

April 16, 1929.

E. VROOM ET AL

1,708,983

TELEPHONE SYSTEM

Filed Aug. 17, 1926

7 Sheets-Sheet 1

Fig. 1.

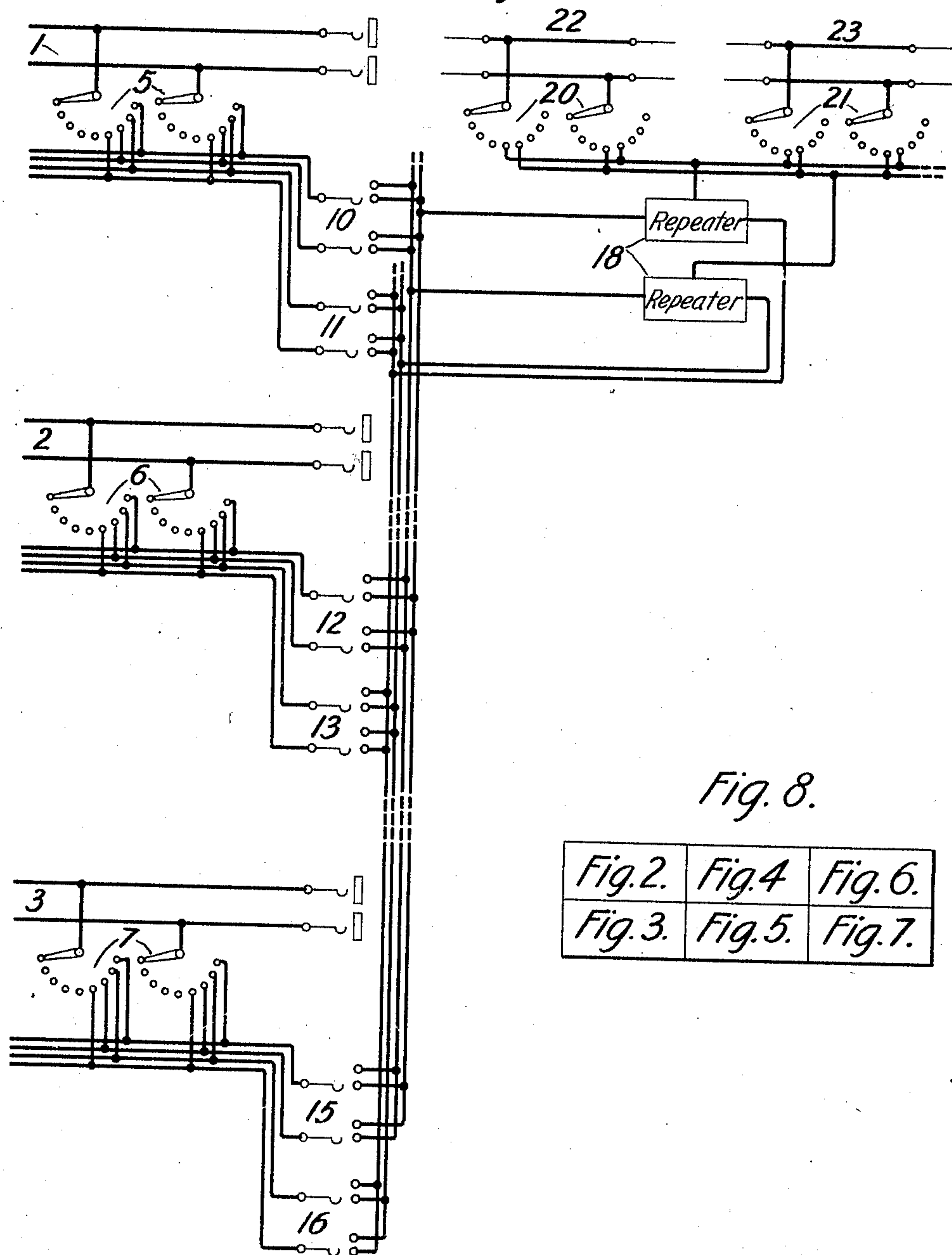


Fig. 8.

Fig. 2.	Fig. 4	Fig. 6.
Fig. 3.	Fig. 5.	Fig. 7.

Inventors:
Edward Vroom.
Ferdinand S. Entz.
by *J. C. Palmer* Att'y.

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7 Sheets-Sheet 2

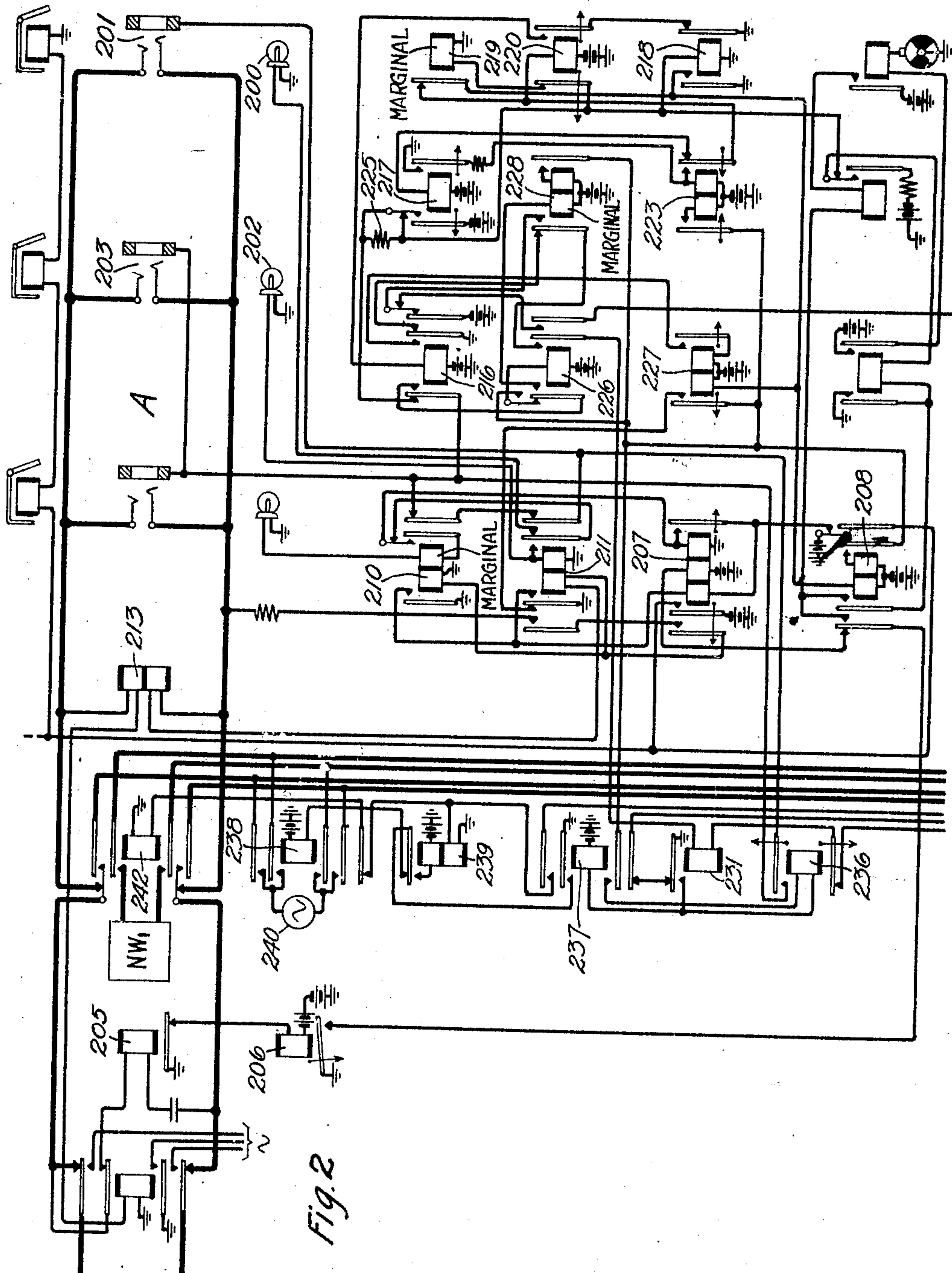


Fig. 2

Inventors:
Edward Vroom
Ferdinand S. Entz
by Joe C. Palmer Att'y.

April 16, 1929.

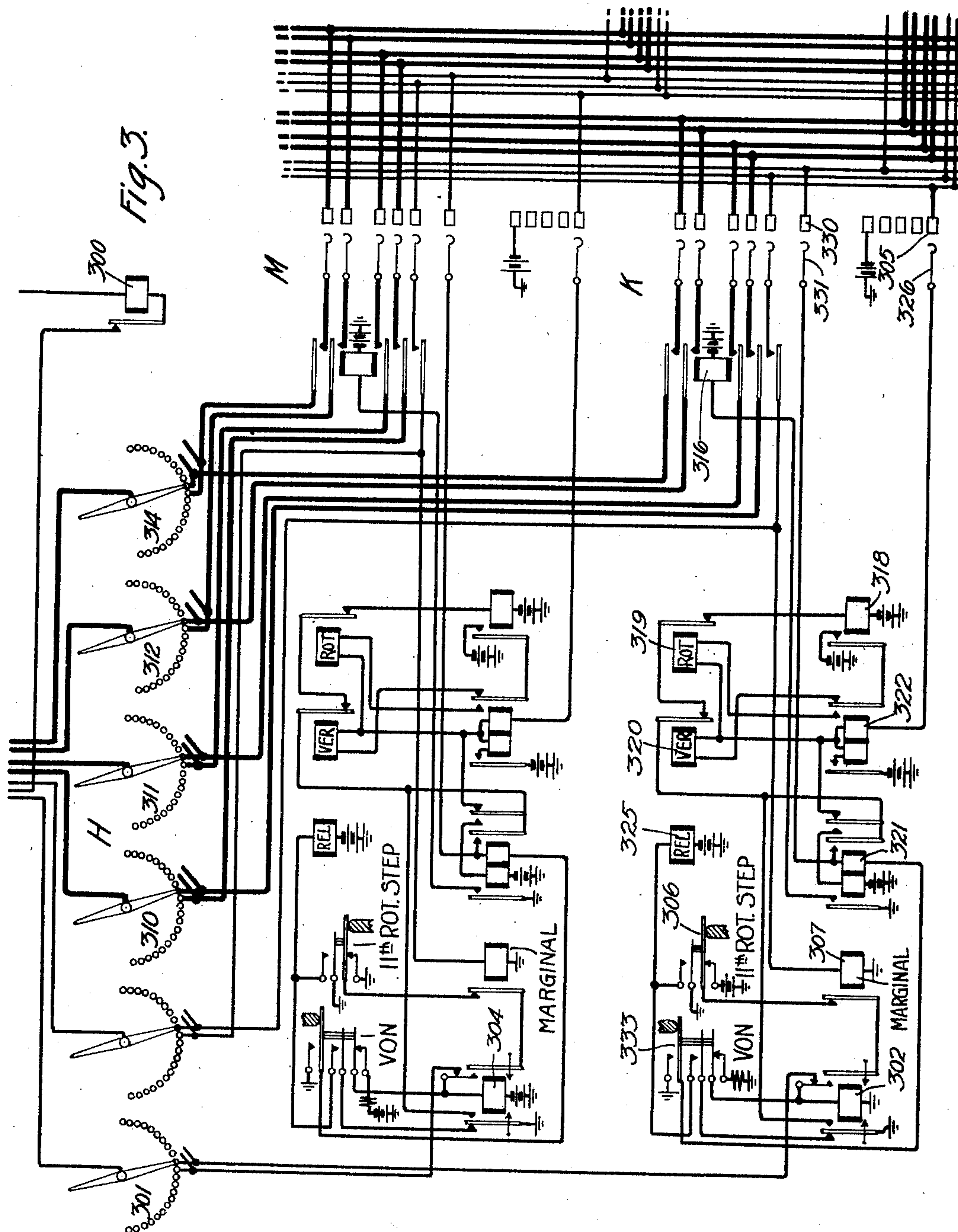
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7 Sheets-Sheet 3



Inventors:
Edward Vroom
Ferdinand S. Entz
by Jos. C. Palmer Att'y.

April 16, 1929.

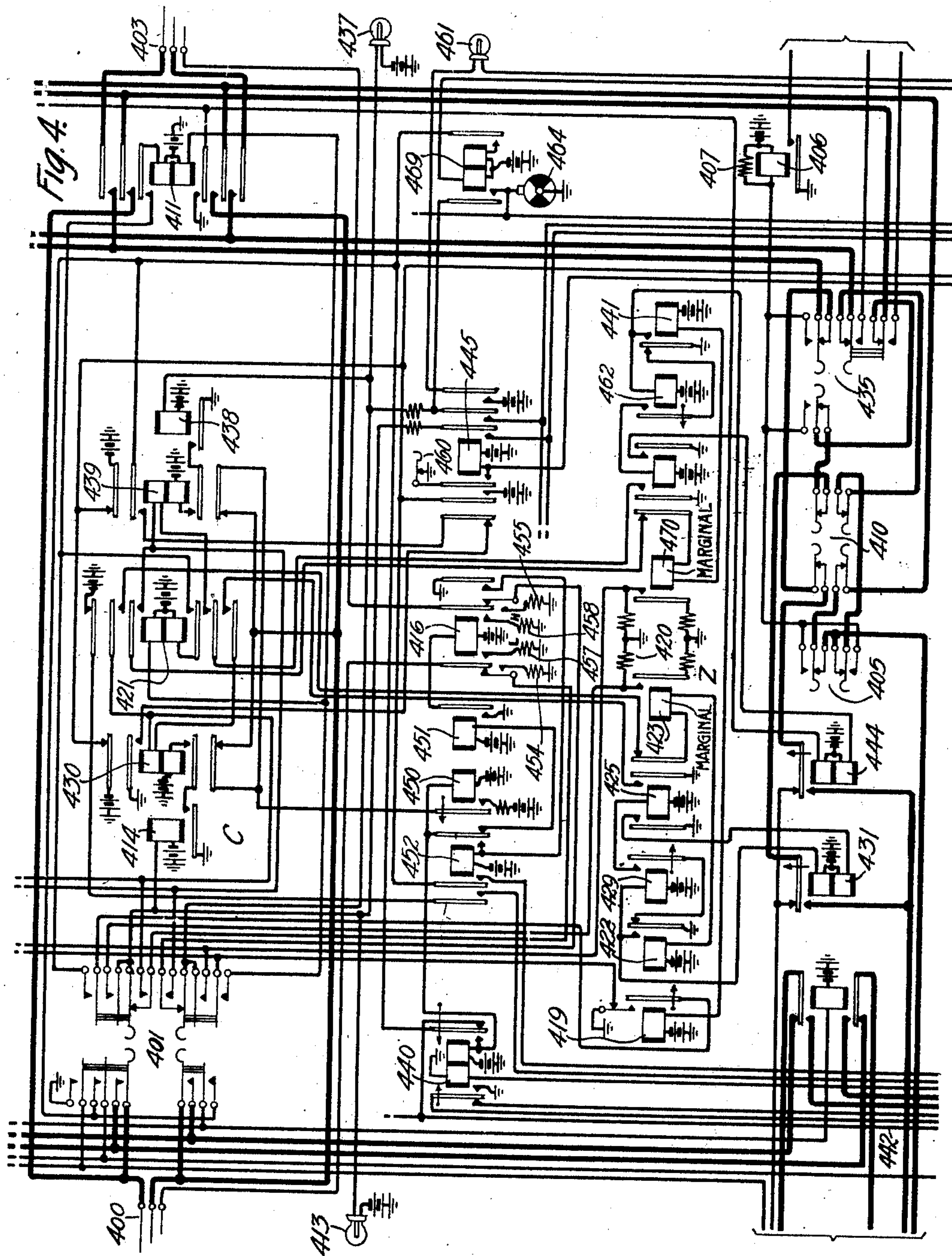
E. VROOM ET AL

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7 Sheets-Sheet 4



Inventors:
Edward Vroom
Ferdinand S. Entz
by J. C. Palmer Att'y.

April 16, 1929.

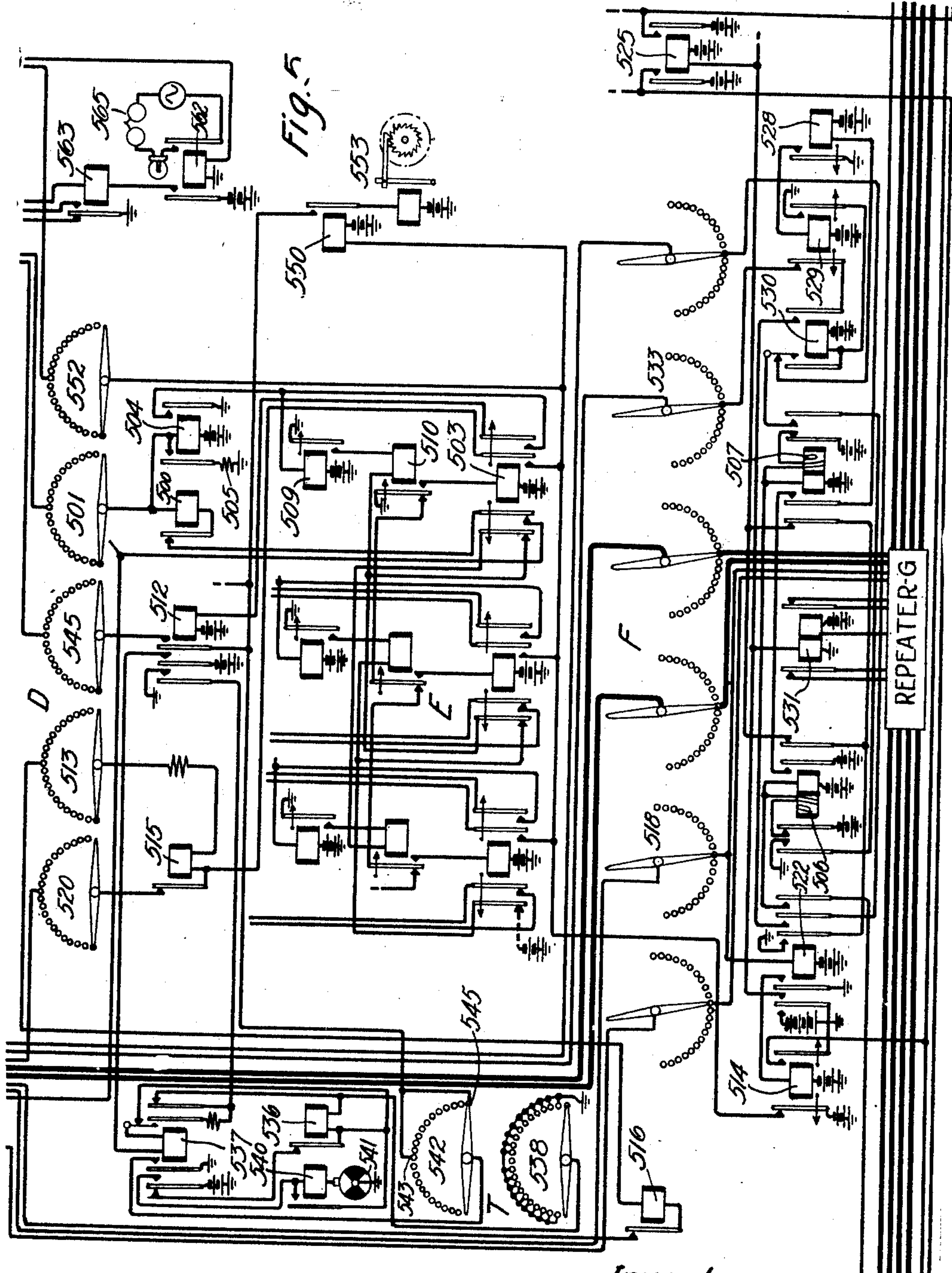
E. VROOM ET AL

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TELEPHONE SYSTEM

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7 Sheets-Sheet 5



Inventors:
Edward Vroom
Ferdinand S. Entz
bv J. C. Palmer Att'y.

April 16, 1929.

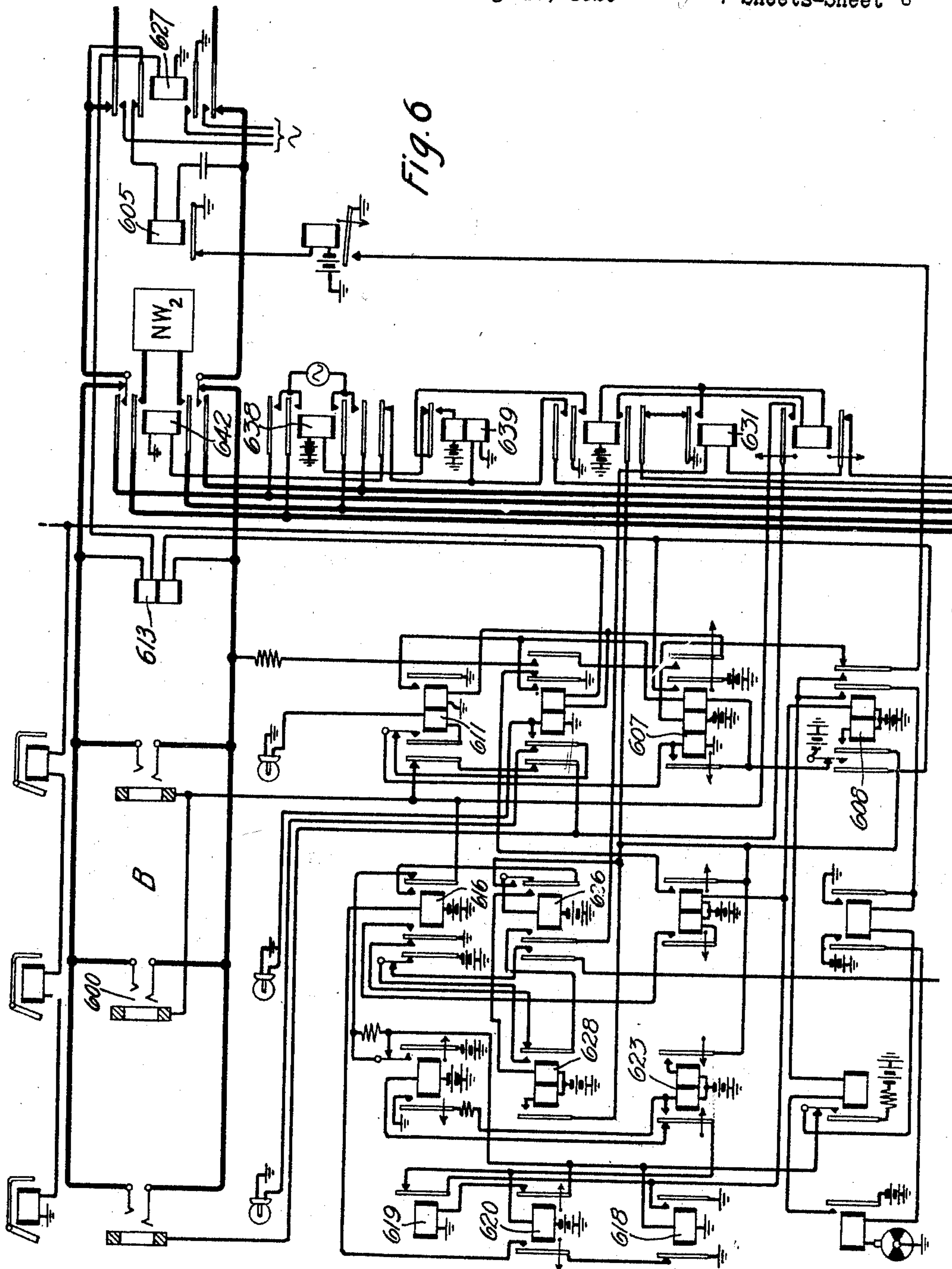
E. VROOM ET AL

1,708,983

TELEPHONE SYSTEM

Filed Aug. 17, 1926

7 Sheets-Sheet 6



Inventors:
Edward Vroom
Ferdinand S. Entz
by Joel R. Palmer Att'y.

April 16, 1929.

E. VROOM ET AL

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7 Sheets-Sheet 7

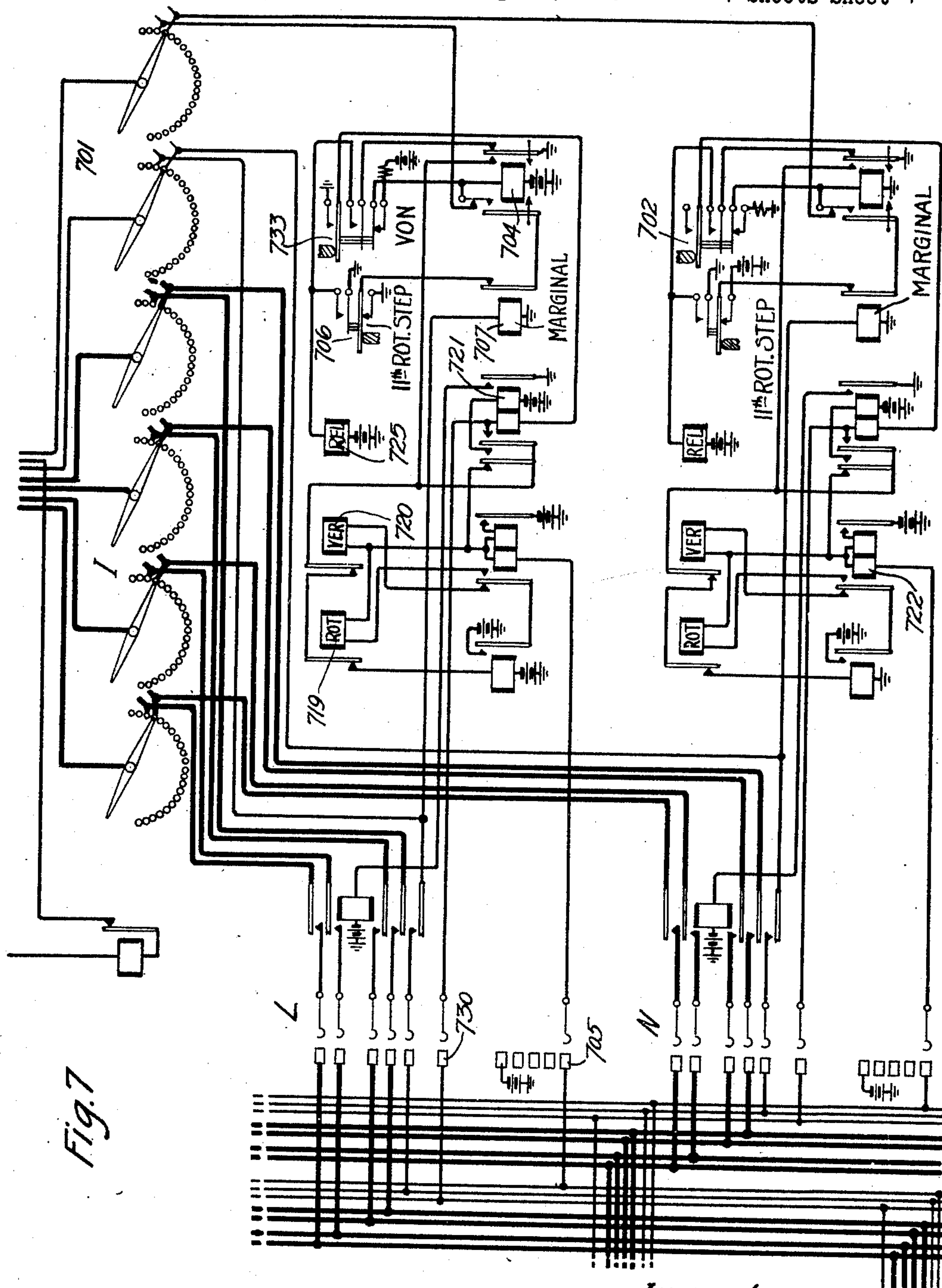


Fig. 7

Inventors:
Edward Vroom
Ferdinand S. Entz
by Joel A. Palmer Att'y.

UNITED STATES PATENT OFFICE.

EDWARD VROOM, OF OSSINING, AND FERDINAND S. ENTZ, OF MOUNT VERNON, NEW YORK, ASSIGNORS TO BELL TELEPHONE LABORATORIES, INCORPORATED, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK.

TELEPHONE SYSTEM.

Application filed August 17, 1926. Serial No. 129,683.

This invention relates to telephone exchange switching systems and more particularly to the automatic selection of speech amplifying and repeating apparatus and the insertion of the same in toll connections.

Systems, such as those disclosed in Patent No. 1,647,796, issued to L. L. Glezen, S. P. Shackleton and E. Vroom Nov. 1, 1927, and the copending applications of E. Vroom and J. A. Krecek, Serial No. 39,882, filed June 27, 1925, and E. Vroom and S. F. Entz, Serial No. 129,682, filed Aug. 17, 1926, have been devised for automatically inserting repeating amplifiers in toll connections. In these cases toll cord circuits are arranged for toll lines that do not require the addition of repeaters and toll lines that do require such an addition. In general, the arrangement is such that an automatic discrimination is made between the two kinds of toll lines when a cord circuit is employed to interconnect the toll lines. When a repeater is required, this discriminating arrangement functions to start the automatic selection and connection of the repeater between two lines. A selecting mechanism or repeater selector is associated with each cord circuit so arranged as to be automatically started by the discriminating means to hunt for and connect the associated cord circuit with an idle repeater, a plurality of repeaters being provided for the common use of said cord circuits. In the last mentioned copending application the connection between the lines and repeater is accomplished by means of links comprising two switches of the line finder type with their brushes connected together. The arrangement is such that when a cord circuit has been connected between two lines and an idle repeater has been found, the switches of one link are actuated to connect one of the lines with the incoming end of the selected repeater, while simultaneously, the switches of another link are actuated to connect the other line with the outgoing end of the selected repeater.

According to the present invention each toll line is equipped with a selective switch which responds automatically when the line is taken in use to connect such line, depending on whether it is calling or being called, to one or the other side of a selected idle repeater. Thus when a calling and a called line

are taken in use by an operator to extend a toll call the corresponding selective switches operate simultaneously to include the selected repeater in the toll connection. In such a system toll lines are divided in comparatively small groups, each toll line being provided with a switch, hereinafter called the trunk selector, having access to a plurality of trunks, each trunk being connected to a line finder switch, hereinafter called the repeater finder, having access to a plurality of repeater units. Each trunk selector is arranged to connect the associated line with an idle trunk in either of two groups, the trunks in one group leading to repeater finders having access to the incoming ends of repeaters and the trunks in the other group leading to repeater finders having access to the outgoing ends of repeaters.

This switching and grouping arrangement is applied to a system in which an idle repeater may be selected by means similar to the arrangement shown in the last mentioned copending application, the arrangement being such that when a cord circuit is connected between two lines requiring a repeater inserted between them, the repeater selector associated with this cord is actuated to select an idle repeater. The cord circuits may also be arranged in groups with each repeater selector having access to a certain number of the total number of repeaters available to all of the cord circuits in the group. When, therefore, a cord circuit has been connected between two lines and an idle repeater has been found, the trunk selectors associated with said lines are automatically and simultaneously actuated to select trunks. The selector associated with the call originating line will select a trunk associated with a repeater finder having access to the incoming end of the selected repeater, said repeater finder in turn being actuated to find the repeater and connect it with the call originating line. On the other hand the selector associated with the desired line will select a trunk associated with a repeater finder having access to the outgoing end of the selected repeater, said repeater finder in turn being actuated to find the repeater and connect it with the desired line. This arrangement, therefore, is particularly adapted and suitable for small exchange installations that are

only likely to grow to a moderate size. It should be understood that the expressions "incoming and outgoing ends" of repeaters are merely used for convenience in distinguishing between the line end to which the various switches have access and does not refer to the transmission characteristics of the repeater.

This invention has been illustrated in the accompanying drawings, in which;

Fig. 1 is a diagrammatic representation of a typical grouping arrangement of the toll lines, trunk selectors, repeater finders, cord circuits and repeater selectors;

Fig. 2 illustrates the incoming end of one toll line requiring the addition of a repeater;

Fig. 3 illustrates the trunk selector associated with the toll line shown in Fig. 2 and two repeater finders having access respectively to the incoming and outgoing ends of repeaters with their respective trunks terminating in the banks of the trunk selector shown in this figure;

Figs. 4 and 5 illustrate a cord circuit and its associated repeater selector and a repeater, the repeater being merely indicated by means of an inclosure. These figures also show various common circuits and switching arrangements for preventing more than one interconnection of toll lines from taking place at any one time;

Fig. 6 illustrates the incoming end of another toll line requiring the addition of a repeater; while

Fig. 7 shows the trunk selector associated with the toll line shown in Fig. 6, a repeater finder having access to the outgoing ends of repeaters, and a repeater finder having access to the incoming ends of repeaters with their respective trunks terminating in the banks of the trunk selector shown in this figure;

Fig. 8 shows the arrangement of the drawings forming part of this application.

The general arrangement of the various equipments for carrying out this invention may take the form shown in Fig. 1. For example, the toll lines may be divided into three groups, 1, 2 and 3, with 40 lines and the corresponding number of trunk selectors such as 5 and 6 in groups 1 and 2 and with 20 lines and the corresponding number of trunk selectors such as 7 in group 3. The trunk selectors such as 5 and 6 may have access to about 22 trunks, 11 of which will be connected to repeater finders such as 10 and 12 that have access to incoming ends of repeaters, while the other 11 trunks may be connected to repeater finders such as 11 and 13 that have access to outgoing ends of repeaters. The trunk selectors at 7 would only require 12 trunks, 6 of which would be connected to repeater finders such as 15 having access to incoming ends of re-

peaters, and the other 6 may be connected to repeater finders such as 16 having access to outgoing ends of repeaters. The terminals of these repeater finders may be connected to 24 repeaters such as 18 and multiplied to all finders so that each repeater finder will have access to all the repeaters. The 24 repeaters are represented at the terminal banks of repeater selectors such as 20 and 21 connected to different groups of cord circuits such as 22 and 23. The repeater selector terminals may be multiplied in any convenient manner. It is not necessary to have all of the repeaters available to each repeater selector but a small number of repeaters may be connected to each group of repeater selectors, for example, 12 repeaters may be multiplied to the terminals of selectors 20 and the other 12 to the selectors 21. It should be understood that any arrangement best suited to meet the conditions in any particular exchange may readily be made with this organization of switches and repeaters and that additions within reasonable limits can be made without decreasing the efficiency of the system.

Referring now to Figures 2 to 7, the general scheme of interconnecting toll lines and inserting repeaters into these connections in accordance with this invention, will be outlined as follows: Let it be assumed that the toll line A is to be connected through a repeater with the toll line B and that cord circuit C is to be used for the establishing of this connection. In accordance with the well known practice a call incoming over line A is observed by the inward operator on the usual toll board by the lighted lamp 200. After inserting the answering plug of an ordinary cord circuit into jack 201 of line A, and communicating with the operator at the distant end of line A, it is found that the call requires a through connection, this inward operator will switch the call to a through operator's position causing lamp 202 to light. The through operator has access to a plurality of cords such as C, and observing the lamp 202 of line A lighted, this operator inserts plug 400 of cord C into jack 203 of line A and operates the talking key 401 to connect her telephone set to line A for the purpose of communicating with the operator at the distant end to ascertain the destination of the desired connection. After having received the desired information the through operator now inserts plug 403 into jack 600 of line B and restores the talking key 401.

As it has been assumed that both lines A and B require the insertion of a repeater, these lines have special electrical characteristics on their sleeve circuits that will initiate, when the toll lines are connected to a cord circuit, automatic operations for the inserting of a repeater into the connection. For this purpose there is provided a so-called lockout selector switch or cord finder, one of which is

indicated at D. Each cord finder is common to a position or group of cords. Cord finder D will now start to find the cord C and when found the cord finder remains associated with the cord until the operations for inserting a repeater in the connection are completed. This is in order to prevent any other cord circuit in this group from starting its operations until cord C is released. As soon as the cord finder D finds the cord circuit C, it starts operations to associate a secondary lockout circuit or position finder indicated at E. This finder is common to all the groups of cords in the system. The position finder E remains associated with the cord circuit C until the complete sequence of operations for inserting a repeater into the connection has been effected and functions to prevent any other cord circuit in any other group from starting the selection of a repeater until cord circuit C has completed its functions in this respect. The association of the position finder takes place immediately, provided no other cord in the system is going through the process of inserting a repeater in a connection. The reason for the provision of a cord finder for each group of cords and a position finder for all the groups of cords in the system, is to insure that only one connection of a repeater between toll lines may take place at any one time. However, in order not to delay the connection of repeaters any longer than is necessary, the cord finders of the various groups of cords may operate to find cords connecting toll lines, independently and simultaneously and prepare the associated circuits to the point where the common position finder begins to operate to permit one cord circuit at a time to complete the repeater selecting and connecting functions.

Once the cord C has assumed control over the position finder E it starts its repeater selector indicated at F to hunt for an idle repeater. One of these repeaters has been indicated at G merely by means of an inclosure with all the leads from the repeater finders having access to the incoming end, from the repeater finders having access to the outgoing end of the repeater and from the repeater selector F shown leading into the same. As the repeater itself forms no part of the invention and as any repeater of any well known type may be used, it is thought that this representation will be sufficient. The repeater selectors and the cord finder units may be of any well known type having a series of terminal banks with the brushes arranged to travel thereover in steps under control of stepping magnet mechanisms. These selectors and finders have no home positions.

When the repeater selector F finds an idle repeater, certain electrical conditions are established for the sleeve circuits of the lines A and B to cause these lines to actuate their associated trunk selectors H and I, re-

spectively, to select idle trunks. In the case of the trunk selector H, a trunk connected to a repeater finder such as K having access to the incoming end of the repeater G will be selected and in the case of the trunk selector I a trunk connected to a repeater finder such as L having access to the outgoing end of the repeater G will be selected. It will be recalled that each trunk selector has access to two groups of trunks connected with repeater finders having access, respectively, to the incoming and outgoing ends of the common group of repeaters. A trunk and a repeater finder M companion to the repeater finder K, and the repeater finder N companion to the repeater finder L have been shown in Figs. 3 and 7, respectively. The construction of the trunk selectors H and I may be of any well known type having a series of terminal banks with brushes arranged to travel thereover in steps under control of stepping magnet mechanisms. These selectors have no home positions. The construction of the repeater finders may be of any well known Strowger type having terminal banks arranged in horizontal layers with brushes traveling in a vertical followed by a horizontal step-by-step movement.

In general, the connection of the repeater G with lines A and B is accomplished by having, for example, the line A select through the trunk selector H, the trunk connected to repeater finder K, and having the repeater finder K hunt for the incoming end of the selected repeater G, and by having, for example, the line B select through the trunk selector I, the trunk connected to repeater finder L, which is actuated to hunt for the outgoing end of the selected repeater G. It should be pointed out at this time that the operations of the trunk selectors H and I and the repeater finders K and L are simultaneous so that no time is lost in finding the repeater G to be interconnected between the lines A and B.

As soon as the lines have been connected through the repeater, the cord and position finders are released so that the cord finder becomes available for other cords in the group to which cord C belongs and so that the position finder becomes available for any other group of this or any other position. Circuit changes will now take place to separate the two lines from the cord C and connect them to the repeaters through the trunks mentioned and at the same time connect the proper networks, NW₁ and NW₂, in this case, to balance the lines and also to remove certain short circuits in the repeater to make it operative.

Transmission may then take place through the repeater while the connection to the cord circuit is opened. However, the usual ringing bridge is left across the toll line conductors so that supervisory signals may be

received in the cord circuit over the sleeve circuits. Arrangements are also made whereby whenever the talking key of the cord circuit is operated, the repeater is cut out from the connection which, under these circumstances, will extend through the cord circuit. Monitoring keys are also provided whereby connections from the repeater to the operator's telephone set may be established through the repeater selector.

If either one of the plugs of the cord C is withdrawn from the line jack, the repeater is released from the connection. The repeater selector brushes, the cord finder brushes and the trunk selector brushes remain in the position in which they were last used, while the repeater finders are returned to normal positions. The sleeve circuit of the line still connected to the cord remains in busy condition until both plugs are removed when the entire equipment is restored to its normal condition.

For the purpose of providing against failure of any part of the system during the establishing of a connection involving a repeater, a time delay circuit, indicated by T, is used. Each connection is allowed a certain time, for example five seconds, in which to be completed. If completed within this time the time circuit is restored to normal, but if it is not completed in this allotted time, the time circuit functions to give an alarm indicating which cord circuit is involved, and also to cause the release of the cord finder involved to allow connections through another cord to take place. The arrangements are also such that the toll operator receives a signal when all of the repeaters are busy. Cord circuits, such as C are also arranged for connecting ordinary toll lines that do not require the addition of repeaters. However, this invention is essentially concerned with the inclusion of repeaters in toll line connections and the following detailed description will therefore be confined to the description of the functions taking place under such conditions.

As stated, when a call comes in over line A, it is observed by the inward operator at the usual toll board by the fact that the lamp 200 is lighted. This lamp is lighted by a signal incoming over line A to operate relay 205 which causes the release of relay 206 over an obvious circuit. The release of relay 206 closes a circuit for the operation of relay 207 as follows: battery, middle winding of relay 207, outer left hand armature and back contact of relay 208, armature and back contact of relay 206 to ground. Relay 207 in operating, closes a locking circuit for itself through its right hand winding, armature and front contact to battery at the make-before-break contacts of relay 208. A circuit is now also closed from this battery for the lighting of lamp 200, over a circuit as fol-

lows: battery, make-before-break contact of relay 208, right hand armature and front contact of relay 207, make-before-break contacts of relay 210, inner right hand armature and back contact of relay 211, lamp 200 to ground. The inward operator answers this call by inserting the answering plug of an ordinary cord circuit into jack 201 and connects her telephone set through this cord to line A. If it is found that the call requires a through connection, this inward operator transfers the call to a through operator's position.

It should be noted that the toll cord C shown in Fig. 3 may also be used by the inward operator for this purpose. The transfer of the call to the through operator's position, if a cord like C is used, may be accomplished by the operation of key 405 which causes battery to be applied to the ring spring of jack 201 for effecting the transfer. It should be understood that the talking key of the cord circuit used by this inward operator when operated to connect her telephone set to the line, causes the operation of relay 411. The operations in the cord circuit C, to cause this effect, will be described later. A circuit will now therefore be completed from battery, through relay 406 and the resistance 407 in parallel, through key 405, splitting key 410, lower middle armature and front contact of relay 411, ring terminals of the plug 400 and jack 201, retardation coil 213, left hand winding of relay 211, left hand winding of relay 210 to ground. The character of the winding of relay 406 and of resistance 407 are such as to cause only the operation of relay 211 as relay 210 is marginal. The operation of relay 211 opens the circuit for lamp 200 and transfers this circuit at the inner right hand armature and front contact of relay 211 to lamp 202 which lights at the through operator's position. A locking circuit is provided for relay 211 through its inner right hand armature and front contact to the battery at the make-before-break contacts of relay 208.

The lighting of lamp 202 indicates that a through connection is desired. The through operator now inserts plug 400 into jack 203 and the inward operator removes the plug corresponding to plug 400 from jack 201. The through operator then actuates the talking key 401 to connect her telephone set to the line A for the purpose of communicating with the operator at the distant end of toll line A to ascertain the destination of the desired connection. The first effect, after the insertion of plug 400 into jack 203 and before the key 401 is operated, will be the lighting of lamp 413 and the operation of relays 414 and 218 over a circuit as follows: battery, winding of relay 414, in parallel with battery through lamp 413, inner upper normal contacts of key 401, left hand armature and back contact of relay 416, sleeve terminals

of plug 400 and jack 203, left hand armature and back contact of relay 216, make-before-break contact of relay 217, winding of relay 218 to ground. The electrical condition of this circuit is such that relay 219 although marginal is also operated over a continuation of this circuit through the left hand armature and back contact of relay 220. Relay 220 is thus prevented from operating on the operation of relay 218 which would provide a circuit for relay 220 to ground through its left hand armature and front contact. The lighting of lamp 413 indicates to the through operator that the talking key 401 has not yet been operated. The operation of relay 218 closes a circuit for the operation of relay 208 as follows: battery, left hand winding of relay 208, left hand armature and front contact of relay 218 to ground. The operation of relay 208 causes the release of relays 207 and 211 so that lamp 202 is extinguished.

If the through operator now operates talking key 401 to associate her telephone set with the cord C, relay 411 is operated over a circuit as follows: battery, lower winding of relay 411, lower outer made contacts of key 401, make-before-break contacts of relay 419 to ground. The operation of key 401 also closes a circuit for the operation of relay 421 as follows: battery, upper winding of relay 421, lower outer made contacts of key 401, to ground at the make-before-break contacts of relay 419. On the operation of relay 411 an obvious circuit is closed for the operation of relay 419 which in turn transfers the ground from its make-before-break contacts through its armature and front contact, the upper made contacts of key 401, to a locking circuit for relay 421, that extends through the inner lower armature and front contact and lower winding of relay 421 to battery and to a locking circuit for relay 411, that extends through the upper inner armature and front contact and upper winding of relay 411 to battery. Relays 421 and 411 will therefore be locked from the ground at relay 419 while relay 419 is locked by relay 411. The operation of key 401 also transfers the circuit for lamp 413 and relay 414 from the sleeve circuit through the upper middle make contacts of key 401 to the operator's position circuit indicated by the letter Z where it encounters ground through a resistance 420. The sleeve circuit itself is transferred through to the relays 423 and 422 of the operator's position circuit Z. Lamp 413 is now extinguished as the resistance 420 is too high to permit the lamp to remain lighted but not sufficiently high to cause the release of relay 414. The extinguishing of lamp 413 indicates to the operator that the talking key has been operated.

Relay 422 is now operated but marginal relay 423 remains in an unoperated condition due to the high resistance of the winding of

relay 219 which also releases due to its marginal characteristic and the fact that the resistance of the windings of relays 422 and 423 is higher than the resistance of lamp 413 and the winding of relay 414. The circuit for these relays is as follows: battery, winding of relay 422, winding of relay 423, outer right hand armature and back contact of relay 425, upper middle armature and front contact of relay 421, upper inner made contacts of key 401, left hand armature and back contact of relay 416, sleeve terminals of plug 400 and jack 203, left hand armature and back contact of relay 216, make-before-break contacts of relay 217, winding of relay 218 to ground and winding of relay 219 to ground. The operation of relay 422 closes an obvious circuit for relay 429 and also an obvious circuit for the operation of relay 431. The operation of these relays, however, has no effect on the circuits at present. The release of the marginal relay 219 closes a circuit for the operation of relay 220 as follows: battery, winding of relay 220, armature and back contact of relay 219, armature and front contact of relay 218 to ground. The operation of relay 220 opens the circuit through its left hand armature and back contact for relay 219 so that this relay cannot again be operated as long as relay 218 remains operated. Relay 219 also closes a circuit for the operation of relay 217 as follows: battery, winding of relay 217, right hand armature and back contact of relay 223, armature and back contact of relay 219, left hand armature and front contact of relay 218 to ground. Relay 218 is maintained operated over the sleeve circuit through the resistance 225 from the battery and front contact of relay 217. This connection from battery is also extended to the sleeve circuit and causes the release of relay 422. The release of relay 422 causes the operation of relay 425 as relay 429 is slow to release so that a momentary ground for the operation of relay 425 is provided from the armature and back contact of relay 422 through the armature and front contact of relay 429. The operation of relay 425 opens the sleeve circuit through relays 423 and 422 at the outer right hand armature and back contact of this relay and closes a circuit for the operation of relay 430 as follows: from battery, left hand armature and front contact of relay 217, left hand armature and back contact of relay 216, sleeve terminals of jack 203 and plug 400, left hand armature and back contact of relay 416, inner upper made contacts of key 401, upper winding of relay 430, lower armature and front contact of relay 421, inner right hand armature and front contact of relay 425 to ground. Relay 430 closes an obvious locking circuit for itself under control of relay 414 which, it should be noted, is maintained operated through re-

sistance 420 to ground. The operation of relay 217 closes an obvious circuit for the operation of relay 223 which now locks up through its right hand armature and front contact to ground at the left hand armature and front contact of relay 218, and this relay 223 in operating opens the circuit for relay 217. Relay 217 in releasing removes the battery from its left hand armature and front contact and as relay 425 is only momentarily operated due to the release of relay 429 the sleeve circuit is now again completed for the reoperation of relay 422, and the maintaining of relay 218 operated. The reoperation of relay 422 closes an obvious circuit for the operation of relay 431 which is now held operated. The above mentioned cycles of operations therefore, leave the circuits in such a condition that in Fig. 4 relays 419, 422, 429, 430, 431, 411, 414 and 421 are operated and lamp 413 is extinguished while in Fig. 2 relays 218, 220, 223 and 208 are operated and lamps 200 and 202 are extinguished.

The operator's telephone set is now connected through talking key 401 from the tip conductor of toll line A, through the tip terminals of jack 203 and plug 400, upper middle armature and front contact of relay 411, lower outer right normal contacts and upper inner left normal contacts of ringing key 435, right hand upper normal contacts of splitting key 410, armature and front contact of relay 431 to one side of the operator's telephone set and from the ring conductor of toll line A to the ring terminals of jack 203 and plug 400, lower middle armature and front contact of relay 411, lower left normal contacts of splitting key 410, through normal contacts of relay 405 to the other side of the operator's telephone set.

After the through operator has received the desired information from the operator at the distant end of toll line A, she will insert plug 403 into jack 600 of toll line B which is assumed to be the toll line leading to the exchange where the wanted subscriber may be found. The incoming end of toll line B functions with the cord circuit C in the same manner as the incoming end of toll line A did when it was connected to the cord circuit C to cause the operation of various relays and lamps. For example, the relays that will be maintained operated in toll line B are, 618, 620, 623 and 608, while in cord circuit C lamp 437 is extinguished and relays 441, 462, 444, 439 and 438 are maintained operated. Relay 444 connects the operator's telephone set to the toll line B so that the toll operator will now be able to talk to the operator at the distant end of toll line B to give this operator the information necessary for the completion of the connection to the wanted subscriber's line. The talking connection in this case may be traced from the tip conductor of toll line B, to the tip terminals of jack 600 and plug

403, upper outer armature and front contact of relay 411, upper inner right normal contact of ringing key 435, left hand upper normal contacts of splitting key 410, armature and front contact of relay 444 to one side of the operator's telephone set, while the other side of the operator's telephone set is connected from the ring conductor of toll line B, ring terminals of jack 600 and plug 403, outer lower armature and front contact of relay 411, lower inner normal right hand contacts of ringing key 435, right hand lower normal contact of splitting key 410, through the contacts of key 405 to the opposite side of the operator's telephone set.

It should be noted that the operator at the distant end of the toll line B, may be rung by operating the right hand set of springs of ringing key 435 to apply battery through relay 406 and resistance 407 to the upper outer right contacts of ringing key 435, upper outer armature and front contact of relay 411, tip terminals of plug 403 and jack 600, retardation coil 613, ringing relay 627 to ground. The operation of this relay applies ringing current from the usual source to the tip and ring terminals of toll line B. Having completed the information to the distant operator, key 401 will be restored.

On the connection of the two lines A and B to the cord circuit C relays 430 and 439 are operated. These relays complete a circuit to ground to the position finder E provided the position finder is not in use in connection with any other cord. This ground will start the stepping magnet 500 of cord finder D to operate the finder to hunt for cord C. The circuit for this stepping magnet extends to battery over any terminal of bank 501 on which the brush of this bank happens to rest at the time, this battery being supplied from the idle or busy cord circuit to which the terminal 501 is connected over the upper outer armatures and back contacts of relays corresponding to relays 439 and 430. The only cord that has no battery on its terminal in bank 501 is cord C. This circuit will therefore be completed from battery, brush of bank 501, winding of stepping magnet 500 and its armature and back contact, inner left hand armature and back contact of relay 503, common lead 442, right hand armature and back contact of relay 440, upper inner armature and front contact of relay 439, outer left hand armature and back contact of relay 445, upper inner armature and front contact of relay 430 to ground. As the stepping magnet 500 breaks its own circuit it will continue to operate until the terminal of the bank 501 from which battery has been removed is found. This terminal is associated with cord circuit C and the stepping magnet will therefore stop its operation and cause the operation of relay 504. Relay 504 has a high resistance winding and operates in series with the stepping magnet with-

out causing the stepping magnet to operate.

Relay 504 in operating locks through resistance 505 and its left hand armature and front contact to ground and remains in this condition until it is released by the operation of relays 506 and 507 as will hereinafter be described. The operation of relay 504 closes an obvious circuit for the operation of relay 509 which in turn closes a circuit for the operation of relay 510. Relays 503, 509 and 510 of the position finder E are individual to the group of cord circuits to which cord circuit C belongs. Relay 510 will receive battery for its circuit through a series circuit over the outer left hand armatures and contacts of relays corresponding to relay 503 individual to other groups of cord circuits. The individual relays for each group of cord circuits corresponding to relays 503, 509 and 510 are connected in a manner similar to these relays. Two sets of such relays are shown to the left of the group of relays individual to this position. On the operation of relay 510, an obvious circuit will be closed for relay 503, which by operating its inner left hand armature opens the connection for the stepping magnet 500. Thus, no other cord in the group of which cord C is one can cause cord finder D to operate until the release of cord circuit C in the manner to be hereinafter described. Similarly, the operation of relay 510 by attracting its armature removes ground normally connected to a chain circuit through the armatures of other relays corresponding to relay 510 in other groups, so that none of the relays corresponding to relay 503 can be operated while relay 510 is actuated. Thus, connections from other cord circuits in other groups are prevented from going through the position finder until the functions of the cord circuit C are completed.

On the operation of relay 503 a circuit is closed for relay 512 as follows: battery, winding of relay 512, outer right hand armature and front contact of relay 503, left hand armature and front contact of relay 504 to ground. The operation of relay 503 closes a circuit to battery through bank 513 through the cord circuit C to cause the operation of the repeater finder F. This circuit may be traced as follows: battery, left hand armature and back contact of relay 514, inner right hand armature and front contact of relay 503, winding of relay 515, brush and a terminal of bank 513, right hand armature and back contact of stepping magnet 516 of repeater finder F, left hand armature and back contact of relay 440 to the brush of bank 518 of the repeater finder F. If the brushes of the repeater finder happen to rest on the terminals of a busy repeater, which is indicated by the fact that ground is connected to the terminals of bank 518, the stepping magnet 516 will start to operate and advance the brushes of repeater finder F until an idle re-

peater is found, which is indicated by the absence of ground on the terminals of bank 518. In other words if a busy repeater is encountered, ground will be connected to brush 518 through the multiple contacts from the corresponding brush of the repeater finder connected to the busy repeater. This ground will be supplied from the left hand armature and front contact of the relays corresponding to relay 440 in the engaged cord circuits. Relay 515 in the above mentioned circuit is a fast operating relay as compared to relay 440 which is slow to operate. This relay 515 will therefore prevent relay 440 from operating although a circuit for relay 440 is completed through the armature and back contact of relay 515. This circuit may be traced as follows: battery, left hand armature and back contact of relay 514, inner right hand armature and front contact of relay 503, armature and back contact of relay 515, the brush of the terminal bank 520, left hand winding of relay 440 to ground. The stepping magnet 516 will continue to operate until an idle repeater is found, that is, one that has no ground on its multiplied terminals of a bank such as 518. The circuit through the relay 515 and the stepping magnet 516 will therefore be opened and consequently cause the release of relay 515 and the stopping of magnet 516. When this takes place the previously traced circuit for relay 440 will be completed through the armature and back contact of relay 515 so that relay 440 will now be energized and apply ground through its left hand armature and front contact to the brush 518 thus making repeater G busy to other cord circuits. Relay 440 in operating provides a locking circuit for itself through its right hand armature and right hand winding, inner upper armature and front contact of relay 439, outer left armature and back contact of relay 445 to ground at the inner upper armature and front contact of relay 430. The operation of relay 440 also closes a circuit for relay 522 as follows: battery, winding of relay 522, the selected terminal and the brush of bank 518, left hand armature and front contact of relay 440 to ground. The operation of relay 522 provides ground for the operation of relay 514 over an obvious circuit. This latter relay in operating removes the multiple battery from the position finder E.

The operation of relay 522 also connects battery through the windings of relays 506 and 507 and its two outer right hand armatures and front contacts to terminals 330 and 730 of the switches K and L, respectively, to mark these terminals of the repeater G in the levels on switches K and L in which the incoming and outgoing terminals of the repeater G terminate. The operation of relay 522 also closes a circuit for the operation of relay 525 over a circuit as follows: battery,

winding of relay 525, outer right hand armature and back contact of relay 506 or the outer left hand armature and back contact of relay 507, inner right hand armature and front contact of relay 522 to ground. Relay 525 is common to all repeaters that have their terminals located in the marked levels of the switches K and L and the operation of this relay therefore marks these levels on switches K and L by closing its armatures and front contacts to battery. For switch K the terminal 305 is marked with the battery from relay 525 and for switch L the terminal 705 is marked with the battery from relay 525.

The operation of relay 440 also closes at its right hand armature and front contact a connection from ground at relay 430 for the operation of relays 450 and 451. The circuit for relay 450 may be traced from battery through the winding of relay 450, right hand armature and front contact of relay 440 to ground at relay 430 and the circuit for relay 451 may be traced from battery, winding of relay 451, right hand armature and back contact of relay 452, through the right hand armature and front contact of relay 440 to ground at relay 430. The purpose of the operation of relay 450 will become apparent as the description proceeds. The operation of relay 451 closes an obvious circuit for relay 416. The operation of relay 416 now disconnects battery from the cord circuit sleeves by operating its left hand armature and inner right hand armature, that is, battery applied through the windings of relays 414 and 438 are disconnected. These relays 414 and 438, however, are maintained operated by the closure of the make-before-break contacts of relay 416 to ground through resistances as follows; the circuit for relay 414 may be traced as follows: battery, winding of relay 414, upper inner normal contacts of key 401, left hand make-before-break contact of relay 416, high resistance 454 to ground, while the circuit for relay 438 may be traced from battery, winding of relay 438, lower inner normal contact of key 401, right hand make-before-break contact of relay 416 through the high resistance 455 to ground. The sleeve circuits for the cord are now connected as follows: The sleeve of plug 400 is connected over the inner left hand armature and front contact of relay 416 through a low resistance 457 to ground, while the sleeve circuit for the plug 403 is connected over the inner right hand armature and front contact of relay 416 through high resistance 458 to ground.

The functions of the circuits for lines A and B from now on are practically identical and therefore only the operations for line A, until these operations differ from the operations of line B, will be described. The application of ground through the low resistance 457 to the sleeve of plug 400 causes the release of relay 218, which in releasing, pro-

vides ground for the operation of relay 216, that is, relay 216 is momentarily operated as relay 220 is slow to release so that on the release of relay 218 relay 216 operates over a circuit as follows: battery winding of relay 216 right hand armature and front contact of relay 220 to ground at the right hand armature and back contact of relay 218. The operation of relay 216 opens the sleeve circuit to relay 218 and connects the winding of relay 226 to the sleeve circuit which, on finding the ground supplied by the operation of relay 416, operates over a circuit as follows: battery, winding of relay 226, left hand armature and back contact of this relay, left hand armature and front contact of relay 216 to ground through the resistance 457 at the left hand armature and front contact of relay 416. Relay 226 in operating, provides a locking circuit for itself as follows: battery, winding of relay 226, make-before-break contacts of this relay, left hand armature and front contact of relay 227, inner left hand armature and back contact of relay 211 to ground. It should be noted that on the original operation of relay 218 an obvious circuit was closed for the operation of relay 227. As this relay is slow to release, on the release of relay 218 a locking circuit is provided for relay 227 as follows: battery, right hand winding of relay 227 and its right hand armature and front contact to ground at the inner right hand armature and front contact of relay 216. A locking circuit is also provided for relay 223 to the ground at the inner left hand armature and back contact of relay 211 through the left hand armature and front contact of relay 227 so that this relay will not release on the release of relay 218. When relay 216 is again released the circuit for relay 218 is restored as will be hereinafter described and on the operation of this relay, relay 220 is reoperated and on the operation of relay 218 the first circuit for the operation of relay 227 is reestablished. Therefore, the temporary operation of relay 216 has the effect of operating relay 226 and this relay locks to the ground at the inner left hand armature and back contact of relay 211. It should be noted that relay 226 in operating connects the sleeve circuit through to the left hand winding of the marginal relay 228. This relay is operated from the ground supplied through the resistance 457 due to the operation of relay 216. The circuit for relay 228 may be traced from battery, left hand winding of relay 228, left hand armature and front contact of relay 226, left hand armature and front contact of relay 216, over the sleeve circuit to the ground at relay 416.

As the resistance 457 is low and relay 228 is marginal in character, relay 228 is operated. It should be noted that in the case of the operation of the corresponding relays of line B, the marginal relay 628 which corresponds to relay 228, does not operate as the

circuit from relay 416 extends through the high resistance 458 to ground. The operation of relay 228 and the non-operation of relay 628 marks the difference between the call originating line A and the line B to which the connection is being extended. In other words, these relays determine that the line A shall be connected to the incoming end of a selected repeater G and that line B shall be connected to the outgoing end of a selected repeater. Relay 228 in operating provides a locking circuit for itself through the inner left hand armature and back contact of relay 211.

As stated, the functions of the circuits for lines A and B are practically identical except for this marking of the lines and as this applies also to the functions of the repeater finders K and L only the operation of the finder K to connect line A to the incoming end of repeater G will be described, while the description of the connection of line B to the outgoing end of repeater G through link L will be abbreviated. While the above mentioned operations of the circuits of the line A take place, relay 452 in the cord circuit C is operated over a circuit as follows: battery, winding of relay 452, outer right hand armature and front contact of relay 416 to ground. This relay is locked through its right hand armature and front contact to ground at the inner upper armature and front contact of relay 430. Relay 452 in operating causes the release of relay 451 which in turn releases relay 416 so that the sleeve circuits are now restored to their normal condition to allow, in this case, the reoperation of relay 218 hereinbefore mentioned on the release of relay 216.

The release of relay 216 connects battery through armatures and contacts of relays 226 and 228 to the winding of relay 231 and to the stepping magnet 300. The circuit for the stepping magnet 300 may be traced as follows: battery, outer right hand armature and back contacts of relay 216, outer right hand armature and front contact of relay 226, winding of the stepping magnet and its armature and back contact to the outer lower armature and back contact of relay 237, upper armature and back contact of relay 231 to ground. The circuit for relay 231 extends from battery, at the outer right hand armature and inner back contact of relay 216, left hand armature and front contact of relay 228, inner right hand armature and front contact of relay 226 through the winding of relay 231 and to the brush of bank 301 of the trunk selector H. Provided this selector is not resting on an idle trunk connected to a repeater finder such as K having access to the incoming end of repeaters, the stepping magnet will operate, that is, if the brush of bank 301 is in contact with terminals that either are open or connected to battery as

will hereinafter be explained. The selector will continue to step over idle trunks leading to repeater finders such as M having access to outgoing ends of repeaters and busy trunks of this type and also busy trunks such as are connected to repeater finders like K having access to the incoming ends of repeaters. In case of busy repeater finders such as M and K, relays 302 and 304 are in operated condition, so that the terminals of the bank 301 that lead to the make-before-break contact of these relays are opened. In the case of idle trunks having access to repeater finders such as M, the terminals for these trunks at the bank 301 are connected to battery, through the make-before-break contacts and windings of relays such as 304. In either case therefore, the stepping magnet 300 will continue to operate until an idle trunk such as the one connected to repeater finder K will be encountered. When this takes place the ground connected through the winding of relay 302 and the make-before-break contacts of this relay will cause the operation of relays 231 and 302. The complete circuit for these relays may be traced as follows: battery, outer right hand armature and back contacts of relay 216, left hand armature and front contact of relay 228, inner right hand armature and front contact of relay 226, winding of relay 231, lower armature and back contact of relay 236, brush of bank 301, make-before-break contacts of relay 302, winding of relay 302 to ground. Relay 231 in operating removes the ground from the stepping magnet circuit thus stopping the brushes of the selector H on the terminals of the idle trunk. Relay 231, also by operating closes an obvious circuit for the operation of relay 237. Relay 237 in operating closes a circuit for relay 236 as follows: battery, winding of relay 237, winding of relay 236, lower armature and front contact of relay 237, left hand armature and front contact of relay 227, inner left hand armature and back contact of relay 211 to ground. Relay 236, however, does not operate at this time as it is short-circuited by the ground connected to the upper armature and front contact of relay 231. When relay 302 operates it disconnects its winding from the terminal of bank 301 and provides a locking circuit for itself as follows: battery, 11th step rotary contacts 306 under control of finder K, armature and back contact of relay 307, right hand armature and front contact and winding of relay 302 to ground. The removal of the ground from the terminal of bank 301 releases relay 231 which when releasing removes the short-circuiting ground from the circuit for relay 236, allowing this relay to operate in series with the relay 237. The circuit for the stepping magnet 300 is held open by the operation of relay 237.

In case a trunk connected to repeater finders such as M or L having access to the outgoing ends of repeaters had been desired, ground instead of battery would have been connected to the winding of relay 231. This is exactly the function in the case of relay 631 for line B. It will be noted that this ground will be supplied by relay 616 through the outer right hand armature and back contact of relay 628, inner left hand armature and front contact of relay 626 and in this case relay 704 will operate when the brush of bank 701 encounters battery through a trunk connected to a repeater finder such as L having access to the outgoing end of repeaters. Consequently the fact that relay 628 is not operated causes the trunk selector I to select a trunk connected to a repeater finder such as L having access to the outgoing end of repeater G.

Returning now to the operation of the repeater finder K the operation of relay 236 opens the lead from the brush of bank 301 thus making the selected trunk busy. The operation of relay 237 closes a circuit for the operation of relay 238 as follows: battery, winding of relay 238, armature and back contact of relay 239, inner upper armature and front contact of relay 237 to ground. Relay 238 in operating connects ringing current from source 240 to the trunk extending from the line A through the trunk selector H and the selected trunk terminating in repeater finder K. The purpose of this ringing current is to burn out or clean the contacts of switch H and the contacts of repeater finder K from particles of dust, which is a well known expedient for securing a good connection between brushes and terminals of switches. The connections established from the ringing source 240 through the armatures and front contacts of relay 238, brushes and terminals of banks 310, 311, 312 and 314, the armatures and front contacts of relay 316 and the brushes and terminals of switch K to the incoming leads of repeater G are sufficiently clear to require no further description.

The operation of relay 302 of the circuit arrangement for repeater finder K provides a circuit for the operation of relay 318 as follows: battery, winding of relay 318, armatures and back contacts of the rotary magnet 319 and the vertical magnet 320, left hand armature and front contact of relay 302 to ground. The operation of relay 318 closes a circuit for the vertical magnet 320 as follows: battery, armature and front contact of relay 318, right hand armature and back contact of relay 322, winding of vertical magnet 320, outer right hand armature and back contact of relay 321, to ground at the left hand armature and front contact of relay 302. The alternate operation and release of the vertical magnet 220 and the relay 318 will now take place and the vertical magnet 320 will there-

fore now step the brushes of the repeater finder K upward to the level in which the terminals of the repeater G selected by the cord circuit C may be found, that is, until the battery on the contact 305 is encountered by the brush 326. When this level is reached, relay 322 will operate over a circuit as follows: battery, outer left hand armature and front contact of relay 525, terminal 305, brush 326, right hand winding of relay 322, outer right hand armature and back contact of relay 321 to the ground at the left hand armature and front contact of relay 302. The vertical magnet will thus be prevented from operating further and the battery at the armature and front contact of relay 318 will be transferred through the right hand armature and front contact of relay 322 to the rotary magnet 319 and the circuit for the rotary magnet will thus be completed from the above mentioned battery to the ground at the left hand armature and front contact of relay 302. Relay 322 upon operating closes a locking circuit for itself from battery through its left hand armature and front contact and left hand winding to the ground at the left hand armature and front contact of relay 302. The rotary magnet 319 will now operate to step the brushes of the finder K around on the selected level to the terminals of the desired repeater G, which have been previously marked by the operation of relay 522 as hereinbefore described. When the brush 331 of finder K makes contact with the marked terminal 330, relay 321 will be operated over a circuit as follows: battery, windings of relay 506, outer right hand armature and front contact of relay 522, terminal 330, brush 331, right hand winding of relay 321 to ground at the upper closed contacts of the vertical off normal contacts 333. Relay 321 in operating, opens the circuit for the rotary magnet 319 and also causes the release of relay 322 since the circuit for this magnet and relay is opened at the outer right hand armature and back contact of relay 321. Relay 321 in operating provides a locking circuit for itself before any of its other contacts close from the ground at relay 302 through its outer right hand armature and front contact and left hand winding to battery. The operation of relay 321 closes a direct connection to ground independent of the right hand winding of this relay through its inner right hand armature and front contact for the operation of relay 506. The terminal 330 of the repeater G is thereby made busy to other repeater finders. Relay 506 does not operate at the same time as relay 321, since the current through the winding of relay 321 is insufficient to operate relay 506 while its active winding is shunted by the battery through its non-inductive left hand winding. The operation of relay 321 closes an obvious circuit for the operation of relay 316. The operation of this relay closes the

transmission leads from the trunk selector H through repeater finder K to the leads of the incoming end of repeater G. It is at this time that the ringing current from source 240 is connected to the repeater for burning out the brushes and terminals of selector H and finder K.

The line B is connected to the outgoing end of repeater G in the same manner as line A is connected to the incoming end of repeater G as previously explained. In this case the connection will, of course, extend through the trunk selector I and the repeater finder L. While the operations of the switches H and K and I and L may begin simultaneously, it is evident that these switches will not complete their operations at the same time as they may have to travel different distances to find their respectively marked terminals. Not until both relays 506 and 507 are operated will further circuits to complete the connection be effective. When these two relays operate, a circuit will be closed for relay 528 as follows: battery, winding of relay 528, make-before-break contact of relay 530, outer right hand armature and front contact of relay 507, outer left hand armature and front contact of relay 506 to ground. The operation of relay 528 closes an obvious circuit for the operation of relay 529 and this relay in operating closes an obvious circuit for the operation of relay 530. Relay 530 in operating locks at its left hand armature and front contact to the ground at the outer left hand armature and front contact of relay 506 and opens at its make-before-break contact the circuit for relay 528, which in releasing opens the circuit for relay 529, which in releasing opens the original energizing circuit for relay 530. As soon as the toll operator has finished her conversation with the operator at the distant end of line B, relating to the extension of the connection, she will restore the telephone key 401 and in so doing cause the release of relays 421 and 411. When relay 421 is released a circuit will be completed for the operation of relay 531 as follows: battery, upper outer armature and back contact of relay 421, outer left hand armature and front contact of relay 452, bank 533 of repeater finder F, left hand armature and back contact of relay 529, right hand armature and front contact of relay 530, left hand winding of relay 531 to ground. The operation of relay 531 removes the usual short circuits from the bridge points of the repeater G and prepares the repeater for transmission. This cycle of operations just described for relays 528, 529 and 530 serves as a means for allowing time for the burning out of the contacts of the selectors H and I and repeater finders K and L as hereinbefore described before the repeater G is actually included in the connection, that is, there is a certain interval before relay 531 is operated after the connections have been completed from

lines A and B to the repeater G. It should be noted that a circuit is also closed from the battery at the upper outer armature and back contact of relay 421 through contacts of relays 529 and 530, 522 and 514 for the operation of relay 239 of the circuit for line A and also a corresponding relay 639 of the circuit for line B. The operation of these relays removes ringing current from the contacts of the switches H, K, I and L by causing the release of relays 238 and 638, respectively. The release of the relays 238 and 638 close circuits from battery, at the upper outer armature and back contact of relay 421 to the windings of relays 242 and 642. These relays in operating disconnect the talking conductors of toll lines A and B, respectively, from the cord circuit C and connect these lines and their respective networks N_1 and N_2 to the repeater through the connections set up by the selectors H and I and repeater finders K and L. The connection from lines A and B through the repeater G is now completed for transmission purposes. It seems unnecessary to trace the circuit from one line to the other, as it is quite obvious from the drawing how this connection is made.

It might be explained here that if, during the vertical movement of the finders K or L, the marking of the terminals such as 305 or 705 should for some reason or other not be identified by the brushes 326 or 726 of the finders K or L, the vertical magnets 320 or 720 would continue to step the brushes up until the tenth level is reached, at which time relay 322 or relay 722 will operate from the battery which is supplied permanently at the tenth level to brushes 326 or 726. In this case rotary magnet 319 or 719 would operate to step the brushes over this level until the 11th rotary step is made at which time the brushes would actuate the 11th step rotary contacts 306 or 706. The operation of these contacts would cause the operation of the release magnets 325 or 725 over obvious circuits so that these switches would be restored to their normal positions. In the case of switch K, for example, the vertical off normal contacts 333 are closed. The release magnet will be held operated by a circuit from battery through the release magnet, operated vertical off normal contacts to ground at the left hand armature and back contact of relay 302. It will be noted that the locking circuit for relay 302 will be opened by the 11th step rotary contacts 306 and relay 302 will remain released until the vertical off normal contacts are restored to normal.

The time alarm circuit T operates as follows: On the operation of relay 512 a circuit is provided for the operation of stepping magnet 536 as follows: battery, outer left hand armature and back contact of relay 537, armature and back contact and winding of stepping magnet 536, outer right hand arma-

ture and back contact of relay 537 to ground at the outer left hand armature and front contact of relay 512. When the stepping magnet 536 operates to move the brush of bank 538 one step this brush connects with a terminal connected to ground and the relay 537 is operated over a circuit as follows: battery, inner left hand armature and front contact of relay 512, winding of relay 537, make-before-break contact of this relay, winding of magnet 536 to ground at the first terminal of bank 538. Relay 537 locks up to the ground at the outer left hand armature and front contact of relay 512. Relay 537 in operating provides battery for the operation of relay 540 through interrupter 541. Relay 540 in operating closes a circuit for the operation of stepping magnet 536 as follows: battery, outer left hand armature and front contact of relay 537, armature and front contact of relay 540, winding of stepping magnet 536, brush of bank 538 to ground at the first terminal. The interrupter 541 causes relay 540 to alternately operate and release. That is, the battery at its armature and front contact will be alternately connected and removed from the circuit for the stepping magnet 536. The stepping magnet therefore advances brushes of banks 538 and 542 step-by-step under the control of interrupter 541. If this condition prevails for a certain period, for example, for five seconds, the brushes will have been advanced to a predetermined position. An alarm will then be given and the position finder and cord finder will be released to prevent holding up the system. If, for example, for some reason or other the system has failed to function in this period, the brush of the bank 542 will be advanced to terminal 543. In this position ground from the inner left hand armature and front contact of relay 537 will be connected through terminal 543, the inner left hand armature and front contact of relay 512, the brush of bank 545 through the winding of relay 445 to battery. Relay 445 operates and locks under control of a key 460 and causes the release of the cord finder and position finder. This is accomplished by placing battery from the middle left hand armature and front contact of relay 445 on the brush of bank 501 to release relay 504 and thus cause the release of relays 509, 512 and 510 and 503 in succession to release the position finder E. The operation of relay 445 also closes a circuit at its outer right hand armature and front contact from battery, through lamp 461 to ground through the winding of relay 562. Lamp 461 lights and indicates to the operator that the circuit has failed to function properly and the operation of relay 562 closes a circuit for relay 563 to an interrupter 464. The operation of relay 562 also closes a circuit for an alarm bell 565 which is common to the office in which the toll operator is located.

Relay 563 is alternately operated and released by the interrupter 464 to flash the lamps 413 and 437 of cord C to indicate the cord involved in the unsuccessful connection. The operation of key 460 will restore the circuit to normal condition.

Assuming, however, that the repeater is inserted in the connection within the allotted time, the time allowance circuit will not function to give an alarm, since relay 512 is released as will hereinafter be described. Relay 512 in releasing causes the release of relay 537 which closes a circuit for stepping magnet 536 to advance the brushes of banks 538 and 542 to the next position marked by terminal 543 or 545 and thus prevent an alarm from being given.

In case all of the repeaters are busy, battery through bank 513 of cord finders such as D will not be available as all relays such as 514 will be actuated. However, battery through the high resistance winding of relay 550 of the common meter circuit R will be available. The high resistance of the winding of relay 550 will prevent relays, such as 440, from becoming operated but will allow the operation of relays 550 and 469 as follows: battery, winding of relay 550, inner right hand armature and front contact of a relay such as 503, armature and back contact of a relay such as 515, a bank such as 520, winding of a relay such as 440 to ground while the circuit for a relay such as 469 will be as follows: battery, right hand winding of a relay such as 469, a bank such as 552, inner right hand armature and front contact of a relay such as 503 to ground through the right hand winding of relay 440. On the operation of relay 550 a circuit will be closed for the operation of the meter magnet 553 when the timing device operates to indicate or count the number of times repeaters were required that were not available due to the fact that all repeaters were busy. It should be understood that in case a repeater becomes idle before the timing device operates the circuit will function to select this repeater in the manner hereinbefore described. Relay 469 in operating closes a locking circuit for itself through its right hand armature and front contact to the ground at the inner upper armature and front contact of a relay such as 430. The operation of this relay also closes a circuit from the interrupter 464 to the lamp 437 and this lamp is now flashed to indicate that no repeater is available. When a plug such as 400 or 403 is removed, lamp 437 stops flashing, as it should be understood, that the above operations take place in the cord that has been taken for use in establishing a connection, when it is found that a repeater was not available.

If the operator has occasion to actuate the talking key 401, after the repeater G has been connected between lines A and B, relay

421 will be reoperated releasing relay 531 and relays such as 242 and 642. The release of relay 531 short-circuits the bridging points of the repeaters used and the release of relays 242 and 642 disconnects lines A and B and their respective networks from the repeater G and connects them to the cord circuit and to the operator's telephone set. As the bridge relays such as 205 and 605 are not disconnected from the cord circuit supervisory signals may be received over the toll lines.

The operation when either of the plugs is removed is substantially the same. For example when plug 400 is removed from toll line A, relay 218 is released. This causes a momentary operation of relay 216 through the right hand armature and front contact of relay 220 which is released soon after the release of relay 218. On the operation of relay 216 the remaining operated relays of the circuit for toll line A are restored to normal such as relays 237, 236, 223, 226, 227, 228 and 208. In the cord circuit C relay 414 is released and this relay in turn releases relay 430. The release of relay 430 connects battery from the armature and front contact of relay 450 to the ring conductor of the cord to cause the operation of relay 611. The operation of relay 611 removes ground from the locking winding of relays 608, 626 and 628 while relays 623 and 620 are held operated by relay 618. Relay 450 of the cord circuit releases through the release of relay 430 and consequently relay 611 will be operated only momentarily. The release of relay 430 by opening the common ground applied at its inner upper armature and front contact also causes the release of relays 440, 452, 522, 506, 507 and 531. The release of relay 522 applies battery for the operation of the marginal relays 307 and 707 of the repeater finders K and L, respectively. These relays are operated only on this battery from the outer left hand armature and back contact of relay 422. Relays 307 and 707 in operating open the holding circuits for relays 302 and 602 and these latter relays in releasing cause the restoration of the repeater finders K and L to normal as hereinbefore described.

While the present invention has been described as particularly applicable to toll systems it may also be applied to switching systems not operated on the toll basis.

What is claimed is:

1. In a telephone system, lines, means for selecting any two of said lines, repeaters arranged for interconnection between selected lines, selecting devices individual to said lines for selecting a repeater, and means operable in response to the selection of two lines for simultaneously actuating the individual devices of said two lines for interconnecting a repeater therebetween.

2. In a telephone system, lines, means for selecting any two of said lines, repeaters, se-

lecting devices associated with each of said lines for interconnecting a repeater between selected lines, and means operable in response to the selection of two lines for controlling two of said selecting devices simultaneously whereby one selected line selects one end of the repeater while the other selected line selects the other end of said repeater.

3. In a telephone system, lines, repeaters, cord circuits, selecting apparatus associated with each of said lines and operable simultaneously for interconnecting a repeater between any two of said lines, and means responsive to the connection of a cord circuit between two of said lines for controlling the selecting apparatus.

4. In a telephone system, lines, repeaters, cord circuits, selecting apparatus associated with each of said lines for interconnecting a repeater between any two of said lines, means responsive to the connection of one end of a cord circuit to one line and to the connection of the other end of said cord circuit to another line for actuating the selecting apparatus of said first mentioned line to connect the incoming end of a repeater thereto and for actuating simultaneously the selecting apparatus of the second mentioned line to connect the outgoing end of said repeater thereto.

5. In a telephone system, lines, repeaters, a selector switch associated with each line, two groups of trunks accessible by said switches, a finder switch associated with each trunk, the finders of one group of trunks having access to the incoming ends of said repeaters while the finders of the other group have access to the outgoing ends of the repeaters, means for operating the selector switch of one of said lines to select an idle trunk leading to a finder having access to the incoming ends of the repeaters, means for operating the finder associated with such trunk to hunt for and connect said line with the incoming end of an idle repeater, means to operate the selector switch of another of said lines to select an idle trunk leading to a finder having access to the outgoing ends of the repeaters, and means to operate the finder associated with said last mentioned trunk to hunt for and connect said second line with the outgoing end of said idle repeater.

6. In a telephone system, lines, repeaters, cord circuits, a selector switch associated with each line, two groups of trunks terminating in said switches, a line finder connected to the free end of each trunk, the line finders of one group of trunks having access to the incoming ends of said repeater, while the line finders of the other group of trunks have access to the outgoing end of said repeaters, means responsive to the interconnection of a cord circuit between two of said lines for operating the selector switch of one of said lines to select

an idle trunk in the group having access through the corresponding line finder to the incoming ends of the repeaters, means to operate said corresponding line finder to hunt for and connect the said line to the incoming end of a repeater, means to operate the selector switch of the other of said lines to select an idle trunk in the other group, and means to operate the line finder corresponding to said last trunk to hunt for and connect said other line to the outgoing end of said repeater.

7. In a telephone system, lines, repeaters, cord circuits for interconnecting said lines, a selecting mechanism for selecting an idle repeater for interconnection between two lines, a selector switch associated with each line, two groups of trunks terminating in said switches, a line finder connected to the free end of each trunk line, the finders of one group of trunks having access to the incoming ends of said repeaters while the line finders of the other group of trunks have access to the outgoing ends of said repeaters, means responsive to the selection of an idle repeater for operating the selector switch of one of said lines to select an idle trunk in the group having access through the corresponding line finder to the incoming ends of said repeaters, means to operate the selector switch of the other of said lines to select an idle trunk in the other group and means for operating the corresponding line finders.

8. In a telephone system, lines, trunks, repeaters, a trunk selecting switch associated with each line, a repeater finder switch associated with each trunk for connecting said trunk to a particular end of any of said repeaters, means to simultaneously actuate the trunk selecting switches of two of said lines for selecting trunks, and means for actuating repeater finders over the selected trunks to interconnect a repeater between said two lines.

9. In a telephone system, lines, trunks, repeaters, a trunk selecting switch associated with each line, a repeater finder switch associated with each trunk for connecting said trunk to a particular end of any of said repeaters, means to actuate the trunk selecting switches of two of said lines for selecting trunks, and means for actuating repeater finders over the selected trunks to interconnect a repeater between said two lines.

10. In a telephone system, lines, means for selecting any two of said lines, equipments arranged for interconnection between selected lines, selecting devices individual to said lines for selecting an equipment, and means operable in response to the selection of two lines for simultaneously actuating the individual devices of said two lines for interconnecting an equipment therebetween.

11. In a telephone system, lines, a primary link for temporarily interconnecting said lines, a secondary link including means for modifying the characteristic of the lines con-

nected with it, and automatic means individual to the lines simultaneously actuated upon the connection of said primary link to seek and connect said secondary link to said lines.

12. In a telephone system, lines, a primary link for temporarily interconnecting said lines, a secondary link including means for modifying the transmission characteristic of the lines connected with it, and automatic means individual to the lines simultaneously actuated upon the connection of said primary link to seek and connect said secondary link to said lines.

13. In a telephone system, lines, means for selecting any two of said lines, links, selecting devices associated with each of said lines for interconnecting a link between selected lines and means operable in response to the selection of two lines for controlling two of said selecting devices simultaneously whereby one selected line selects one end of the link while the other selected line selects the other end of the link.

14. In a telephone system, lines, primary links, secondary links, selecting apparatus associated with each of said lines and operable simultaneously for interconnecting a secondary link between any two of said lines, and means responsive to the connection of a primary link between two of said lines for controlling said selecting apparatus.

15. In a telephone system, lines, a primary link for temporarily interconnecting said lines, a secondary link including means for modifying the transmission characteristic of the lines connected with it, automatic means individual to the lines simultaneously actuated upon the connection of said primary link to seek and connect said secondary link to said lines, and means responsive to said latter connection to open the connection between said lines and said primary link.

16. In a telephone system, lines of various characteristics, a primary link for temporarily interconnecting said lines including means operable for discriminating between line characteristics, a secondary link including means for modifying the lines connected with it, and automatic means individual to the lines simultaneously actuated in response to the operation of said discriminating means to seek and connect said secondary link to lines requiring said modification.

17. In a telephone system, lines of various characteristics, a primary link for temporarily interconnecting said lines including means operable for discriminating between line characteristics, a secondary link including means for modifying the lines connected with it, automatic means individual to the lines simultaneously actuated in response to the operation of said discriminating means to seek and connect said secondary link to lines requiring said modification, and means responsive to said latter connection to open

the connection between said lines and said primary link.

18. In a telephone system, lines of various characteristics, primary links for temporarily interconnecting said lines including means operable for discriminating between line characteristics, secondary links, selecting apparatus associated with each of said lines and operable simultaneously for inter-
10 connecting a secondary link between any two of said lines, and means responsive to the operation of said discriminating means for controlling said selecting apparatus.

19. In a telephone system, lines, means for
15 selecting any two of said lines, primary links including means for modifying the transmission characteristic of lines connected with it, secondary links associated with each of said lines for interconnecting a primary link be-
20 tween selected lines, and means operable in response to the selection of two lines for simultaneously actuating two of said secondary links for accomplishing said interconnection.

20. In a telephone system, lines, means for
25 selecting any two of said lines, primary links including means for modifying the transmission characteristic of lines connected with it, secondary links associated with each of said
30 lines for interconnecting a primary link between any two of said lines, and means operable in response to the selection of two lines for controlling two of said secondary links simultaneously whereby one selected line is
35 connected to one end of said primary link while the other selected line is connected to the other end of said primary link.

21. In a telephone system, lines, primary
40 links for temporarily interconnecting said lines, secondary links including means for modifying the transmission characteristic of the lines connected with it, tertiary links associated with each of said lines for inter-
45 connecting a secondary link between any two of said lines, and automatic means actuated by the connection of a primary link with two lines for simultaneously actuating two of said
50 tertiary links to seek and connect said secondary link to said lines.

22. In a telephone system, lines, primary
55 links for temporarily interconnecting said lines, secondary links including means for modifying the transmission characteristic of the lines connected with it, tertiary links associated with each of said lines for intercon-
60 necting a secondary link between any two of said lines, automatic means actuated by the connection of a primary link with two lines for simultaneously actuating two of said
65 tertiary links to seek and connect said secondary link to said lines, and means responsive to the connection of said secondary link to said lines for opening the connection between said lines and said primary link.

23. In a telephone system, lines of various

characteristics, primary links for temporarily interconnecting said lines including means operable for discriminating between line characteristics, secondary links including means for modifying the transmission
70 characteristic of the lines connected with it, and tertiary links individual to the lines simultaneously actuated in response to the operation of said discriminating means to seek and connect a secondary link to lines
75 requiring said modification.

24. In a telephone system, lines of various characteristics, primary links for temporarily interconnecting said lines including means operable for discriminating between
80 line characteristics, secondary links including means for modifying the transmission characteristic of the lines connected with it, tertiary links individual to the lines simultaneously actuated in response to the
85 operation of said discriminating means to seek and connect a secondary link to lines requiring said modification, and means responsive to said last connection to open the connection between said lines and a primary
90 link temporarily connected between said lines.

25. In a telephone system, lines, a temporary link for setting up a connection between any two of said lines at particular
95 points in said lines, secondary links, and automatically operable means associated with other points of said lines simultaneously actuated in response to the connection of said temporary link between two lines
100 for seeking and connecting a secondary link between said other points of said lines.

26. In a telephone system, lines, a temporary link for setting up a connection between any two of said lines at particular points in
105 said lines, secondary links, automatically operable means associated with other points of said lines simultaneously actuated in response to the connection of said temporary link between two lines for seeking and con-
110 necting a secondary link between said other points of said lines, and means responsive to said last interconnection for substituting said last interconnection for said temporary interconnection.
115

27. In a telephone system, lines, a temporary link for setting up a connection between any two of said lines at particular points in said lines, secondary links, auto-
120 matically operable means associated with other points of said lines simultaneously actuated in response to the connection of said temporary link between two lines for seeking and connecting a secondary link between said other points of said lines, and means re-
125 sponsive to said last interconnection for opening the lines between the first and second points connected together.

28. In a telephone system, lines, a temporary link for setting up a connection be-
130

tween any two of said lines at particular points in said lines, secondary links, tertiary links associated with said lines at other points for selecting a secondary link for connecting together said lines between said other points, and means for simultaneously actuating two of said tertiary links for accomplishing said interconnection between said other points of said lines.

In witness whereof, we hereunto subscribe our names this 16th day of August, A. D., 1926.

EDWARD VROOM.
FERDINAND S. ENTZ.