the last horizontal row. The select magnet 35 representing the digit 1 and the select magnet 36 representing the digit 0 control the first and last horizontal rows respectively. The hold magnets 37, 38, 39 and 40 control the first, second, nineteenth and twentieth verticals respectively.

All of the trunks in the first horizontal row will have the digit 1 as their first digit and all of the trunks in the last horizontal row will have the digit 0 as their first digit. The second and third digits of each trunk will be appropriately numbered to indicate its position in its group of twenty trunks. Thus trunks 101 and 102 will each appear in contact sets 27 and 28 and likewise trunks 019 and 020 will each appear in contact sets 33 and 34. Thus each contact set accommodates two outgoing trunks and each trunk appears in two contact sets.

The nine incoming lines of the first group have a register circuit individual thereto shown in Fig. 5 and the nine incoming lines of the second group have a similar register circuit individual thereto shown in Fig. 6.

Fig. 7 shows the common test circuit for selecting a combination of an idle link and the idle trunk. This circuit consists essentially of twenty cold cathode tubes, each of which is connected to a corresponding trunk of a selected group when the time comes to make a selection as will appear hereinafter.

In operation, when an incoming line, which may be a trunk from a line switch or a selecting stage, is seized, ground will appear on the sleeve and a bridge will appear across the tip and ring. Thus if incoming line 1 is seized, ground will appear on the conductor marked S and this will extend through the normal contacts of the hold magnet 5, through armature 1 and back contact of relay 41, the winding of relay 42 to battery, thus operating relay 42. Relay 42 immediately operates the first slow relay 43, even though the circuit thereof is almost immediately opened by the operation of relay 41. The original circuit for relay 43 may be traced from ground, armature 5 and front contact of relay 42, back contact and armature 3 of relay 41, back contact and armature 2 of relay 44, winding of relay 43 and winding of magnet 45 to battery.

Also upon the operation of relay 42 a circuit is closed from the ground used for the operation of relay 42 through armature 4 and front contact of relay 42 to the winding of relay 41 to battery which results in the operation of relay 41 and the opening of the original circuit of relay 43. However, before relay 43 can release a circuit is closed from ground through the winding of dial tone transformer 47, front contact and armature 1 of relay 42 to the tip of the line, thence through the bridge on the calling line to the ring of the line, armature 2 and front contact of relay 42, winding of line relay 48 to battery. Relay 48 operates and supplies an operating ground for relay 43.

The apparatus is now ready for the dialing operation. The line relay 48 will respond to each break in the line circuit so as to open the circuit of magnet 45 and close the circuit of magnet 46. This latter circuit may be traced from ground, the normal contacts of the line relay 48, armature 1 and back contact of relay 49, armature 2 and front contact of slow releasing relay 43, left-hand winding of slow releasing relay 50, winding of magnet 46 to battery. The device in the broken line rectangle including magnets 45 and 46 is an electromechanical equivalent of a chain of counting relays and is clearly described in an application, Serial No. 389,322, filed April 19, 1941, by George R. Stibitz. When this device has been set by the incoming pulses a ground on conductor 51 will be connected to one of ten conductors such as conductor 52 representing the digit 1 or conductor 53 representing the digit 0.

At the end of the dialing period the slow releasing relay 50 is released and this results in the closure of a circuit from ground, front contact and armature 3 of relay 43, armature 1 and back contact of relay 44, front contact and armature 1 of relay 43, through the off-normal contacts of the stepper, back contact and armature of relay 50, back contact and armature 6 of relay 54, winding of relay 49 to battery to cause the energization of relay 49. It may be noted that relay 49 for the first group and relay 54 for the second group interact in such a way that when, for instance, relay 49 has been operated relay 54 cannot be operated and vice versa. This is a well-known non-interference means. Also in this connection non-interference within the group is provided. Thus while line 1 is calling, the remainder of the lines are temporarily disabled by relay 41.

Upon the operation of relay 49, the digit registered on the stepper is rendered effective to operate the crossbar switch of Fig. 4. Thus a circuit may be traced from ground, the front contact and armature 3 of relay 49, conductor 55, back contact and armature 2 of relay 56, conductor 51, through the circuit of the stepper to conductor 52 (assuming digit 1 to have been registered) to the select magnet 35, thus causing the operation of this select magnet. All contact sets in the first horizontal row are thus prepared for operation.

Ground on conductor 55 is also extended directly to the winding of relay 57 and through armature 4 and back contact of relay 58 to the winding of relay 59. Relays 57 and 59 operate, relay 57 to connect the sleeve circuits of the links, such as 23, to the test tubes and relay 59 to prepare for the operation of the select magnets and the transfer relays of Figs. 2 and 3. Ground on conductor 55 is also extended through back contact and armature 2 of relay 56, back contact and armature 3 of relay 58 to the winding of relay 60 which connects a ground to the lower winding of every other one of the hold magnets such as magnets 37 and 39. The companion relay 61 under control of relay 54 at another time will similarly operate the remainder of the hold magnets such as magnets 38 and 40.

The operation of relay 60 causes the operation of relay 62 whereby the sleeves of the various three-wire circuits controlled by the now operated hold magnets are connected to the test electrodes of the test tubes.

Let it be assumed that the hold magnet 37 was found operated in connection with an already established connection to trunk 002. In this case contact set 31 would be found operated and a ground would appear on the sleeve of trunk 002 leading through the front contact and armature 3 of relay 62 to resistance 63 and thence to a test electrode of tube 64. A ground on this test electrode will prevent the tube from firing and

thus mark the portion of the link controlled by the upper three contacts of the set 31 as unavailable for use.

Now since the portion of the link through the contacts of transfer relay 65 is busy it is evident that the portion leading from the contacts of relay 66 cannot be used. Therefore, the test tube connected to this other portion of the link must be prevented from firing. If trunk 001 is idle then a minus battery will be connected to the sleeve thereof and this may be traced through front contact and armature 1 of relay 62 to resistance 67 leading to a test electrode of tube 68. It will be noted that a plus battery is connected through resistance 69 to the other test electrode of this tube. If this is left unaffected the tube may fire. However, since the link is actually busy a ground from the sleeve thereof may be traced through conductor 70, armature 1 and front contact of relay 57 to the test electrode of tube 68, thus shunting the plus battery supplied through resistance 69 and preventing the firing of tube 68.

Let it now be assumed that link 23 is idle but that trunk 120 is busy. Hold magnet 39 in operating will cause the operation of contact set 29, it being assumed that trunk 120 is busy through the operation of contact set 30 or in some other switch. Ground on the sleeve of trunk 120 will be extended over the front contact and armature 4 of relay 62 to resistance 71 leading to a test electrode of tube 72, thus preventing this tube from firing. The sleeve of link 23 is now connected through conductor 73, armature 2 and front contact of relay 57 to the test electrode of tube 74 normally supplied with a plus battery potential through resistance 75. The other test electrode connected through resistance 76 and thence over armature 2 and front contact of relay 62 to the sleeve of idle trunk 119 will have a minus battery potential on it and the tube should fire. Since the sleeve conductor 73 is free of ground tube 74 will fire. In these tubes the test electrodes are shown with arrowheads and when a minus potential appears on one and a plus potential on the other the tube tends to break down. With a stream of ions passing between the two test electrodes the tube becomes ionized so that a current flow will be established between the main anode shown as a small oblong in the upper part of the tube and the working cathodes shown as small circles near the bottom part of the tube.

With twenty of these tubes simultaneously searching for the combination of an idle trunk and an available idle link it will very often happen that a plurality of tubes will attempt to operate at once. However, one will fire and thereafter the resistance drop due to the resistance of relay 56 will reduce the potential on the anodes of all the tubes to the point where no other one may operate even though it has been sufficiently ionized by its test electrodes.

The inductance of the winding of relay 56 will prevent more than one tube from operating. Due to the fact that when a circuit is closed through an inductance the attainment of a stable value of current is delayed, the natural difference in the operating time characteristics of the tubes is exaggerated because as current begains to flow through the winding of relay 56 the potential on the anodes of the tubes begins to drop and this change adversely affects the striking capabilities of the tubes. Hence where there is an inherent difference in the striking times of the different tubes this inherent difference is developed by the use of an inductance so that one tube will get ahead of the rest and of course as soon as it fires it will lock out the rest due to the sudden lowering of the potential on the anodes below the point where any tube will fire.

Let it now be assumed that tube 74 which has formed an idle trunk and an available idle line succeeds in striking to the exclusion of all other tubes which may have found similar conditions. A circuit will be established from battery, front contact and armature 4 of relay 49, conductor 76, winding of relay 56, the anode of tube 74, to the two working cathodes of this tube. The circuit may be traced from the right-hand cathode of this tube over conductor 77, the left-hand winding of relay 26, to the front contact and armature 3 of relay 59 thence through resistance 78 to a battery which will aid the battery connected to the front contact of armature 4 of relay 49. Conductor 77 also leads through the right-hand winding of select magnet 11 so that this select magnet as well as relay 26 now becomes operated.

A circuit will also be closed through the left-hand working cathode of tube 74 to conductor 79, front contact and armature 2 of relay 59 to the upper winding of hold magnet 39 to maintain this hold magnet operated after the remainder are released by the release of relay 60.

Due to the current flow through the winding of relay 56 this relay now becomes operated and the ground from conductor 55 is disconnected from the armature 2 of relay 56 and from conductor 51. This releases the select magnet 35 and relay 60 so that the temporarily operated sets of contacts in the switch of Fig. 4 are released. The contact set 29 however is maintained operated and as will shortly appear this is held under control of the holding conductor 78. Upon the operation of relay 56 a circuit is closed over the front contact and armature 1 of relay 56 to the winding of relay 80 and this same ground is now extended by the operation of relay 80 over its front contact and armature 3, the front contact and armature 2 of relay 49 to the windings of relay 44 and hold magnet 5 in parallel. Hold magnet 5 causes the operation of contact set 9 so that the incoming line 1 is now extended through this contact set to link 23, through the front contacts of relay 26, to link 25 and through the contact set 29 to trunk 119. The ground on the sleeve of the incoming line is connected through the front contact of hold magnet 9 to the conductor 73 and the sleeve of the outgoing trunk 119. Ground on conductor 73 allows relay 26 to lock to the sleeve of the trunk. In the same manner that relay 41 immediately returned a ground back over the sleeve of the incoming line 1, similar means associated with the trunk 119 will return a ground which will hold the hold magnet 5 and the relay 26. The hold magnet 39 is held from ground connected by the upper contact of the set 9 to the hold wire 78.

Due to the operation of relay 44 the circuit of the first slow relay 43 is opened which now results in the release of all common apparatus. Relay 43 releases and opens the circuits of the register magnets 45 and 46 thus restoring this apparatus to normal. Relay 43 is released and the relay 42 is released. Relay 42 disconnects the incoming line 1 from the register circuit so that the line relay 48 releases. After the release of relay 49 relay 44 also releases.

In the circuits of Fig. 7, ground being removed

from conductor 55, relay 57 and relay 59 release thus disconnecting the test electrodes of the tubes from the sleeves of the links and the working cathodes from the upper windings of the holding magnets of Fig. 4. Battery being removed from conductor 76, relay 56 is released and the tube 74 extinguished thus releasing the select magnet 11 and returning all common apparatus to normal.

When an all-trunks-busy condition is encountered the slow acting relay in time will be operated. The circuit may be traced from ground, front contact and armature 3 of relay 49, conductor 55, back contact and armature 2 of relay 56, conductor 51, thence through a chain circuit including the upper armatures and front contacts of hold magnets 37 and 39, the normal contacts of armature 2 of relay 58 and the winding of relay 58 to battery. This circuit of course is closed under ordinary conditions, but due to the slow operating characteristics of relay 58 does not become effective until the operations heretofore described have been completed. Under the all-trunks-busy condition however, no tube will fire and in time relay 58 will become energized and will lock directly to the ground on conductor 55. Thereupon the all-trunks-busy relay 86 will become energized. This relay connects negative battery through resistance 81 to the resistances 82 and 83 thus placing an artificial idle indicating condition on the ten tubes indicated by tubes 64 and 72. Since relay 58 through its operation has released relay 60 this potential will be effective. Also since there are but nine incoming lines in a group and there are ten links some one of the tubes 64 to 72 will fire. Let us assume that tube 72 operates. Relay 59 having been released, hold magnet 39 cannot be operated. The other working cathode of tube 72 however will be effective to energize the left-hand winding of select magnet 11. The circuit for the left-hand winding of relay 84 is closed at the same time but the release of relay 59 prevents its operation.

Upon the operation of tube 72 the relay 56 operates and this in turn causes the operation of relay 80 so that now a circuit is closed from ground on conductor 55 through armature 3 and front contact of relay 86, front contact and armature 2 of relay 80, armature 5 and front contact of relay 49, armature and back contact of relay 85, winding of holding magnet 87, to battery. At the same time holding magnet 5 is operated as hereinbefore described so that now contact sets 9 and 13 are operated and the incoming line 1 is connected through link 23 to the circuit 91. Upon the establishment of this connection the release of the common apparatus will be started.

A connection is now established from ground, winding of transformer 88 supplying an all-trunks-busy tone, the tip of the line over the bridge from the tip to the ring of the line, winding of relay 89 to battery. All-trunks-busy tone is thus transmitted to the subscriber on the incoming line. Relay 89 operates and extends a ground through the contacts of relay 90 to hold the hold magnet 87. The subscriber in hanging up releases relay 89 whereupon the apparatus is returned to normal.

If at the time ground is put on armature 5 of relay 49 the tenth vertical circuit 91 is being used, relay 85 will be operated and hence this ground will cause the operation of relay 90. This will open the holding circuit of magnet 87 thus releasing the incoming line connected to circuit 91 and giving another incoming line which has encountered the all-trunks-busy condition an opportunity to be connected to the source of tone 88. If only one line uses the circuit 91 then relay 85 will remain operated without effect until the subscriber hangs up and releases relay 89.

What is claimed is:

1. A dial operated crossbar switch, comprising a coordinately arranged field of sets of permanently paired contacts operated through the temporary operation of one of a plurality of selecting magnets arranged in one coordinate direction and, during the period of operation of said selecting magnet, the operation of one of a plurality of holding magnets arranged in another coordinate direction, incoming lines one each multipled to all said sets of contacts under control of a holding magnet, a group of equivalent outgoing lines appearing in the sets of contacts under control of each said selecting magnet, means for selectively operating said selecting magnets, means for selecting an idle one of said outgoing lines of the group under control of said selectively operated selecting magnet, comprising a plurality of discharge tubes, means to temporarily connect said tubes each in a circuit to an outgoing line and a corresponding incoming line, means responsive to the busy condition of either said outgoing or incoming line to prevent the operation of the corresponding tube, lockout means for preventing more than one tube connected to a pair of idle lines from operating, and means responsive to the operation of one such tube for establishing a connection between the corresponding incoming and outgoing lines and dismissing said test circuit connection.

2. A dial operated crossbar switch, comprising a coordinately arranged field of sets of permanently paired contacts operated through the temporary operation of one of a plurality of selecting magnets arranged in one coordinate direction and, during the period of operation of said selecting magnet, the operation of one of a plurality of holding magnets arranged in another coordinate direction, incoming lines one each multipled to all said sets of contacts under control of a holding magnet, a group of equivalent outgoing lines appearing in the sets of contacts under control of each said selecting magnet, means for selectively operating said selecting magnets, means for selecting an idle one of said outgoing lines of the group under control of said selectively operated selecting magnet, comprising means to temporarily operate all said holding magnets to establish a testing circuit, a testing circuit, and means responsive thereto for releasing all of said holding magnets except the one corresponding to the selected outgoing line.

3. A dial operated crossbar switch, comprising a coordinately arranged field of sets of permanently paired contacts operated through the temporary operation of one of a plurality of selecting magnets arranged in one coordinate direction and, during the period of operation of said selecting magnet, the operation of one of a plurality of holding magnets arranged in another coordinate direction, incoming lines one each multipled to all said sets of contacts under control of a holding magnet, a group of equivalent outgoing lines appearing in the sets of contacts under control of each said selecting magnet, means for selectively operating said selecting magnets, means for selecting an idle one of said outgoing lines of the group under control of said

selectively operated selecting magnet, comprising means to temporarily operate all remaining unoperated holding magnets to connect said outgoing lines to corresponding idle incoming lines, a test circuit, means to connect said test circuit to said incoming lines, means responsive to the busy condition of either an incoming line or a corresponding outgoing line to hold the corresponding portion of said test circuit unresponsive to said connection, a lockout means for holding all remaining portions of said test circuit except one unresponsive to said connection, means controlled by the response of said excepted one portion of said test circuit for holding the corresponding holding magnet energized and for releasing all other holding magnets, not otherwise operated.

4. A dial operated crossbar switch, comprising a coordinately arranged field of sets of permanently paired contacts operated through the temporary operation of one of a plurality of selecting magnets arranged in one coordinate direction and, during the period of operation of said selecting magnet, the operation of one of a plurality of holding magnets arranged in another coordinate direction, incoming lines one each multipled to all said sets of contacts under contral of a holding magnet, a group of equivalent outgoing lines appearing in the sets of contacts under control of each said selecting magnet, means for selectively operating said selecting magnets, means for selecting an idle one of said outgoing lines of the group under control of said selectively operated selecting magnet, comprising means to temporarily operate all remaining unoperated holding magnets to connect said outgoing lines to corresponding idle incoming lines, a test circuit comprising a cold cathode tube for each incoming line, means to connect said tubes to corresponding incoming lines to test for the busy or idle condition of either said incoming lines to said temporarily connected outgoing lines, a lockout circuit for allowing the operation of only one tube of the remainder connected to idle paired incoming and outgoing lines, and means responsive to the operation of one such tube for dismissing said test circuit and releasing all holding magnets corresponding to idle paired lines except the said holding magnet corresponding to the selected one of said idle paired lines.

5. A dial operated crossbar switch, comprising a coordinately arranged field of sets of permanently paired contacts operated through the temporary operation of one of a plurality of selecting magnets arranged in one coordinate direction and, during the period of operation of said selecting magnet, the operation of one of a plurality of holding magnets arranged in another coordinate direction, incoming lines one each multipled to all said sets of contacts under control of a holding magnet, a group of equivalent outgoing lines appearing in the sets of contacts under control of each said selecting magnet, means for selectively operating said selecting magnets, means for selecting an idle one of said outgoing lines of the group under control of said selectively operated selecting magnet, comprising a plurality of discharge tubes equal in number to the number of outgoing lines appearing in the sets of contacts under control of each said selecting magnet, means comprising a circuit established by the holding magnet for each outgoing line for simultaneously starting all of said tubes associated with an idle outgoing line and an idle incoming line, and lockout means for preventing the firing of more than one of said tubes for selecting an idle outgoing line and for connecting such selected idle outgoing line to an idle incoming line.

6. A dial operated crossbar switch, comprising a coordinately arranged field of sets of permanently paired contacts operated through the temporary operation of one of a plurality of selecting magnets arranged in one coordinate direction and, during the period of operation of said selecting magnet, the operation of one of a plurality of holding magnets arranged in another coordinate direction, incoming lines one each multipled to all said sets of contacts under control of a holding magnet, a group of equivalent outgoing lines appearing in the sets of contacts under control of each said selecting magnet, means for selectively operating said selecting magnets, means for selecting an idle one of said outgoing lines of the group under control of said selectively operated selecting magnet, comprising a plurality of discharge tubes equal in number to the number of outgoing lines appearing in the sets of contacts under control of each said selecting magnet, means comprising a circuit established by the holding magnet for each outgoing line for simultaneously starting all of said tubes associated with an idle outgoing line and idle incoming line, a source of tone, and means responsive to the prior operation of all said holding magnets for connecting said source of tone for indicating an all-lines-busy condition to one of said incoming lines.

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