Nov. 4, 1947. J. H. VOSS 2,430,316

CROSSBAR SWITCH SYSTEM WITH SEQUENTIALLY OPERATED MAGNETS

Filed Nov. 21, 1945 6 Sheets-Sheet 1

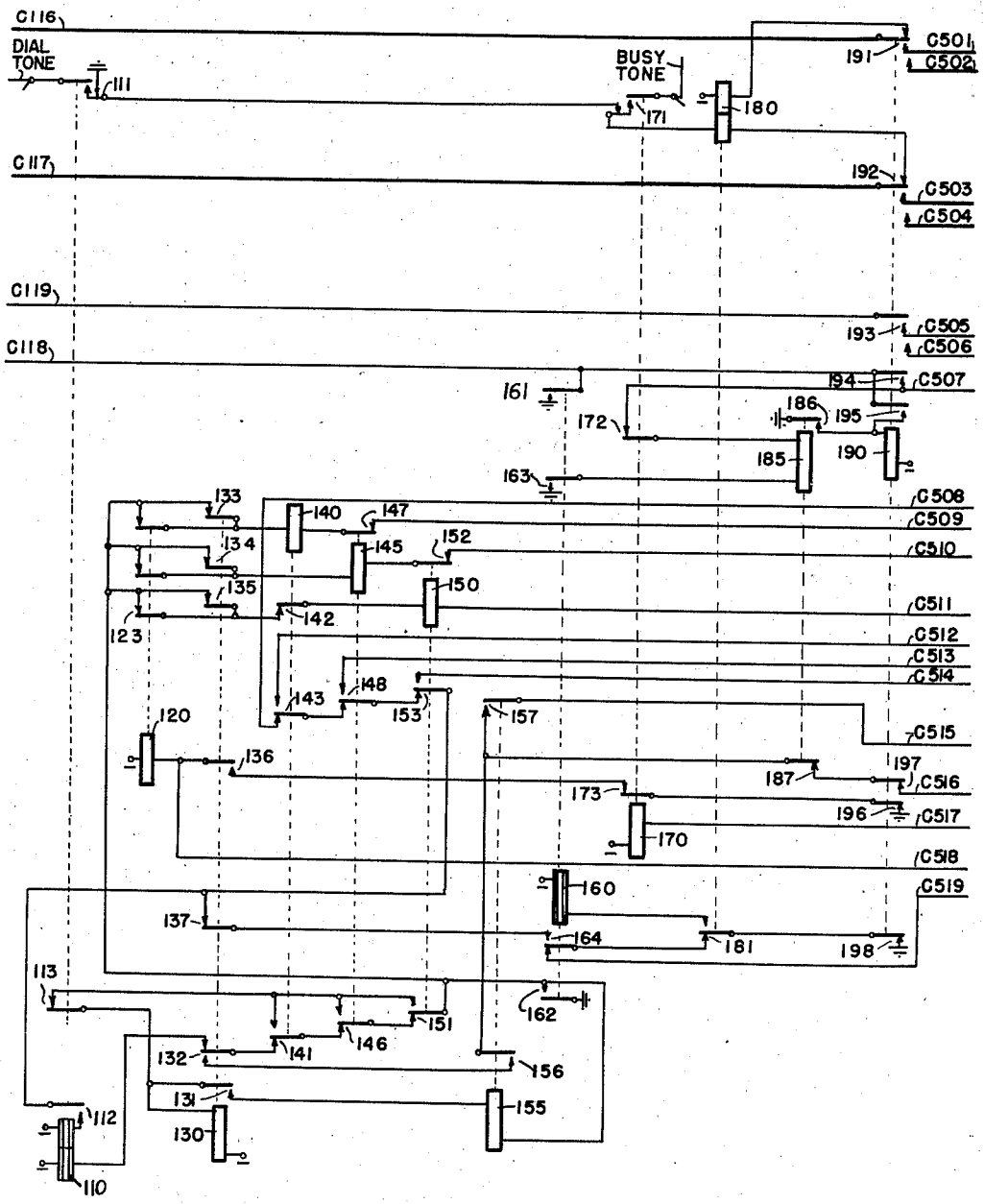


FIG. 1

INVENTOR.
JOHN H. VOSS

BY Chas. Fr. Candy

ATTORNEY

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CROSSBAR SWITCH SYSTEM WITH SEQUENTIALLY OPERATED MAGNETS

Filed Nov. 21, 1945 6 Sheets-Sheet 2

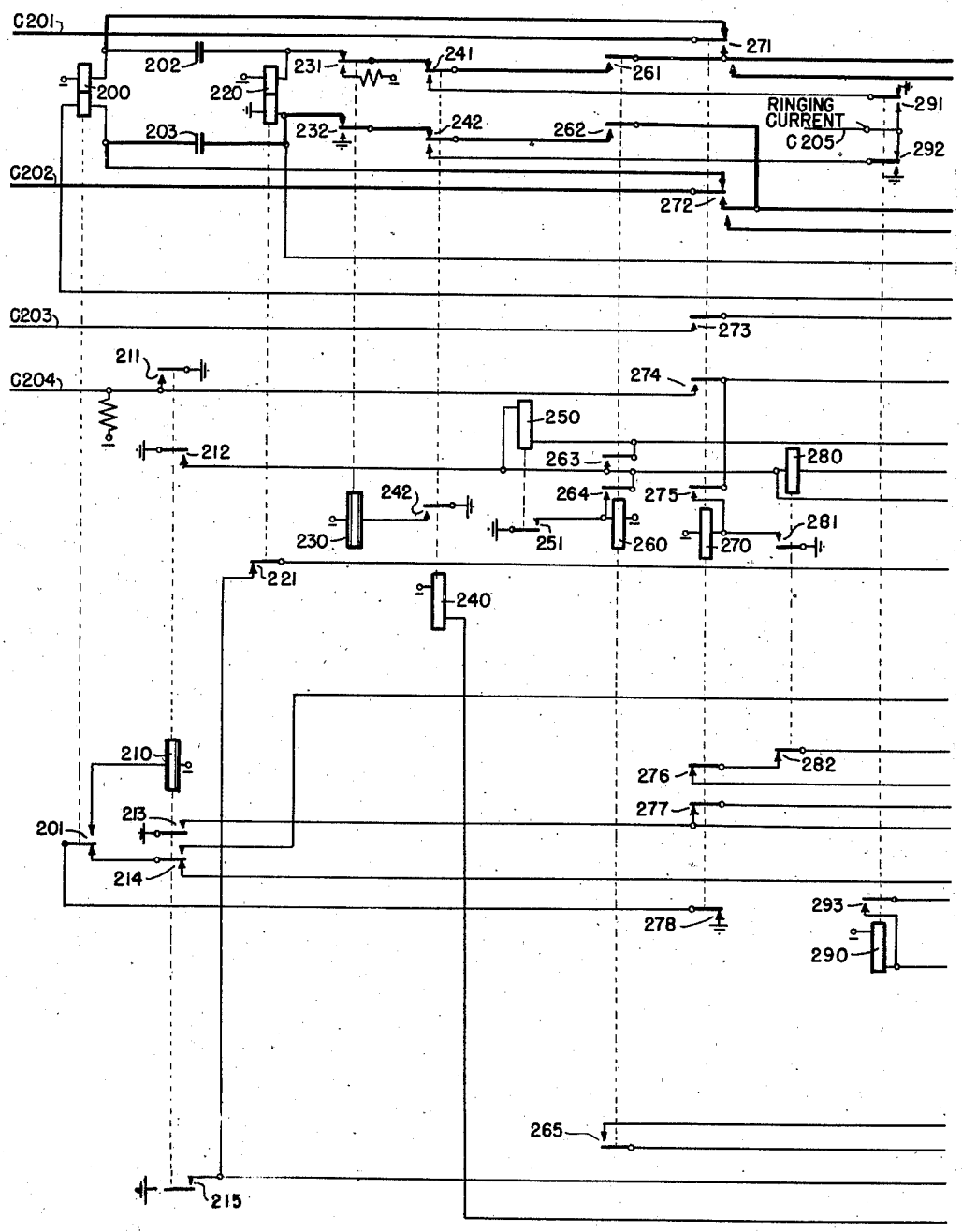


FIG. 2

INVENTOR.
JOHN H. VOSS

BY

ATTORNEY

Nov. 4, 1947. J. H. VOSS 2,430,316

CROSSBAR SWITCH SYSTEM WITH SEQUENTIALLY OPERATED MAGNETS

Filed Nov. 21, 1945 6 Sheets-Sheet 3

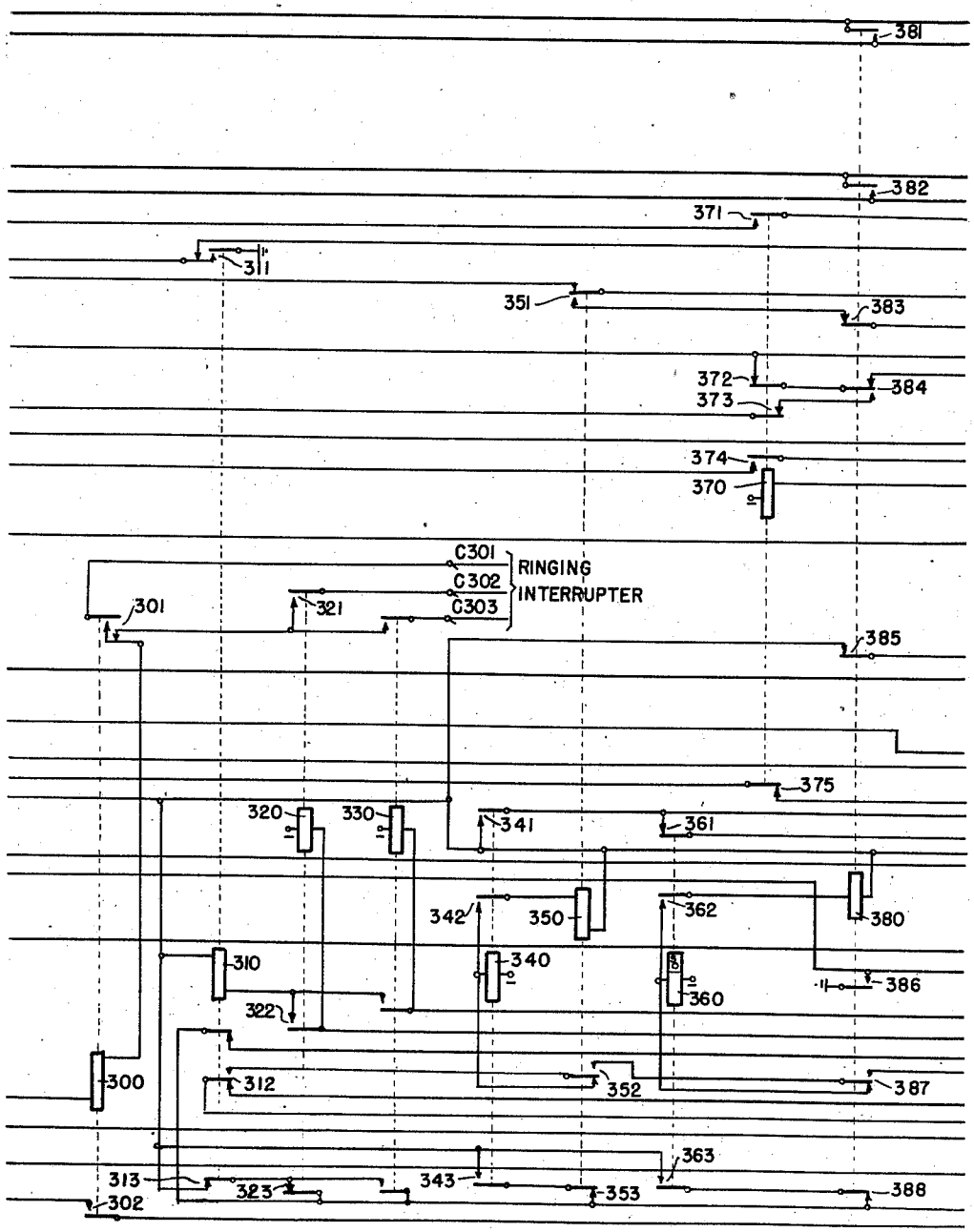


FIG. 3

INVENTOR.
JOHN H. VOSS

BY

Chas. Tu. Tandy.

ATTORNEY

Nov. 4, 1947. J. H. VOSS 2,430,316

CROSSBAR SWITCH SYSTEM WITH SEQUENTIALLY OPERATED MAGNETS

Filed Nov. 21, 1945 6 Sheets-Sheet 4

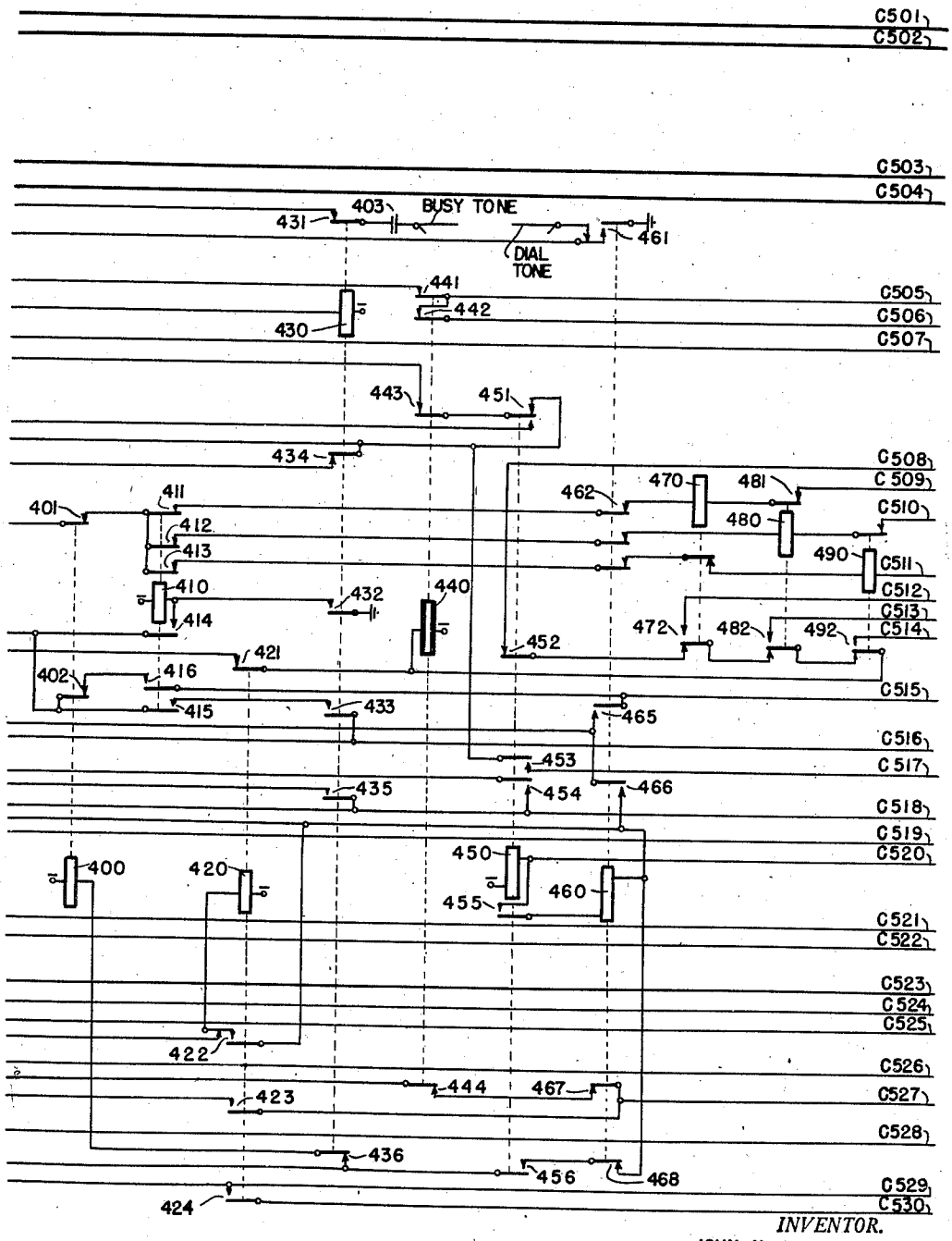


FIG. 4

INVENTOR.
JOHN H. VOSS

BY

ATTORNEY

Nov. 4, 1947. J. H. VOSS 2,430,316

CROSSBAR SWITCH SYSTEM WITH SEQUENTIALLY OPERATED MAGNETS

Filed Nov. 21, 1945 6 Sheets-Sheet 5

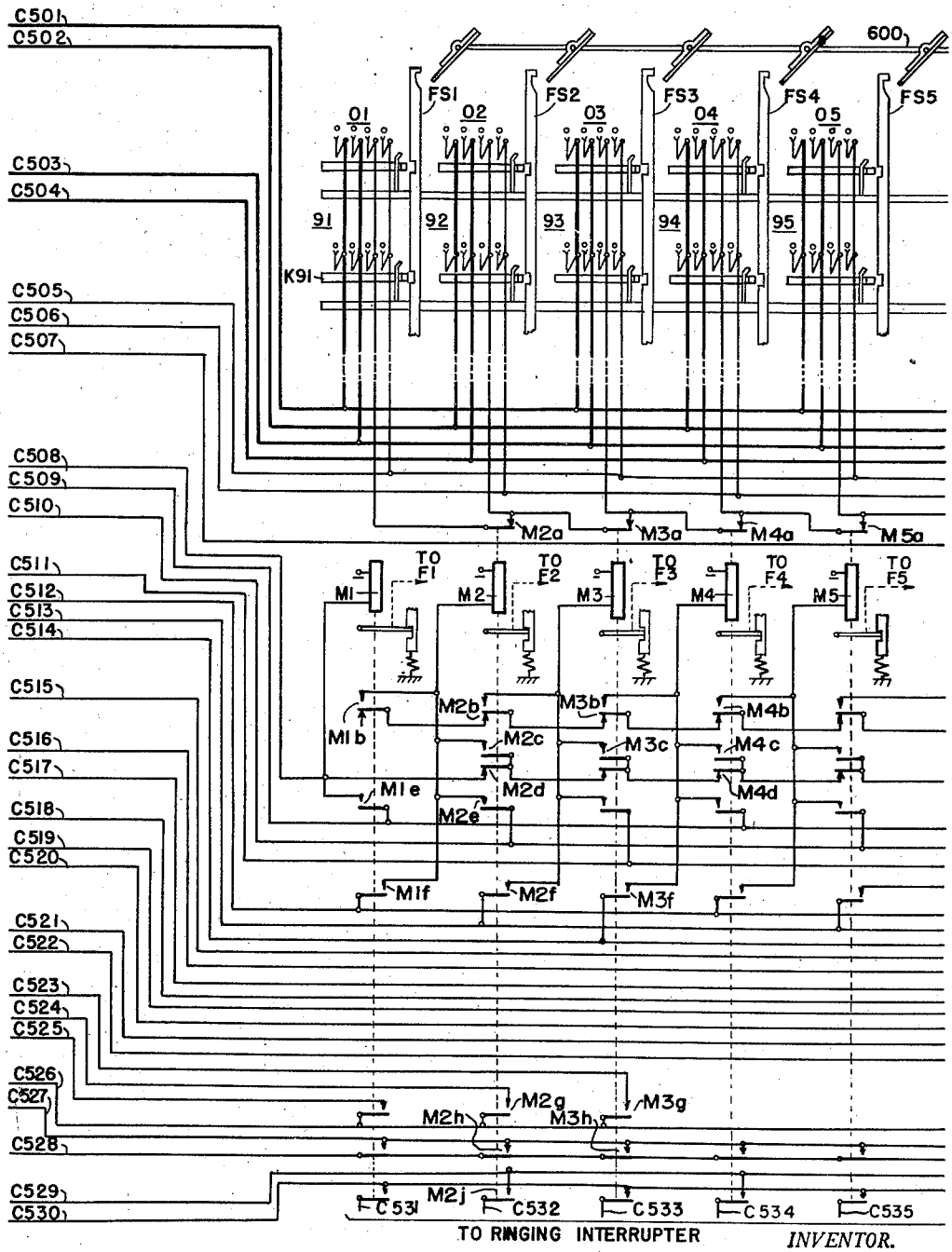


FIG. 5

INVENTOR.
JOHN H. VOSS

BY
Chas. Tu. Candy.
ATTORNEY

Nov. 4, 1947. J. H. VOSS 2,430,316

CROSSBAR SWITCH SYSTEM WITH SEQUENTIALLY OPERATED MAGNETS

Filed Nov. 21, 1945 6 Sheets-Sheet 6

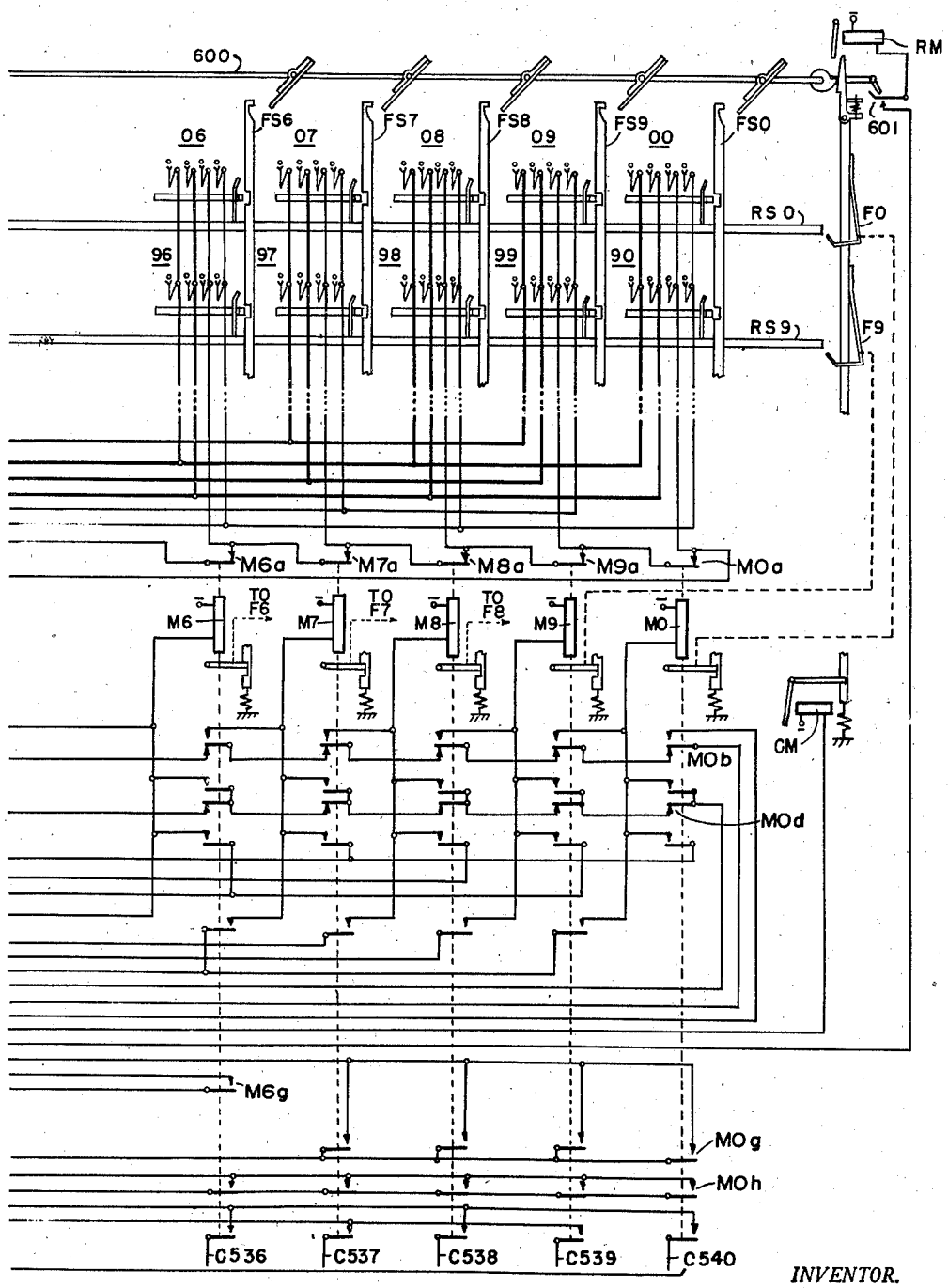


FIG. 6

INVENTOR.
JOHN H. VOSS

BY

ATTORNEY

Patented Nov. 4, 1947

2,430,316

UNITED STATES PATENT OFFICE

2,430,316

CROSSBAR SWITCH SYSTEM WITH SEQUENTIALLY OPERATED MAGNETS

John H. Voss, Downers Grove, Ill., assignor to Automatic Electric Laboratories, Inc., Chicago, Ill., a corporation of Delaware

Application November 21, 1945, Serial No. 630,064

15 Claims. (Cl. 179—22)

1

The present invention relates in general to telephone systems, and in particular to automatic telephone systems which employ switches of the crossbar type to effect connections.

The objects of the invention are to improve telephone systems of this character through the provision of simplified and more efficient circuit arrangements for directing the operation of the crossbar switches, to reduce the amount of control equipment associated with each switch to a minimum, to reduce the time required to establish connections in such a system, and to eliminate common equipment insofar as practical so as to provide increased reliability of operation.

The main feature of the invention is the provision of a crossbar switch system wherein the operating magnets of the crossbar switches are operated directly from dial impulses, thereby eliminating the need for separate impulse counting relays and other auxiliary control equipment.

Another feature is the provision of a crossbar switch system wherein the operating magnets of the crossbar switches are employed to perform selecting operations other than, and in addition to, the selection of a line to which the switch has access; such, for example, as selecting the ringing code in accordance with received dial impulses in a party line connector.

Still another feature is the provision of means for first operating a crossbar switch to select a group of lines; and for thereafter causing the switch to automatically hunt for, and establish connection with, an idle line in the selected group.

The foregoing and other features will be described more fully in the following description. Circuits embodying the invention have been shown in the accompanying drawings in which:

Fig. 1 discloses the control circuit for a crossbar selector,

Figs. 2, 3 and 4, which should be placed side by side in the order named, taken together disclose the control circuit for a crossbar connector, and

Figs. 5 and 6, which should be placed side by side with Fig. 5 on the left, taken together disclose a crossbar switch adapted for use either as a selector or a connector. For use as a selector Fig. 5 should be placed to the right of Fig. 1, and for use as a connector Fig. 5 should be placed to the right of Fig. 4.

The crossbar switch employed in the present system is only schematically illustrated in Figs. 5 and 6. The novel construction and details of operation of this switch are fully described and illustrated in the copending application of K. W. Graybill et al., Serial No. 630,065, filed November 21, 1945.

2

The invention will first be described briefly, following which a detailed description of the illustrated embodiment thereof will be given. The crossbar switch, schematically illustrated in Figs. 5 and 6, comprises a plurality of contact sets, which are disposed in intersecting rows, and two intersecting groups of selecting members which are arranged to permit selective operation of any of the contact sets through operating members individual thereto. Each selecting member of one group is arranged to move a row of the operating members so that any one of the operating members so moved may be engaged by corresponding ones of the selecting members in the second group to operate the contact set at the intersection of the two actuated selecting members. Individual magnets are provided for actuating each selecting member in the second group. A common control magnet is provided for operating the selecting members in the first group. This control magnet is normally ineffective to operate any of the members associated therewith unless one of the selecting magnets is operated, in which case a corresponding finger is moved by the operated selecting magnet so that the control magnet is effective to actuate a selecting member in the first group which corresponds to the operated selecting magnet. These fingers are arranged so that the control magnet is effective to hold the actuated selecting member in the first group after the selecting magnet is released. Thus by first operating a selecting magnet, next operating the control magnet, and then releasing the selecting magnet; the selecting member in the first group corresponding to the operated selecting magnet will be actuated and held by the control magnet. The actuated selecting member moves its associated row of operating members so that a subsequent operation of any of the selecting magnets will operate the contact set located at the intersection of the selecting member in the first group held by the control magnet and the selecting member in the second group actuated by the subsequently operated selecting magnet. A latching mechanism is provided which is operated in response to the restoration of the control magnet to hold the actuated selecting member in the second group when the selecting magnet associated therewith is subsequently released. The operated contact set is thus held independently of the selecting and control magnets. The selecting magnets may then be reoperated to perform

other switching operations without disturbing the established connection. A common release magnet is provided for releasing the latching mechanism to restore the switch to normal. The selecting magnets are provided with individual contact sets which are interconnected so as to permit sequential operation of the magnets in the manner of a counting chain, whereby the switch may be operated directly from received dial impulses in a step by step manner, and whereby the magnets may be controlled by received dial impulses to perform additional selecting functions.

When this novel crossbar switch is employed as part of a selector, the control relays shown in Fig. 1 are associated therewith; and when the switch is employed as part of a connector, the control relays shown in Figs. 2, 3 and 4 are associated therewith. Either of these groups of control relays may be made accessible to subscriber's lines in any well known manner; such, for example, as line finders, plunger lineswitches or rotary lineswitches. Alternatively, the connector control relays may be reached from a selector which may be of the type herein disclosed.

When the selector relays are seized by the extension thereto of a subscriber's line from a preceding switch, they prepare circuits for sequentially operating the selecting magnets of the associated crossbar switch under the control of the calling subscriber's dial. Upon the termination of a series of impulses, the control magnet of the switch is operated to select a group of lines corresponding to the last operated selecting magnet, which selecting magnet is subsequently released. The selecting magnets are then sequentially operated under the control of the selector relays to find, and extend the calling line to, an idle line in the selected group. Upon connection with an idle line the control magnet is released, causing the established connection to be held by the latching mechanism. When the calling party hangs up, the release magnet of the switch is operated to release the latching mechanism and thereby restore the switch to normal.

When the connector relays are seized by the extension thereto of a subscriber's line from a preceding switch, such as the selector just described, they prepare circuits for sequentially operating the selecting magnets of the associated crossbar switch under the control of the calling subscriber's dial. Upon the termination of the first series of impulses, which determines which one of two groups of ringing codes are to be used, a register relay corresponding to the last operated selecting magnet is operated and the selecting magnet is then released. The selecting magnets of the crossbar switch are then again sequentially operated in response to a second series of impulses from the calling party's dial. At the end of this second series of impulses the control magnet of the crossbar switch is operated and the last operated selecting magnet is released to complete the group selection. The selecting magnets are then operated in response to a third series of impulses to select the desired line in the previously selected group. The control magnet is then restored causing the established connection to be maintained by the latching mechanism of the switch independently of the selecting magnets, which are restored to normal. The selecting magnets are then finally operated in accordance with a fourth series of impulses to select the code for ringing the called station. When the conversation is completed the latching mechanism is released by the operation of the release magnet to restore the switch to normal.

The invention will now be described in detail with reference to the accompanying drawings. It will be assumed that the selector and connector switches are connected in tandem and that the selector is associated with a calling subscriber's line by means of a line finder such as that shown in Fig. 1 of Patent No. 2,214,908, issued to Lomax et al. The conductors C116 to C118 extending from the left of Fig. 1, in the present case connect with the corresponding conductors extending from the right of Fig. 1 in the Lomax patent. No provision is made for a fourth conductor in the Lomax patent, which fourth conductor C119 usually extends to make contacts, such as RA153 and RA 163, on relays R150 and R160 of the patent, the armatures of these contact sets extending to wipers, such as 143 and 146, which engage added sets of bank contacts when the finder switch is operated. These added bank contacts may be strapped to ground as desired so that when the finder switch is associated with certain lines the fourth conductor C119 will be grounded to provide a special service or restriction in the succeeding switch train.

I. Operation of the Selector

A. *Group selection in accordance with first digit dialled*

When the finder switch associated with the selector relays of Fig. 1 is operated to find a calling line, it closes a loop circuit over conductors C116 and C117 to relay 180 which operates and closes a circuit to relay 160 at contacts 181. Relay 160 operates, closes a multiple ground to conductor C118 at contacts 161 to hold the finder switch after it is released by the finder distributor, closes a circuit to the lower winding of relay 110 at contacts 162, and prepares an impulsing circuit to the crossbar switch magnets and a holding circuit to the upper winding of relay 110 at contacts 164. Relay 110 operates and replaces direct ground on the lower winding of relay 180 with ground through a dial tone transformer, not shown, at contacts 111.

When the preceding finder switch has seized the calling line it is extended to relay 180 over conductors C116 and C117 in place of the original seizing loop. Upon hearing dial tone transmitted from the selector relays the calling party proceeds to dial the first digit of the desired subscriber's number, causing relay 180 to be momentarily released a corresponding number of times. Upon the first restoration of relay 180 a circuit is completed from ground through contacts 198, 181, 164, 137 and 112 to the upper winding of relay 110. A circuit is also completed over a portion of the above traced circuit and through contacts 153, 148, 143 and over conductor C508 to magnet M1 (Fig. 5). Magnet M1 operates; at contacts M1*e* prepares its holding circuit over conductor C509, through contacts 147, relay 140, and contacts 133 and 162 to ground; and prepares a circuit for operating magnet M2 over conductor C512 at contacts M1*f*. Upon the first reoperation of relay 180 a short circuit is removed from relay 140 at contacts 181, causing this relay to be energized in series with magnet M1. Relay 140 operates, opens the circuit to the lower winding of relay 110 at contacts 141, and transfers the impulsing circuit from magnet M1 to magnet M2 over conductor C512 at contacts 143. Upon the second restoration of relay 181, magnet M2 is energized

in multiple with the upper winding of relay 110 through contacts 181. Magnet M2 operates; at contacts M2*e* prepares its holding circuit over conductor C510, through contacts 152, relay 145, and contacts 134 and 162 to ground; and at contacts M2*f* prepares a circuit for operating magnet M3 over conductor C513. Upon the second reoperation of relay 180 a short circuit is removed from relay 145 at contacts 181, causing it to be energized in series with magnet M2. Relay 145 operates, opens the holding circuit to magnet M1 through relay 140 at contacts 147 causing them to restore, and transfers the impulsing circuit from magnet M2 to magnet M3 over conductor C513 at contacts 148. Upon the third restoration of relay 180, magnet M3 is operated and subsequently held in series with relay 150, which operates when relay 180 reoperates. The operation of relay 150 opens the holding circuit to maget M2 through relay 145 at contacts 152 causing them to restore, and transfers the impulsing circuit from magnet M3 to magnet M4 over conductor C514 and contacts M3*f* at contacts 153. It should now be apparent that the fourth restoration of relay 180 will cause magnet M4 to operate and hold in series with relay 140 when relay 180 reoperates. The operation of relay 140 opens the holding circuit to magnet M3 through relay 150 at contacts 142 causing them to restore, and prepares a circuit to magnet M5 over conductor C512 at contacts 143. The subsequent restoration of relay 150 results in the transfer of the impulsing circuit from magnet M4 to magnet M5 at contacts 153. In this manner the magnets M1 to M0 are sequentially operated by successive restorations of relay 180. Relays 160 and 110 are both rendered slow to release by means of copper sleeves so that they will remain operated during impulsing.

Assuming that the first digit in the desired number is "9," magnet M9 will be operated in series with relay 150 after the ninth reoperation of relay 180. Relay 110 restores shortly after the termination of the series of impulses, reconnects direct ground to the lower winding of relay 180 at contacts 111, and closes a circuit to relay 130 at contacts 113 from ground through contacts 151 and 162. Relay 130 operates, closes its holding circuit through relay 155 at contacts 131, and closes a circuit to relay 120 in multiple with control magnet CM over conductor C518 at contacts 136. It may here be noted that the contacts on relay 120 are preferably operated by the control magnet CM, but have here been illustrated as being on a separate relay for convenience. Control magnet CM operates and causes finger F9, which is operated by magnet M9, to engage rank selecting member RS9 and shift it so as to permit the contact operating members associated therewith to fall into slots in corresponding ones of the file selecting members, such as FS1. Relay 120 operates and opens the holding circuit to magnet M9 through relay 150 at contacts 123. Magnet M9 and relay 150 restore. Finger F9 is shaped so that it is held operated and holds rank selecting member RS9 operated independently of magnet M9. The restoration of relay 150 removes a short circuit from relay 155 at contacts 151 causing it to be energized in series with relay 130.

B. *Selector trunk hunting*

Relay 155 operates and closes a circuit from ground through contacts 162, 151, 146, 141, 132, 156, 157 over conductor C515, and through chain contacts, such as M2*d*, on magnets M2 to M0 to magnet M1. Magnet M1 operates; closes a circuit from ground over a portion of the last traced circuit, through contacts 187 and 197, over conductor C516, and through chain contacts, such as M2*b*, on magnets M2 to M0 to magnet M2 at contacts M1*b*; and operates file selecting member FS1 to cause contact operating member K91 to press its associated contact set 91 into engagement with the multiple conductors positioned adjacent thereto and represented by small circles. Each of these sets of four multiple conductors extend to a corresponding connector over conductors such as C201 to C204 (Fig. 2). Alternatively, these multiple conductors may extend to a second selector. If the first connector in the 900 group is idle there will be resistance battery on the control lead, such as C204, extending therefrom, while if this connector is busy the control lead will be grounded. The control lead is extended through contact set 91 to conductor C507 which extends through contacts 172, relay 185, and contacts 163 to ground. Assuming that the first connector is busy, relay 185 will not be energized. Magnet M2 operates over the previously traced circuit, locks to ground over conductor C515 through break contacts on all succeeding selecting magnets and its preliminary make contacts M2*c*, opens the circuit to magnet M1 at contacts M2*d*, closes a circuit to magnet M3 from ground over conductor C516 at contacts M2*b*, opens the circuit between conductor C507 and contact set 91 at contacts M2*a*, and operates file selecting member FS2 to operate contact set 92. Assuming that the connector associated with the multiple conductors engaged by contact set 92 is idle, relay 185 will be energized from the resistance battery extended over the control lead of the connector, through contact set 92, contacts such as M3*a* on magnets M3 to M0, over conductor C507, through contacts 172, relay 185, and through contacts 163 to ground. Relay 185 operates, closes a circuit to relay 190 at contacts 186, and opens the circuit to magnet M3 at contacts 187 before this magnet has time to operate. By this time magnet M1 will have restored. Relay 190 operates; transfers the calling party's line extended over conductors C116 and C117 from relay 180 to relay 200 in the connector at contacts 191 and 192, over conductors C502 and C504, through contact set 92, and over the multiple conductors engaged thereby to conductors C201 and C202, thence through contacts 271 and 272 to relay 200; extends the fourth conductor C119 to conductor C203 of the connector over conductor C506 and through contact set 92 at contacts 193; extends ground through contacts 161 and 194, over conductor C507, and through contact set 92 to conductor C204 to mark the connector busy to other selectors; closes its locking circuit to ground through contacts 161 at contacts 195; opens the circuit to magnet CM and relay 120 at contacts 196; and opens the circuit to relay 160 at contacts 198. Since each magnet is operated for a brief time after the next succeeding magnet is operated during trunk hunting, separate conductors are multipled to the odd and even numbered contact sets. Thus conductors C501, C503 and C505 extend to contact sets 91, 93, 95, etc., while conductors C502, C504 and C506 extend to contact sets 92, 94, 96, etc. These two groups of conductors are separated except when relay 190 is operated to prevent momentary connections be-

tween successively numbered lines during trunk hunting. Control magnet CM restores and rotates the shaft 600 of the latching mechanism to hold file selecting member FS2 operated independently of magnet M2. Relays 120, 180 and 185 restore. Relay 160 restores after a brief delay, removes a multiple ground from control conductor C118 at contacts 161 (by this time ground will have been extended over conductor C507 from conductor C204 of the connector), and opens circuits to relays 130 and 155 in series and magnet M2 at contacts 162. Relays 130 and 155 and magnet M2 restore. At this time relay 190 will be the only relay operated. Also all magnets in the crossbar switch will be restored, the operated contact set 92 being held mechanically by the latching mechanism.

C. *Release of selector*

The connection is now extended by the connector under the control of the subscriber's dial as will subsequently be described. After the call is terminated the loop circuit to the connector will be opened causing it to release and remove the ground extended over conductor C507 from the control conductor C204 of the connector. Relay 190 then restores and closes a circuit to magnet RM over conductor C519 at contacts 198. Magnet RM operates to release the latching mechanism and thereby permit file selecting member FS2 to restore and open contact set 92. When the latching mechanism restores the circuit to magnet RM is opened at contacts 601.

D. *All trunks busy*

In the event that all of the connectors associated with contact sets 91 to 90 are busy, magnets M1 to M0 will be sequentially operated as should be apparent from the preceding description. When magnet M0 operates it closes a circuit to relay 170 over conductor C517 at contacts M0*b* from ground over conductor C516 at the same time that it extends the control conductor of its associated connector to relay 185 over conductor C507 and through contact set 90. Relay 170 is slower to operate than relay 185. Consequently, if this connector is free relay 185 operates and extends the calling line to the connector in the previously described manner. The operation of relay 185 also opens the circuit to relay 170 at contacts 187 to prevent operation thereof. If this last connector is busy, relay 185 will not be energized but relay 170 now will operate and substitute ground through a busy tone transformer, not shown, for direct ground on the lower winding of relay 180 at contacts 171, open a point in the circuit to relay 185 at contacts 172 to prevent operation thereof in case the connector subsequently becomes free, and open the circuits to control magnet CM and relay 120 at contacts 173 causing them to restore. When the calling party disconnects in response to the busy tone the loop circuit to relay 180 is opened. Relay 180 restores and opens the circuit to relay 160 at contacts 181. Relay 160 restores; removes ground from conductor C118 at contacts 161 to release the preceding finder switch; opens the circuits to relays 130 and 155 in series, relay 170, and magnet M0 at contacts 162; and closes a circuit to release magnet RM over conductor C519 at contacts 164. Relays 130, 155, and 170 restore. Magnet M0 restores. Magnet RM operates and releases the latching mechanism to permit file selecting member FSO to restore to complete the restoration of the selector to normal. When the latching mechanism restores the circuit to magnet RM is opened at contacts 601.

II. Operation of the Connector

A. *Selection of ringing code group*

When the connector is seized by a preceding selector as just described, or by a preceding finder switch, the calling party's line is extended to relay 200 over conductors C201 and C202. It may here be noted that the lower winding of relay 200 is shown connected through contacts 311 and 461 to ground through a dial tone transformer, not shown. When the connector is seized from a preceding selector the dial tone is not required and these contacts may then be omitted and direct ground connected to the lower winding of relay 200. Relay 200 operates and closes a circuit to relay 210 at contacts 201. Relay 210 operates and grounds control conductor C204 at contacts 211 to hold the preceding switch train and to mark the connector busy. The first dialled digit received by the connector will be either a "2" or a "3." Upon the first restoration of relay 200 a circuit is completed from ground through contacts 278, 201, 214, and 421 to relay 440. A circuit is also completed in multiple with relay 440 through contacts 492, 482, 472, and 452, and over conductor C508 to magnet M1 of the crossbar switch associated with the connector relays. Relay 440 operates. Magnet M1 operates; closes its holding circuit through contacts M1*e*, over conductor C509, through contacts 481, relay 470, contacts 462, 411, 401, 221, and 215 to ground; and prepares a circuit for operating magnet M2 over conductor C512 at contacts M1*f*. Upon the first reoperation of relay 200 a short circuit is removed from relay 470 at contacts 201 causing it to be energized in series with magnet M1. Relay 470 operates and transfers the impulsing circuit from conductor C508 to conductor C512 at contacts 472. The succeeding operations of the selecting magnets and relays 470 to 490 in response to successive restorations of relay 200 should be apparent from the preceding description of the selector. Relays 210 and 440 remain operated during impulsing due to the use of copper sleeves on their cores which render them slow to release. Shortly after the series of impulses is completed relay 440 restores and closes a circuit from ground through contacts 215, over conductor C528, through contacts M2*h* or M3*h*, over conductor C527, through contacts 467, 444, and 312, over conductor C526, and through contacts M2*g* and over conductor C524 to relay 320, or through contacts M3*g* and over conductor C523 to relay 330. Thus either relay 320 or 330 will be energized depending on whether a "2" or a "3" was dialled. Assuming that the digit was "2," relay 320 operates, closes its holding circuit through relay 310 to ground through contacts 213 at contacts 322, and closes a circuit from ground through contacts 213, 313, 323, and 436 to relay 490. Relay 490 operates and opens the holding circuit to magnet M2 through relay 480 at contacts 491 causing them to restore. Magnet M2 in restoring removes a short circuit from relay 310 at contacts M2*g* causing it to be energized in series with relay 320. Relay 310 operates, prepares a circuit for operating relay 340 at the end of the next series of impulses at contacts 312, and opens the circuit to relay 490 at contacts 313 causing it to restore.

B. *"Tens" group selection*

The next series of impulses received by the connector causes the magnets M1 to M0 to again be operated sequentially in response to successive restorations of relay 200 as previously described. Upon the completion of this series of impulses, relay 440 restores and completes a circuit from ground through contacts 215, over conductor C528, through contacts such as M2*h* of the operated selecting magnet M1 to M0, over conductor C527, through contacts 467, 444, 312, and 352 to relay 340. Relay 340 operates; closes a circuit to control magnet CM from ground through contacts 213, 341, 361, and over conductor C518; closes its holding circuit through relay 350 to ground through contacts 213 at contacts 342; and closes a circuit to relay 400 from ground through contacts 213, 343, 353, and 436. Magnet CM operates and causes the rank selecting member corresponding to the operated selecting magnet to operate. Assuming that the last dialled digit was an "0," finger F0 will be operated by magnet M0 causing magnet CM to operate rank selecting member RS0. Relay 400 operates and opens the holding circuit to magnet M0 through relay 470 at contacts 401. Magnet M0 restores and removes a short circuit from relay 350 at contacts M0*h* causing it to be energized in series with relay 340. Relay 350 operates, prepares a circuit for operating relay 360 at the end of the next series of impulses at contacts 352, and opens the circuit to relay 400 at contacts 353 causing it to restore.

It has been assumed in the preceding paragraph that the "tens" digit was an "0." When the connector is associated with a preceding finder switch instead of a selector it is sometimes desirable that it operate as a selector on particular digits. The present connector is adapted to operate as a selector when the first digit received thereby is a 7, 8, 9, or 0, as will presently be described. If the contact sets 71 to 00 are used for trunk service the type of call just described would be completed through a lower numbered contact set. However, due to space limitations, only the contact sets from 91 to 00 have been shown in detail. For this reason it was assumed that the connection described in the preceding paragraph was completed over the 01 to 00 group of contact sets, it being readily understood that the same operations would be involved if the connection had been assumed to be completed over a lower numbered group.

C. *"Units" selection*

The third series of impulses received by the connector again causes magnets M1 to M0 to be operated sequentially, this time the operation of the corresponding file selecting members FS1 to FS0 operating the contact sets 01 to 00 successively since rank selecting member RS0 is held operated by magnet CM and finger F0. When relay 440 restores at the end of this series of impulses it extends the control conductor of the called line through the last operated contact set (which will be assumed to be 03), through contacts such as M4*a* of the selecting magnets succeeding that last operated, over conductor C507, and through contacts 372, 384, 443, 451, and 434 to relay 370. Relay 440 also completes a circuit from ground through contacts 215, over conductor C528, through contacts M3*h*, over conductor C527, and through contacts 467, 444, 312, 352, and 337 to relay 360.

Relay 360 is rendered slow to operate by means of a copper slug on the armature end of its core. If the called line is busy its control conductor will be grounded causing relay 370 to operate before relay 360 has time to operate. When relay 370 operates it locks through contacts 434, preliminary make contacts 374, and contacts 212 to ground; and connects a source of busy tone through condenser 403, contacts 431, 371 and through condenser 203 to the calling line extended over conductor C202. When relay 360 operates it opens the circuit to magnet CM at contacts 361, closes its holding circuit through relay 360 to ground through contacts 213 at contacts 362, and closes a circuit from ground through contacts 213, 363, 388, and 436 to relay 400. Magnet CM restores and rotates shaft 600 of the latching mechanism to hold file selecting member FS3 independently of magnet M3. Relay 400 operates and opens the holding circuit to magnet M3 through relay 490 at contacts 401 causing them to restore. When magnet M3 restores it removes a short circuit from relay 380 at contacts M3*h* causing it to be energized in series with relay 360. Relay 380 operates; connects the conductors C501 and C503 (which are multipled to the odd numbered contact sets 01, 03, etc.), to conductors C502 and C504 (which are multipled to the even numbered contact sets 02, 04, etc.) at contacts 381 and 382, respectively; and at contacts 384 transfers conductor C507 from relay 370 to ground through contacts 373, relay 250, and contacts 212. If the called line is busy the circuit to relay 250 will be open at contacts 372 and 373. However, if the called line is free battery will be extended through the cut-off relay of the called line circuit over conductor C507, through contacts 372, 384, 373, relay 250, and through contacts 212 to ground. Relay 250 operates and closes a circuit to relay 260 at contacts 251. Relay 260 operates, extends the called line to relay 220 at contacts 261 and 262, short-circuits relay 250 at contacts 263, and locks to ground through contacts 212 at contacts 264. Relay 250 restores.

D. *Release when called line is busy*

In the event that the called line is busy, relay 370 will have operated to return busy tone to the calling party and to prevent the operation of relays 250 and 260. When the calling party disconnects in response to the busy signal, relay 200 restores and opens the circuit to relay 210 at contacts 201. Relay 210 restores; removes ground from conductor C204 at contacts 211 to release the preceding switch train; opens circuits to relays 310, 320, 340, 350, and 380 at contacts 213; and closes a circuit to magnet RM from ground through contacts 278, 201, 214, over conductor C519, and through contacts 601. Magnet RM operates and releases the latching mechanism to permit file selecting member FS3 to restore. When the latching mechanism restores, the circuit to magnet RM is opened at contacts 601. All relays and magnets are now restored to normal.

E. *Selecting the ringing code*

If the called line is idle relays 250 and 260 will have operated as previously described. The calling party then dials a further series of impulses to select the ringing code, in the previously selected group, corresponding to the desired party on the called line. Magnets M1 to M0 are again sequentially operated but do not affect the contact sets 01 to 00 since rank selecting member

RS0 has been released by the restoration of magnet CM. Contact set 03 remains operated however since file selecting member FS3 is held operated by the latching mechanism. This latching mechanism is constructed so as not to interfere with the operation of the magnets M1 to M0. When relay 440 restores at the end of this last series of impulses it completes a circuit from ground through contacts 215, over conductor C528, through contacts such as M2*h* on the last operated magnet M1 to M0, over conductor C527, through contacts 467, 444, 312, 352, 367, and 422 to relay 420. Relay 420 operates; opens a point in the impulsing circuit at contacts 421; locks to ground through contacts 213 at contacts 422; prepares a circuit from ground over conductor 527, through contacts 423, 265, relay 300, and contacts 301 and 321 to conductor C302; and connects conductors C529 and C530 together at contacts 424. These last two conductors are separated prior to the operation of relay 420 to prevent momentary connections between conductors C531 to C540 during overlapping operations of the magnets M1 to M0. Each of these latter conductors is intermittently grounded in accordance with two different ringing codes. Conductor C302 is momentarily connected to battery just prior to the transmission of one of these sets of codes over conductors C531 to C540, and conductor C303 is momentarily connected to battery just prior to the trasnmission of the second set of codes over conductors C531 to C540. Conductor C301 is normally connected to battery and is momentarily disconnected therefrom just prior to the start of each code. As previously described, the first digit received by the connector determines which of the two sets of codes is to be used by operating either relay 320 or 330. In the present instance it was assumed that relay 320 was operated, therefore when the battery pulse is received over conductor C302 relay 300 operates over a previously traced circuit. When relay 300 operates it locks to battery on lead C301 at contacts 301 and connects relay 240 through contacts 302 and over conductor C529, or through contacts 424 and over conductor C530, to one of the conductors C531 to C540 through contacts such as M2*j* on the last operated magnet M1 to M0. Relay 240 will be intermittently operated in accordance with the next code transmitted over the one of the conductors C531 to C540 to which it is connected. As soon as this code is completed battery is removed from conductor C301 by the ringing interrupter. Relay 300 consequently restores and opens a point in the circuit to relay 240 at contacts 302 to prevent operation thereof by the second code transmitted over the one of the conductors C531 to C540 to which it is connected. The same cycle of operations is repeated for each cycle of the ringing interrupter.

F. *Signalling the called party*

Each time that relay 240 operates it transfers the called line from relay 200 to a source of ringing current over conductor C205 and to ground. The side of the called line to which conductor C205 is connected depends upon whether relay 290 is operated or normal. If the last digit dialed was 1 to 5 this relay will be normal, whereas if the last digit dialed was 6 to 0 a circuit will have been completed from ground through contacts 386, over conductor C522, through contacts M6*g*, and over conductor C521 to relay 290 during the time that magnet M6 was operated. Relay 290 would then operate, lock to ground through contacts 386 at contacts 293, and reverse the connections between conductor C205 and contacts 242 and between ground and contacts 241 at contacts 291 and 292. Assuming that relay 290 is normal, ringing current is transmitted over conductor C205, through contacts 292, 242, 262, over conductor C503, through contact set 03, over one side of the called line, through the ringers connected to said one side of the line to ground in case divided ringing is used, or, in case of bridged ringing, through all of the bridged ringers, over the other side of the line, through contact set 03, over conductor C501, and through contacts 261, 241, and 291 to ground. When relay 240 is operated it also closes a circuit to slow release relay 230 at contacts 242 so that when relay 240 restores it connects the called line to resistance battery and ground through contacts 231 and 232 during the release time of relay 230 to thereby insure that relay 220 will not be operated falsely by the charging current of the condensers connected across the line in series with the substation ringers.

When the called party answers, a loop circuit will be completed to relay 220 causing it to operate and open the holding circuit to the last operated magnet M1 to M0 in series with one of the relays 470 to 490 at contacts 221. When this magnet restores it opens the circuit between relay 240 and the one of the conductors C531 to C540 to which it had been connected at contacts such as M2*j*, and also opens the circuit to relay 300 at contacts such as M2*h*, thereby preventing further ringing. The calling party receives transmission battery through relay 200 and the called party receives transmission battery through relay 220. Speech currents are transmitted between the calling and called lines through condensers 202 and 203.

G. *Releasing the connector*

When the calling party disconnects, the loop circuit to relay 200 is opened causing it to restore and open the circuit to relay 210 at contacts 201. Relay 210 restores, removes ground from conductor C204 at contacts 211 to release the preceding switch train, opens the locking circuit for relay 260 and removes ground from conductor C507 at contacts 212 to release the called line equipment, opens circuits to relays 310, 320, 340, 350, 360, 380, and 420 at contacts 213, and closes a previously traced circuit to magnet RM over conductor C519 at contacts 214. Magnet RM releases the latching mechanism, the restoration of which opens the circuit to RM at contacts 601. All relays now restore to normal.

H. *Call to a P. B. X. group*

P. B. X. service is provided by strapping the pair of multiple conductors which are extended to conductors C505 and C507, or C506 and C507, by the operation of the crossbar switch contact set corresponding to the first line in the P. B. X. group. The corresponding pairs of multiple conductors for all other lines in the same group, excepting the last line, are strapped through a resistance. Due to this strapping, if the first line in the called P. B. X. group is busy, the ground extended over conductor C507 from the control conductor of the first line circuit will also be extended over conductor C505, or C505, and through contacts 441, or 442 and 441, 351, and 383 to relay 430 when relay 440 restores after the third digit has been received by the connector. Relay 430 operates over the above circuit, closes a circuit to relay 410 at contacts 432, opens the

circuit to relay 370 at contacts 434, shunts contacts 361 at contacts 435 to prevent magnet CM from restoring when relay 360 operates, and opens a point in the circuit to relay 400 at contacts 436. Relay 360 operates as previously described but without effect at the moment. Relay 410 operates; opens the holding circuit to the last operated magnet (which will be assumed to be M3) in series with the corresponding relay 470 to 490 (in this case relay 490) at contacts 411, 412, or 413; closes a circuit to the succeeding magnet M4 from ground through contacts 432, 414, 415, 433, over conductor C516, and through chain contacts such as M3*b* on the selecting magnets; and closes a holding circuit to magnet M3 from ground through contacts 432, 414, 402, 416, over conductor C515, and through chain contacts such as M3*c* and M4*d* on the selecting magnets. Relay 410 also locks to ground through contacts 213 and 385 at contacts 414. Magnet M4 operates, locks to ground over conductor C515 at contacts M4*c*, opens the circuit to magnet M3 at contacts M4*d*, closes a circuit to magnet M5 from ground over conductor C516 at contacts M4*b*, and operates file selecting member FS4 to operate contact set 04. Magnet M3 restores and opens contact set 03. If the second P. B. X. line is busy relay 430 will remain energized through the resistance strap between the third and fourth multiple conductors engaged by contact set 04 to ground on the control conductor of the associated line circuit. Magnet M5 will then be permitted to operate and a similar test will be made on the third P. B. X. line. This cycle will continue until an idle line is found or until the last line in the group is reached. In either case the relay 430 will be released and will remove ground from conductor C516 at contacts 433 to prevent further trunk hunting. If relay 430 restores before the last P. B. X. line is reached, battery will be extended over conductor C507 from the control conductor of the idle line circuit. If relay 430 does not restore until the last P. B. X. line is reached, either battery or ground will be extended over conductor C507 depending upon whether the last line is idle or busy. In the latter case relay 370 is operated as previously described when relay 430 restores to give the calling party a busy signal. When relay 430 restores it also opens the circuit to magnet CM at contacts 435 and closes a circuit to relay 400 from ground through contacts 213, 363, 388, and 436. Magnet CM restores and rotates shaft 600 of the latching mechanism to hold the operated contact set independently of the selecting magnets. Relay 400 operates and opens the locking circuit to the operated selecting magnet over conductor C515 at contacts 402. The operated selecting magnet restores and removes ground from conductor C527 thus removing a short circuit from relay 380 and causing it to be energized in series with relay 360. Relay 380 operates and opens the locking circuit to relay 410 at contacts 385 in addition to its previously described functions. Relay 410 restores. Subsequent operations are the same as previously described for an ordinary line circuit.

I. *Call to a trunk*

In certain instances it is desirable that a connector be capable of operating as a selector. For instance, in a small exchange having no selectors, it is desirable that only a single digit be required to reach a trunk to another exchange. The present connector is shown adapted to operate as a selector if the first digit received thereby is 7, 8, 9, or 0. In this event, when relay 440 restores at the end of the series of impulses it completes a circuit from ground through contacts 215, over conductor C528, through contacts such as M0*h* of the operated selecting magnet M7 to M0, over conductor C527, through contacts 467, 444, 312, over conductor C526, through contacts such as M9*g* of the operated selecting magnet M7 to M0, and over conductor C520 to relay 450. Relay 450 operates; extends conductor C507 to ground through relay 280 at contacts 451; closes a circuit to magnet CM over conductor C518 from ground through contacts 213, 277, 375, and 454; closes its holding circuit to ground through relay 460 and contacts 213 at contacts 455; and closes a circuit to relay 400 from ground through contacts 213, 468, 456, and 436. Control magnet CM operates to operate the rank selecting member corresponding to the operated selecting magnet M7 to M0. Relay 400 operates and opens the holding circuit to the operated selecting magnet and corresponding relay 470 to 490 at contacts 401 causing them to restore. When the operated selecting magnet restores it removes a short circuit from relay 460 at contacts such as M0*g* causing it to be energized in series with relay 450. Relay 460 operates; substitutes direct ground for ground through a dial tone transformer on the lower winding of relay 200 at contacts 461 (if used); closes ground through contacts 213, 466, and 465 to conductor C515; closes ground through contacts 213, 466, 282, and 276 to conductor C516; and opens the circuit to relay 400 at contacts 468. Relay 400 restores. The ground on conductor C515 energizes magnet M1 through chain contacts such as M2*d* on the succeeding selecting magnets. Magnet M1 operates, closes a circuit to magnet M2 from ground over conductor C516 and through chain contacts such as M2*b* on succeeding selecting magnets at contacts M1*b*, and operates file selecting member FS1 to operate the corresponding contact set in the group previously selected by the operation of one of the rank selecting members RS7 to RS0. If the first trunk in the group is idle, battery will be extended over the control conductor thereof and over conductor C507, through contacts 372, 384, 443, 451, relay 280, and through contacts 212 to ground. Relay 280 then operates and removes ground from conductor C516 at contacts 282 to prevent magnet M2 from operating. If the first trunk in the group is busy the control conductor thereof will be grounded. Consequently relay 280 will not operate. Magnet M2 then operates, closes a circuit to magnet M3 from ground over conductor C516 at contacts M3*b*, locks to ground over conductor C515 at contacts M2*c*, opens the circuit to magnet M1 at contacts M2*d*, and extends the control conductor of the second trunk in the selected group to relay 280 over conductor C507. If the second trunk is free relay 280 will operate and prevent magnet M3 from operating by removing ground from conductor C516 at contacts 282. If the second trunk is busy the selecting magnets continue to operate sequentially until an idle trunk is found or until magnet M0 operates. If an idle trunk is found relay 280 operating will also close a circuit to relay 270 at contacts 281. Relay 270 operates; switches the calling loop, extended over conductors C201 and C202, through to the trunk circuit over conductors C501 and C503, or conductors C502 and C504, at contacts 271 and 272; extends the fourth conductor C203 to the trunk circuit over conductor C505 or C506

at contacts 273; extends the control conductor C204 to the control conductor of the trunk circuit over conductor C507 at contacts 274 (thereby short-circuiting relay 280); closes its locking circuit to ground through contacts 211 and 274 at contacts 275; opens the circuit to magnet CM at contacts 277; and opens the circuit to relay 210 at contacts 278. Relay 280 restores. During the release time of relay 210 the trunk circuit will return ground over conductor C507 to hold relay 270 and the preceding switch train over conductor C204. Magnet CM restores and rotates the shaft 600 of the latching mechanism to hold the operated contact set independently of the selecting magnets. When relay 210 restores it removes multiple grounds from the control conductor C204 at contacts 211 and 212, and opens circuits to relays 450 and 460 and to the operated selecting magnet at contacts 213 causing them to restore.

The connection thus established is maintained under the control of the calling party's loop by the ground returned over conductor C507 from the trunk circuit. When the calling party disconnects, this ground is removed by the trunk circuit to release relay 270 and the preceding switch train. When relay 270 restores it closes a circuit from ground through contacts 278, 201, 214, and over conductor C519 to magnet RM. Magnet RM operates to release the latching mechanism which in turn opens the circuit to magnet RM at contacts 601 when it releases.

If all of the trunks in the selected group were busy, the operation of magnet M0 would have completed a circuit from ground over conductor C516, through contacts M0b, over conductor C517, and through contacts 453 and 434 to relay 370. Relay 370 is slower to operate than relay 280 so that if the last trunk is free relay 280 operates first and opens the circuit to relay 370 at contacts 282. If relay 370 operates, it closes contacts 371 to return busy tone to the calling party, opens a point in the circuit to relay 280 at contacts 372 to prevent operation thereof in case the trunk circuit subsequently becomes idle, locks to ground through contacts 212 at contacts 374, and opens circuit to magnet CM at contacts 375 causing it to restore. When the calling party releases in response to receiving the busy signal the loop circuit to relay 200 is opened causing it to restore and open the circuit to relay 210 at contacts 201. Relay 210 restores, removes ground from conductor C204 at contacts 211 to release the preceding switch train, opens the locking circuit to relay 370 at contacts 212, opens circuits to relays 450 and 460 in series, and magnet M0 at contacts 213, and closes a circuit to magnet RM over conductor C519 at contacts 214. Magnet RM releases the latching mechanism to complete the restoration of the connector to normal.

While a particular embodiment of the invention has been illustrated, it should be apparent that numerous modifications therein may be resorted to without departing from the true spirit and scope of the invention as defined in the appended claims.

What is claimed is:

1. In a telephone system, a crossbar switch having access to a plurality of groups of lines, operating magnets for said switch, a calling line, means responsive to a series of impulses received over said calling line for sequentially operating said magnets to select a group of said lines, and means responsive to the termination of said series of impulses for sequentially operating said magnets to search for an idle line in said one group.

2. In a telephone system, a crossbar switch comprising a plurality of separately operable contact sets, rank and file selecting members for operating said contact sets, and magnets for operating said selecting members, means including said magnets for operating any one of said rank selecting members to select a group of said contact sets, and means operated in response to the selection of a group for sequentially operating certain of said magnets to cause the contact sets in the selected group to be sequentially operated by said file selecting members.

3. In a telephone system, a crossbar switch having access to a plurality of groups of lines, operating magnets for said switch, a calling line, means responsive to a first series of impulses received over said calling line for sequentially operating certain of said magnets to select a group of said lines, and means responsive to a second series of impulses received over said calling line for sequentially operating certain of said magnets to select a line in said one group.

4. In a telephone system as claimed in claim 3, means responsive to the termination of said second series of impulses for continuing the seqential operation of certain of said magnets to search for an idle line in the event that said one line is busy.

5. In a telephone system, a crossbar switch having access to a plurality of groups of lines, operating magnets for said switch, a calling line, means responsive to a first and a second series of impulses received over said calling line for operating certain of said magnets to select a corresponding one of said lines, and means responsive to a third series of impulses received over said calling line for operating a corresponding one of said magnets to select the ringing signal allocated to a desired party on said one line.

6. In a telephone system as claimed in claim 5, means responsive to an answer by the called party for releasing said last operated magnet to prevent further ringing over said one line.

7. In a telephone system, a plurality of groups of crossbar switches each having access to a plurality of groups of lines, a further group of crossbar switches each having access to the switches in said plurality of groups, selecting magnets for each of said switches, a calling line, means responsive to a series of impulses received over said calling line for operating the selecting magnets of a switch in said further group in a step-by-step manner to select one of said first groups of crossbar switches, means responsive to the termination of said series of impulses for operating the selecting magnets of said one switch in a step-by-step manner to select, and extend said calling line to, an idle switch in said one group, and means responsive to further series of impulses received over said calling line for operating the selecting magnets of said one idle switch in said one group in a step-by-step manner to extend said calling line to a desired one of the lines accessible to said one idle switch.

8. In a telephone system, a line, a crossbar switch, operating magnets for said switch, auxiliary switching contacts on each of said magnets, and circuit arrangements including said auxiliary switching contacts connecting said magnets so as to enable sequential operation thereof in response to a series of impulses received over said line.

9. In a telephone system, a crossbar switch comprising a plurality of contact sets disposed in ranks and files and a plurality of magnets each

corresponding to a rank and to a file of said contact sets, lines connected to each of said contact sets, a calling line, means responsive to a series of impulses received over said calling line for operating a corresponding one of said magnets to select a rank of said contact sets, and means operated subsequent to said rank selection for causing said magnets to sequentially operate the contact sets in the selected rank.

10. In a telephone system, a crossbar switch comprising a plurality of separately operable contact sets and two intersecting groups of selecting members therefor, a subscriber's line, means responsive to one or more series of impulses received over said line for actuating a member in each group to operate a corresponding one of said contact sets at the intersection of the actuated members, latching means operated to hold the operated contact set independently of said first means, and means operated under the control of said subscriber's line for releasing said latching means.

11. In a telephone system, a crossbar switch comprising a plurality of separately operable contact sets and two intersecting groups of selecting members therefor, a subscriber's line, means responsive to one or more series of impulses received over said line for actuating a member in each group to operate a corresponding one of said contact sets at the intersection of the actuated members, latching means operated to hold one of said two actuated members to thereby hold the operated contact set independently of said first means, and means operated under the control of said subscriber's line for releasing said latching means.

12. In a telephone system, a switch comprising two groups of crossed bars, a contact set at each point of intersection of said bars, individual magnets for operating each bar in one of said groups, a common magnet for operating any bar in the other of said groups, and means responsive to the operation of one of said individual magnets for selecting a corresponding one of the bars in said other group to be operated by said common magnet, a line, impulsing means responsive to a series of impulses received over said line for operating one of said individual magnets, means responsive to the termination of said series of impulses for operating said common magnet to operate the bar in said other group corresponding to the operated individual magnet, and circuit arrangements causing another of said individual magnets to be operated by said impulsing means in response to a second series of impulses received over said line to selectively operate one of said contact sets corresponding to said two successively operated individual magnets.

13. In a telephone system, a plurality of contact sets disposed in ranks and files, a plurality of selecting magnets each corresponding to a rank and to a file of said contact sets, a common magnet, a line, means responsive to a series of impulses received over said line for jointly operating one of said selecting magnets and said common magnet, means responsive to the joint operation of said two magnets for selecting the corresponding rank of contact sets, said first means being responsive to a further series of impulses received over said line to operate another of said selecting magnets, and means responsive to the operation of said other selecting magnet for selectively operating the contact set in the corresponding file and in the previously selected rank.

14. In a telephone system, a plurality of contact sets disposed in ranks and files, a plurality of magnets associated with said ranks and said files of contact sets, each of said magnets being associated with one of said ranks of contact sets and also with one of said files of contact sets, a line, means responsive to successive series of impulses received over said line for successively operating corresponding ones of said magnets, and means controlled by said successive operations of said corresponding magnets for selectively operating a particular one of said contact sets.

15. In a telephone system, a plurality of contact sets disposed in ranks and files, a plurality of magnets associated with said ranks and said files of contact sets, each of said magnets being associated with one of said ranks of contacts sets and also with one of said files of contact sets, a line, means controlled over said line for operating a particular one of said magnets, means responsive to said operation of said particular magnet for selecting the rank of contact sets associated with said particular magnet, said first means again controlled over said line for reoperating said particular one magnet or for operating another of said magnets, and means responsive to said operation of said last magnet for operating the contact set in said previously selected rank of contact sets which is in the file of contact sets associated with said last magnet.

JOHN H. VOSS.

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