

March 27, 1934.

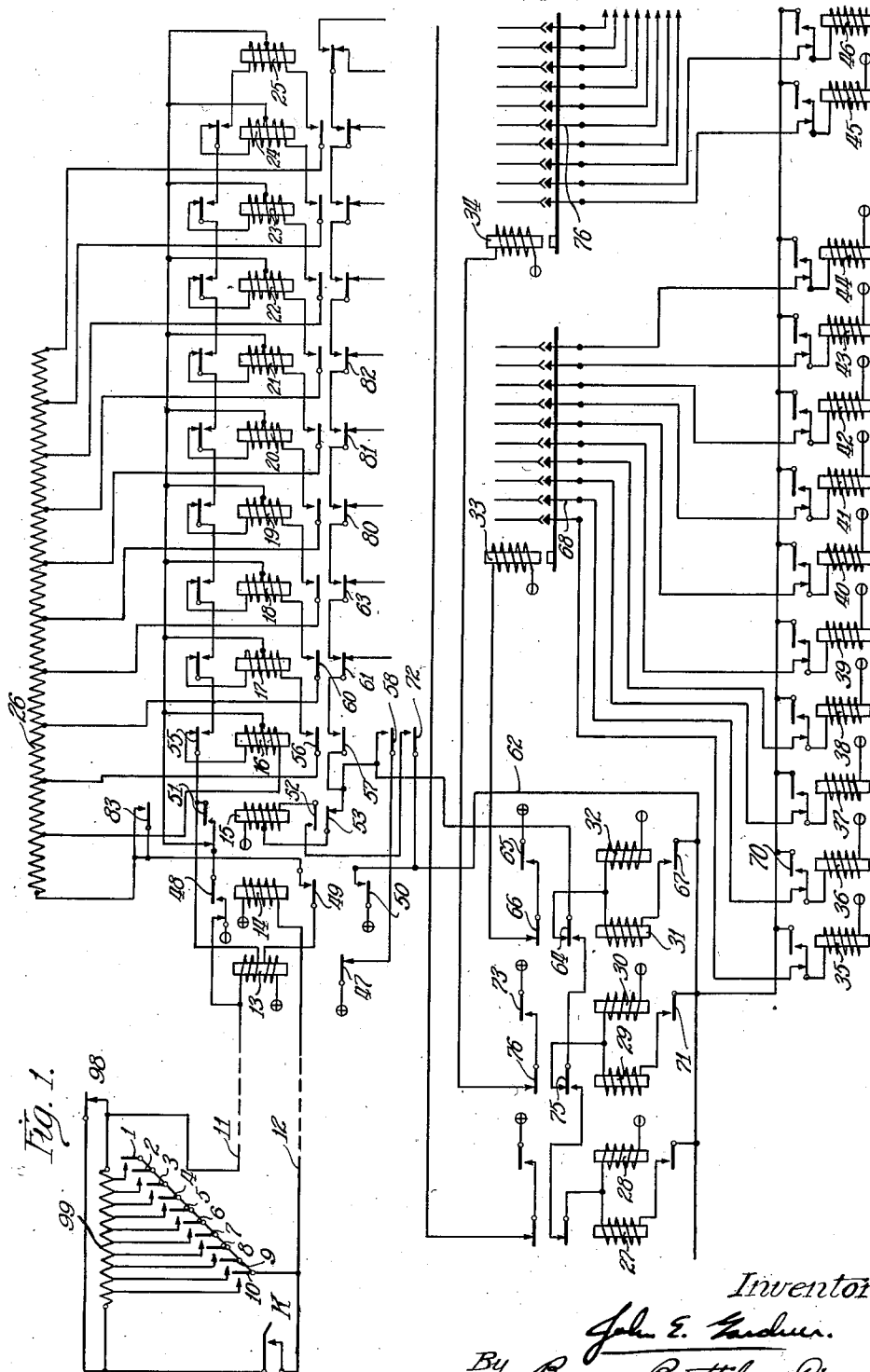
J. E. GARDNER

1,952,368

SELECTING SYSTEM

Original Filed Aug. 6, 1927

8 Sheets-Sheet 1



Inventor
John E. Gardner.
By Brown, Boettcher & Denver
Attys.

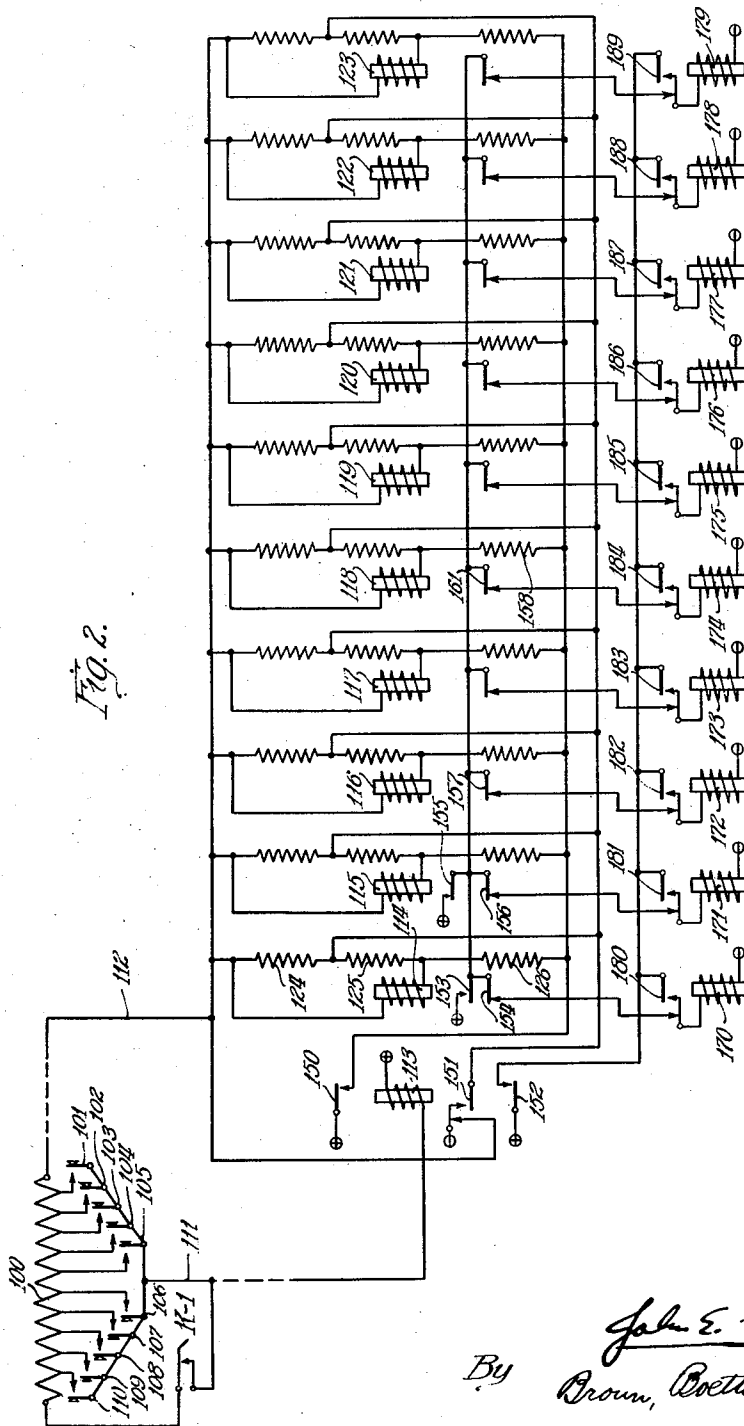
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J. E. GARDNER

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Inventor

John E. Gardner

By

Brown, Boettcher & Diemer
Attys.

March 27, 1934.

J. E. GARDNER

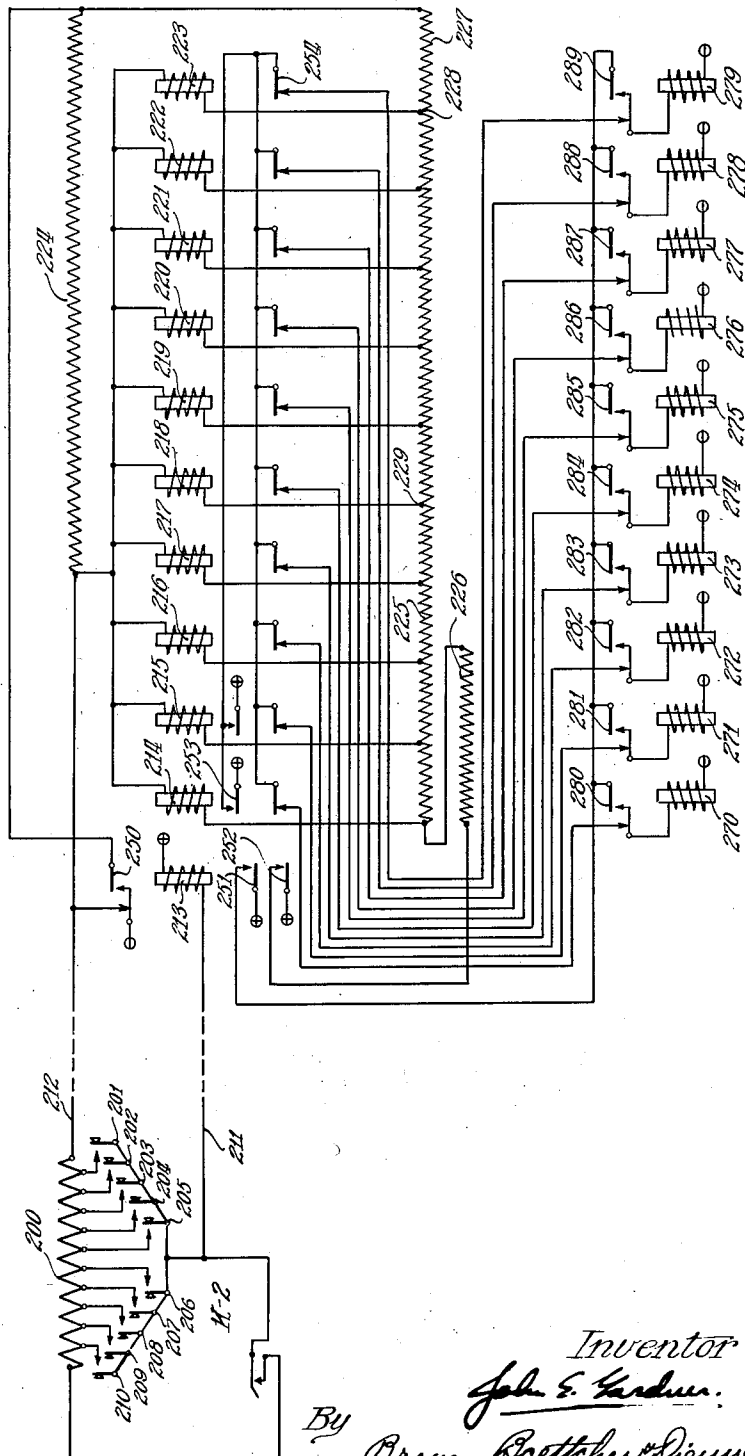
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Fig. 3.



Inventor
John E. Gardner.
By *Brown, Boettcher & Danner*
Attys.

March 27, 1934.

J. E. GARDNER

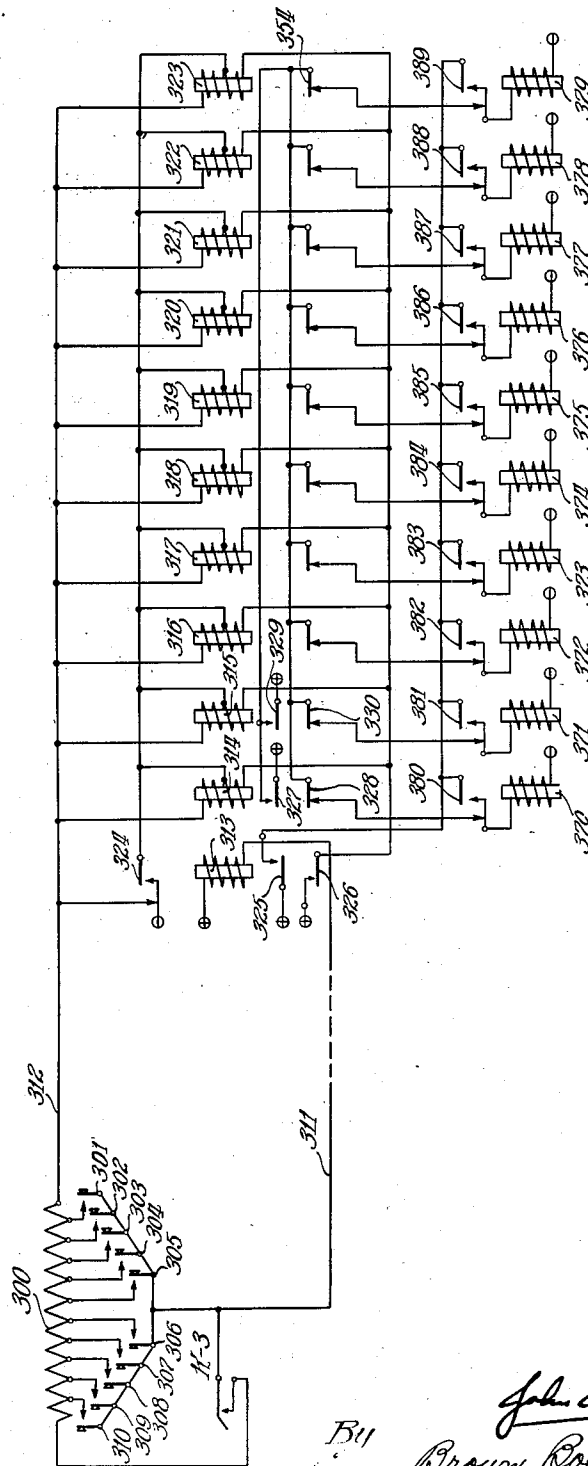
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Fig. 4.



By

Inventor

John E. Gardner.

Brown, Boettcher & Diemer
Atty's.

March 27, 1934.

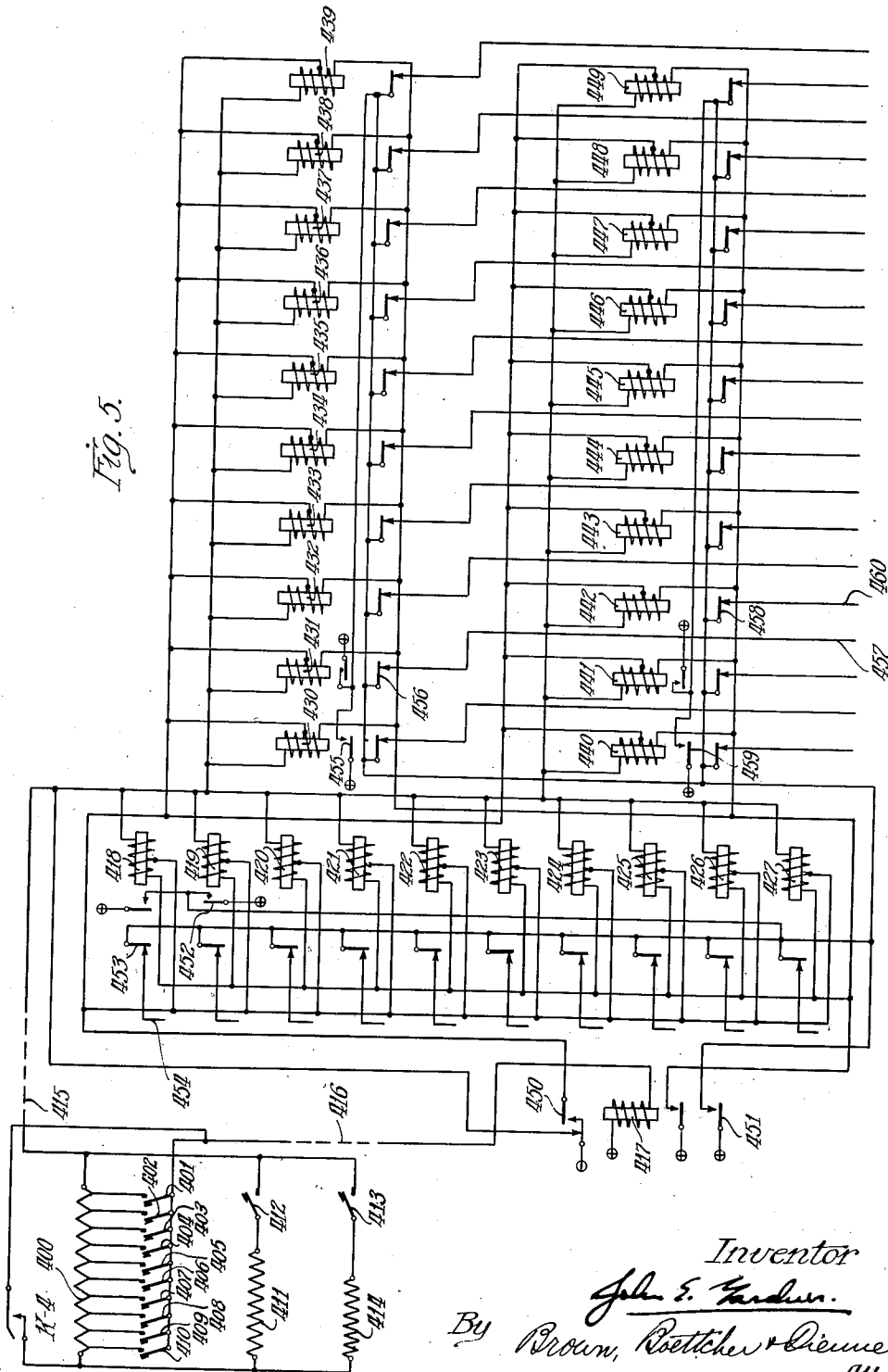
J. E. GARDNER

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Inventor
John S. Gardner.
By *Brown, Roettcher & Diemer*
Attys.

March 27, 1934.

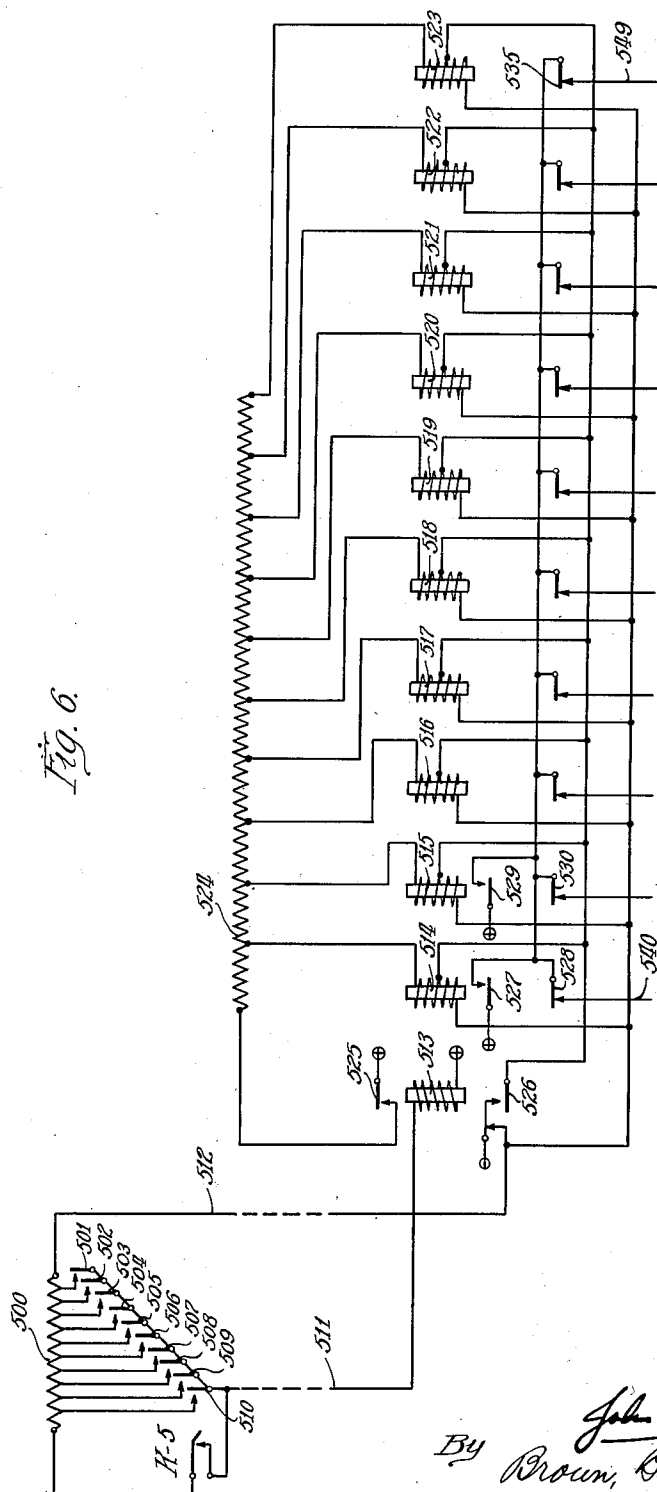
J. E. GARDNER

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Inventor

John E. Gardner.

By

Brown, Boetche & Diemer
Atty's

Atty's.

March 27, 1934.

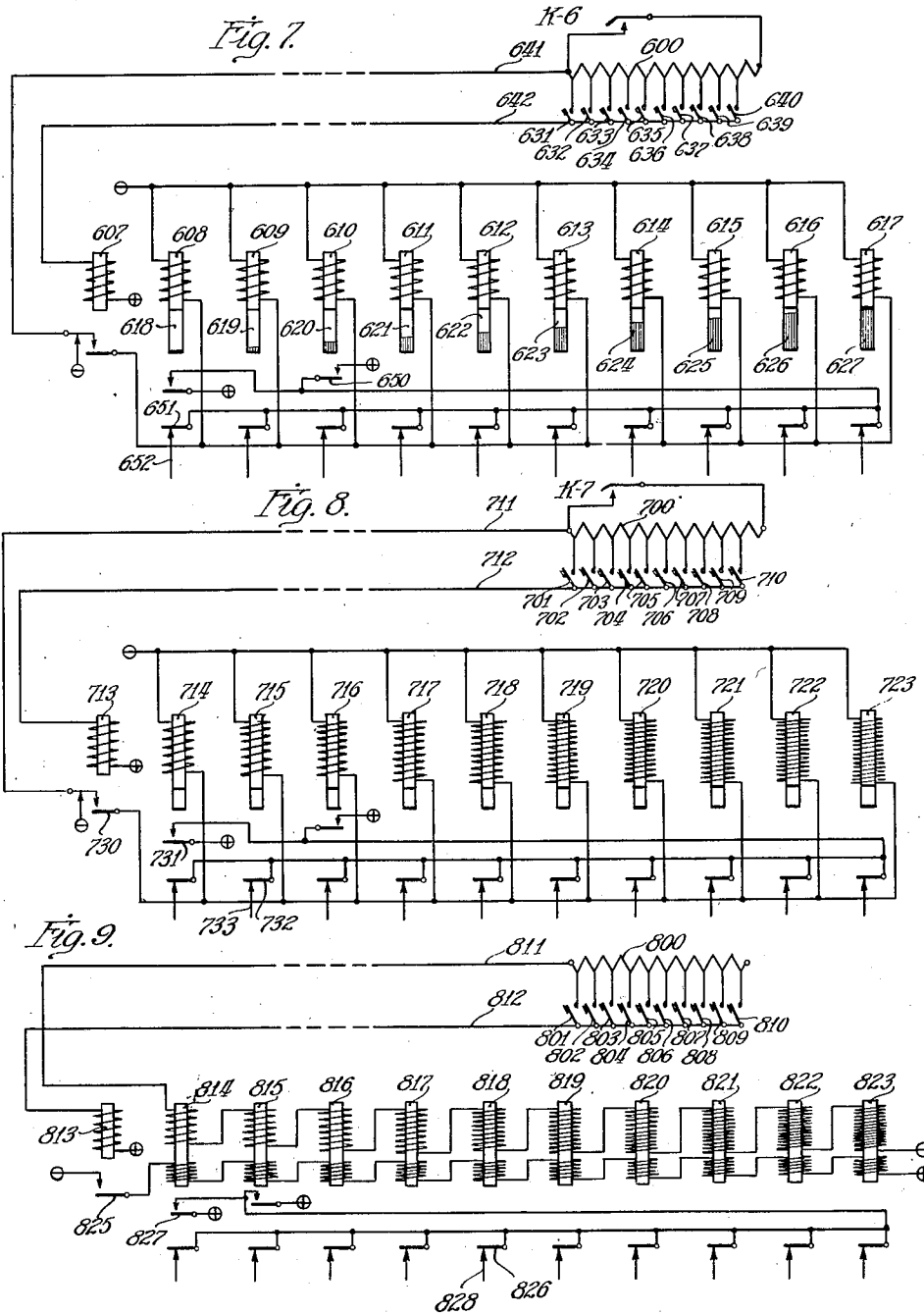
J. E. GARDNER

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Inventor

John E. Gardner
By *Brown, Boettcher & Danner*
Atty's.

March 27, 1934.

J. E. GARDNER

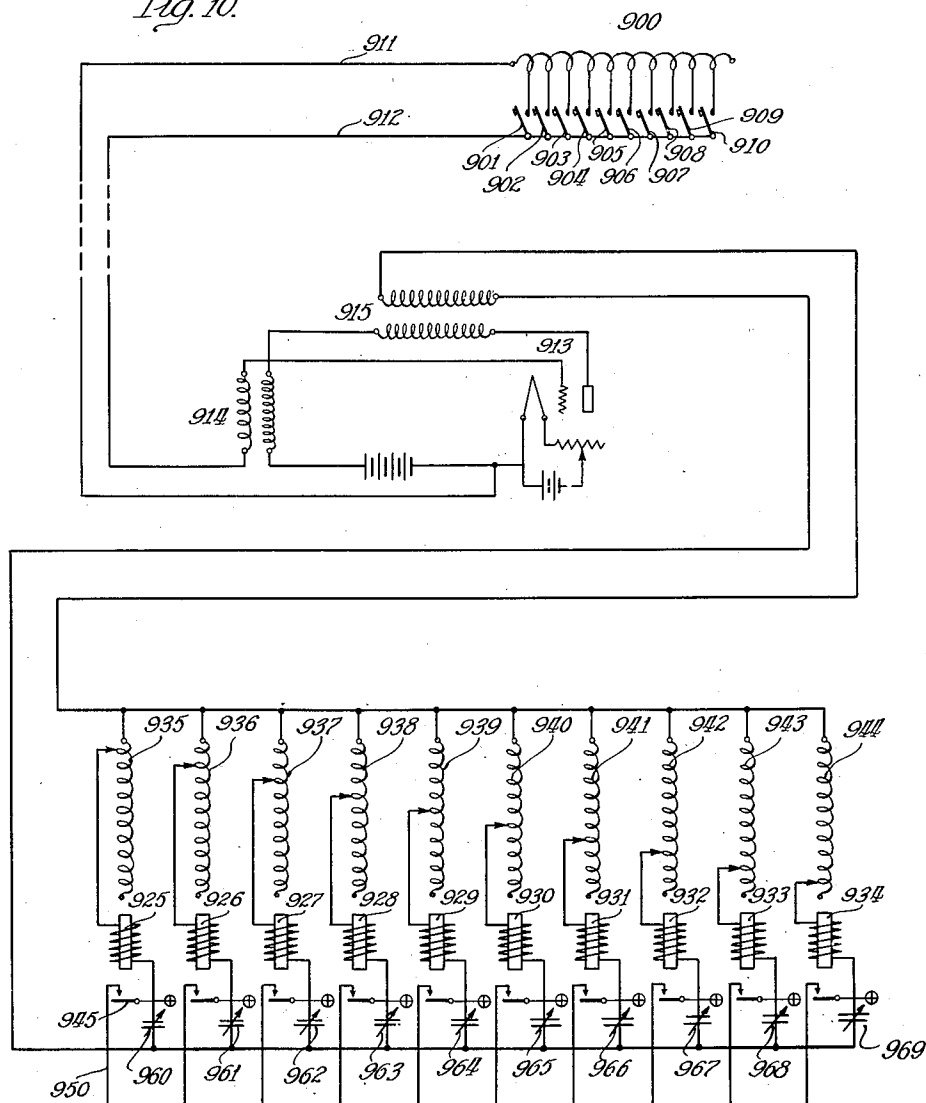
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Fig. 10.



Inventor

John E. Gardner

By

Brown, Baetcher & Danner
Attys.

UNITED STATES PATENT OFFICE

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SELECTING SYSTEM

John E. Gardner, Chicago, Ill.

Application August 6, 1927, Serial No. 211,101
Renewed May 7, 1932

7 Claims. (Cl. 177—353)

My invention relates in general to selecting systems.

One of the objects of my invention is to provide means for instantaneously selecting any one of a plurality of electro-responsive devices over a single circuit.

Another object is to provide positive means for selecting any one of a plurality of devices over a single electrical circuit.

Another object is to provide a plurality of electro-responsive devices connected together by an electric circuit and to select a predetermined one of said devices by changing an electrical characteristic of said circuit.

Another object is to select a predetermined one of a plurality of electro-responsive devices by operating all of those devices but the one selected.

Another object is to provide an electrical balancing circuit for selecting a predetermined one of a plurality of electro responsive devices.

Another object is to provide means for positively selecting a predetermined one of a plurality of devices over a single electrical circuit by employing a magnetic balancing principle.

Another object is to provide means for instantaneously selecting a predetermined one of a plurality of devices which are independent of the usual battery voltage variation.

Another object is to provide means for instantaneously selecting a predetermined one of a plurality of devices by employing a common unvaried current in such selection.

Another object is to provide means for tuning a direct current electrical circuit so that a plurality of devices may be connected to the circuit and individually selected.

Another object is to provide means whereby any one of a plurality of electro-responsive devices may be selected over a single circuit by altering or modifying an electrical characteristic of that circuit.

Another object is to provide a group of relays which will be successively operated very rapidly until the electrical condition causing such energization ceases to exist.

Another object is to energize a number of relays rapidly in sequence until a predetermined relay in the group is reached.

A further object is to provide means for altering an electrical characteristic of a circuit to control unbalanced electrical forces in a plurality of devices.

A still further object is to provide means for selecting a definite one of a plurality of electro-

responsive devices over a single circuit by altering a characteristic of said circuit to balance the electrical forces in a predetermined one of said devices.

Still another object is to provide means for remotely controlling an alternating current device so that it will generate alternating currents at different frequencies to select a predetermined one of a plurality of electro-responsive devices.

There are other objects of my invention which, together with the foregoing, will be described in the detail specification that is to follow taken in conjunction with the accompanying drawings.

Heretofore, many attempts have been made to instantaneously select one of a plurality of devices over a single circuit. However, as far as I am aware, these attempts have been uniformly unsuccessful. The usual methods of attempting to accomplish this result was to provide a number of marginally adjusted relays and attempt to energize these relays selectively over a single circuit by varying the voltage of the battery through a resistor. It is quite obvious that attempts of this kind meet with little success by reason of the varying magnetic circuit of the relays and also by reason of the different constants of the magnetic circuits. In addition the tension or spring adjustment of the armatures of the various selecting or responsive devices have to be differently tensioned so that more or less power is required to energize them. Further, as soon as a relay is energized its magnetic circuit is altered and it requires but a fraction of the current to maintain a relay energized that it does to operate it. Other difficulties will be readily apparent as soon as one examines the magnetization curves of iron. That is, the magnetic field set up by the current flow in a winding of an iron core is not directly proportional to the current. There is also the effect of residual magnetism upon the operation of the device. All these and many other difficulties are encountered when an attempt is made to operate selectively a plurality of relays over a single circuit. The variations of the electromotive force of the battery supplying these relays is also a factor that must be guarded against. In view of the foregoing marginally operated circuits have met with very little commercial success and the only use to which they are put at present is when it is desired to perform selectively two operations over a single circuit.

Another method of instantaneous selection has been the employment of positive and negative current flow with the attended operation of po-

larized relays. Not only is the operation of polarized relays unsatisfactory but, by this method it is still only possible to perform one of two operations selectively.

5 Another method of accomplishing selective operations over a single circuit is by the use of different frequencies of alternating current. In this method a number of tuned devices are connected in a common circuit and are adapted to
10 respond to different frequencies of alternating current, the tuning may be either mechanical or electrical. Even under these circumstances where electrically tuned circuits are employed it is necessary to separate the frequencies to which
15 two devices will respond quite widely in order to secure sharp, prompt and positive operation. This is true even though it is theoretically possible to select frequency responsive devices which are adjusted to respond to frequencies very close
20 together. Also, this alternating current method usually requires a separate frequency producing device at the station from which it is desired to control the selective operation and this in itself is highly undesirable.

25 By the present invention, I have provided means whereby it is possible to select any one of an infinite number of devices in a positive manner over a direct current circuit. The method employed is free from any of the objections
30 pointed out in the foregoing and is not at all concerned with the magnetization curves of the iron in the relays used, nor the variation in the different constants of the magnetic circuits employed. The method used might possibly be
35 termed a zero method of selection. That is, I employ an electrical balancing principle for positively bringing about my selection.

In practicing my invention, I provide a plurality of electro-responsive devices and subject each
40 device to at least two electrical forces. One of these electrical forces with respect to the various devices is graduated or graded and I provide an electrical circuit common to all of the devices which may vary one of the electrical forces to
45 produce a balance of electrical forces or their effects in the device that is to be selected. By setting up electrical interacting forces in the various electro-responsive devices and controlling the variation of one force in each one of the devices I
50 provide means whereby it is possible to affect an electrical balance in any one of the devices over a single circuit. When one device is balanced all the rest are in an unbalanced condition and the only one that is selected is the one that is balanced.

55 In one of its forms, my invention consists of a plurality of Wheatstone bridges, one of the arms of the bridge being common to all and constituting the control circuit, a relay is connected
60 across the mid-point of each bridge. The fourth legs of the bridges each contain a graduated amount of resistance, that is, the conductance of the fourth leg of each Wheatstone bridge is different from the other. A variable resistor is
65 placed in the third leg of the bridge which is common and connections may be made to this resistor at a number of points corresponding to the number of bridges employed. It will be obvious since the fourth leg of each bridge is of
70 different conductance that in order to secure a balance or a selection of a particular bridge the conductance of the common third leg must equal the conductance of the fourth leg of this bridge. This assumes, of course, that the ratio of the
75 first leg of the bridge to the second leg of the

bridge is one to one. Under the conditions above mentioned when a particular bridge is balanced the relay connected across the mid point of the bridge will be deenergized. All the other Wheatstone bridges will be unbalanced and all the other
80 relays connected across the mid-points of the bridges will be energized. In this manner it is thus possible to pick out the desired one of a plurality of electrical devices over a single circuit common to them all. Since an electrical
85 balancing principle is employed it is free from all objections with respect to the magnetic circuit and the constants involved. In fact, this zero method of selection is one of the most accurate known, as will be readily apparent from the sensitivity of the usual Wheatstone bridge employed
90 where accurate measuring is desired. It is thus possible to instantaneously select positively a predetermined one of a plurality of electrical responsive devices. Since this balancing principle
95 is employed it is possible to make a great number of selections over a single circuit, the controlling factors are the voltage of the battery, the value of the resistance, and the sensitivity of the relay. It is obvious that the more sensitive the relay the more selections can be made within given limits, as to resistance change or variation in conductance for a given battery voltage.

In my co-pending application, serial No. 190,-397, filed May 11, 1927, Patent No. 1,736,259 issued November 19, 1929, I have described a
105 method of selection in which the control or selection is secured by altering an electrical characteristic at the control circuit. In this prior application I have disclosed means for governing
110 the selecting operation without employing impulses and without the use of slow acting relays which have heretofore been deemed necessary in almost every type of selecting system, and reference is hereby made to this application
115 where the principles employed in the present invention are first disclosed and explained.

While in the drawings, I have shown positive + and negative - signs as indicating the current supply from the battery it will be understood
120 that a common battery is employed and connected in the manner indicated.

Referring now to the drawings comprising Figs. 1 to 10, inclusive, I have shown sufficient apparatus and circuits by means of the usual conventional diagram to enable my invention to be readily explained and understood.

Referring now to the drawings:

In Fig. 1 the relays 13 to 25, inclusive, are of the usual telephone type. The relays 13 and 16
130 to 25, inclusive, are of the differential type in which the current flow through one winding is adapted to set up a magnetic field which balances the magnetic field set up by the current flow in the other winding. The relays 16 to 25, inclusive, are the selecting relays and are connected at different points to a resistor 26. The points to which these
135 various relays are connected to the resistor 26 are such that the amount of current flow through the lower winding of the differential relay will alter in step, that is assuming that it is desired that there be a ten milliampere current flow change, the relays will be so connected that each
140 succeeding relay will have ten more milliamperes going through a small winding than the preceding relay. The operation of the various selecting relays is adapted to be recorded by groups of registering relays. These groups of registering relays such as relays 35 to 44, inclusive, which
145 constitute the first group, are adapted to be

associated with the selecting relays by the energization of the switching relays or group selecting relays 33 and 34 and other relays of a similar character. The relays 33 and 34 are multicontact relays of the usual telephone type. A group of relays such as 27 to 32, inclusive, of the type known as timing relays is employed to control the successive energization of the group relays at the proper time to associate the particular group desired with the selecting relays. All this selecting equipment is located at one station. The registering relays when they have been operated are adapted to perform any desired selecting function for example, these relays may be located in the register or translator of an automatic telephone system and control the functioning of this device in any well known or approved manner. The conductors extending from the back contacts of the armatures such as 57, 61, 63, 80, 81 and 82 are multiply connected to the springs of the switching relays such as relay 33 and relay 34. These connections have not been shown since they would unnecessarily complicate the drawings.

The selecting equipment described is adapted to be controlled from a remote point or control station. At this control station are located ten push buttons one to ten inclusive of any well known type together with the key K. The push buttons, 1 to 10, inclusive, are adapted to insert a portion of the resistor 99 into the control circuit extending to the station at which the selecting equipment is located. The resistor 99 is adapted to vary an electrical characteristic of the control circuit comprising conductors 11 and 12 so as to alter the conductance thereof. The change in conductance brought about by the operation of any one of the push buttons is equal to the change in conductance in the circuit of the lower winding of one of the selecting relays which corresponds to the push button operated, the change in conductance in the relay circuit being brought about by the successive operation of the preceding selecting relays. That is, the differential selecting relay 16 is adapted to be balanced when the push button 1 is depressed. Under these conditions the circuit which includes the line conductors 11 and 12 the upper winding of the differential relay 13, a portion of the resistor 99 and the winding of the relay 14 is equal to the resistance of the lower winding of the differential relay 16 plus a portion of the resistor 26 and the lower winding on the relay 13. There is likewise a balancing of conductances with any one of the other push buttons at the control station and the corresponding relay. The key K may be of any well known type such as are ordinarily employed in telephone systems and it is adapted to remain in the position in which it is operated. The springs 98 are adapted to be operated each time one of the push buttons such as 1 are operated. Of course, the springs 98 may be individual to each key in a series circuit though the usual practice is to make one set of springs such as 98 be operated by each push button.

Fig. 2 shows a plurality of relays 113 to 123, inclusive, which may be of the usual telephone type. The relays 114 to 123, inclusive, are the selecting relays and may be very sensitive. Resistances, such as 124, 125 and 126 are associated with each relay. The resistance 124 and 125 constitute the first two legs of the Wheatstone bridge and may be of equal value. The resistance 126 constitutes the fourth leg of the bridge. The resistances, such as 126 on the various relays have different values, that is they are graduated. The third leg of the

bridge is common to all the bridges and comprises conductors 111 and 112, the relay 113 and a resistor 100. The resistor 100 is of such value that it will serve to modify the circuit of the third leg of the bridge so that it will balance any one of the Wheatstone bridges associated with any of the relays 114 to 123, inclusive. A number of keys or push-buttons, 101 to 110, inclusive, of any usual or well known type are associated with the resistor 100 and are adapted to connect the conductor 111 to a definite point on the resistor 100. There is one such key 101 for each of the relays 114 to 123, inclusive. The key K—1 is of the usual telephone single throw type and is adapted to remain in the position to which it is operated. The relays such as 170 to 179, inclusive, are registering relays and are for the purpose of registering the operation of the relays 114 to 123, inclusive, which do the selecting.

Fig. 3 shows a modified form of my invention where a single Wheatstone bridge is employed instead of a plurality. In this figure the relays 213 to 223 and the relays 270 to 279, inclusive, are of the usual telephone type. The relays 214 to 223, inclusive, are the selecting relays. These relays are bridged between one terminal of the resistor 224 and various points of the resistor 225. The resistors 224 and 225 constitute two legs of the Wheatstone bridge. The resistor 227 forms the fourth leg of the Wheatstone bridge. The third leg of the Wheatstone bridge extends over the conductors 211 and 212 to the resistor 200 and relay 213. The resistor 200 is similar to the resistor 100 already described and is of such value as to balance the Wheatstone bridge with respect to any of the selecting relays 214 to 223. Keys or push buttons such as 201 to 210, inclusive, are provided for selectively operating the various selecting relays. The relays 270 to 279, inclusive, are merely registering relays for registering the selecting operation. The key K—2 may be of any usual well known type and is provided for closing the selecting circuit.

Fig. 4, shows another modification of my invention in which differential relays are employed instead of Wheatstone bridge circuits. The relays 314 to 323 are differential relays. The ampere turns in either the upper or lower windings of these relays may be graduated. The lower windings of these relays are adapted to be supplied with energy by the operation of the relay 313, the upper windings of these relays have a common circuit that extends through the resistor 300 which is similar to the resistor 200 which has been described. The key K—3 is merely for the purpose of preparing the selecting circuit for functioning. The relays 370 to 379, inclusive, are provided to register the selecting operation of a selecting relay.

In Fig. 5, three groups of selecting relays are shown providing for 1000 possible selections. The relays 418 to 427, inclusive, constitute the first group of selecting relays and are differential in type. These relays might be termed the hundred selecting relays. The relays 430 to 439, inclusive, are differential relays and might be termed the tens selecting group while the relays 440 to 449, inclusive, might be termed the units selecting group. These relays are all differential relays. The relays in each group being graduated from one another and separated into different selecting stages as will appear. The resistor 400 is adapted to alter the current flow through one winding of all the differential relays, this resistor is similar to the resistor 300 previously described and has

ten push buttons such as 401 to 410, inclusive, associated with it. The operation of any push button, 401 to 410, inclusive, brings about the selection of the corresponding relay in the hundreds group, 418 to 427, inclusive. The operation of the push button 412 and then the operation of any one of the push buttons such as 401 serves to operate any one of the relays in the tens selecting group 430 to 439, inclusive. The operation of the push button 412 brings about the insertion of the resistor 411 which serves as a multiplier for the resistor 400. Similarly the operation of the key 413 and any one of the keys such as 401 serves to select a relay in the units group 440 to 449, inclusive. The key 413 introduces the resistance 414 in the circuit thus acting as a multiplier. The key K—4 is similar to the key K, Fig. 1, previously described.

In Fig. 6, the relays 513, to 523, inclusive, are of the usual telephone type. The relays 514 to 523, inclusive are of the well known differential type. The upper windings of these relays are connected to a resistor 524 in a manner similar to the way in which the selecting relays 16 to 25, inclusive, of Fig. 1 are connected, to the associated resistors. The selecting circuit shown in Fig. 6 is in fact a modification of that shown in Fig. 1 so as to permit the principle disclosed in Fig. 1 being enlarged so as to bring about instantaneous selection of any one of a plurality of devices over a single circuit. The resistors 500 together with push buttons 501 to 510, inclusive, and the key K—5 are identically the same as has been described in connection with Fig. 1.

In Fig. 7, the relays 607 to 617, inclusive, are of the usual type and the relays 608 to 616, inclusive, are the selecting relays. These relays may be termed differential though they are of special construction. These relays are polarized by permanent magnets attached to the cores, that is, the permanent magnet 618 is attached to the core of the relay 608 the whole constituting one relay. The permanent magnet 618 serves to take the place of the differential winding in the form described in Fig. 4. The permanent magnets 618 to 627, inclusive, of the various selecting relays are adapted to set up magnetic fields of graduated intensity in the same manner as the windings of the relay where windings are employed to set up one of the electrical forces in the relay. The selecting relays are adapted to be controlled by means of the resistor 600 and the push button 631—640 over the conductors 641 and 642. The resistor 600 and its associated push buttons are of the same construction as the resistors 400 and 100 previously described. The key K—6 is similar to the key K, Fig. 1, previously described.

In Fig. 8, a somewhat similar type of construction is shown. However, in this case the selecting relays 714 to 723, inclusive, have permanent magnets associated with them of the same strength or intensity. The upper windings of these relays are graduated, however. These relays are adapted to be operated by means of a resistor 700 and the associated push buttons 701 to 710, inclusive. The resistor 700 is similar to the resistor 100 previously described.

In Fig. 9, the relays 813 to 823, inclusive, are of the usual type of relays 814 to 823, inclusive, being the selecting relays. The selecting relays are of the differential type and have their upper windings graduated. All selecting relays are connected together in series, that is the lower windings of these relays are all in series and the upper windings are all in series. These relays are adapted to

be controlled by means of the resistor 800 and the associated keys such as 801 over the conductors 811 and 812. The resistor 800 and its associated keys are similar to the resistor 100 and its associated keys (Fig. 1) previously described.

Figure 10, shows the manner in which alternating currents may be used in selecting a predetermined one of the plurality of devices. In this case there is the usual type of vacuum tube oscillator 913 situated at the station where the selecting is to be done. The primary of a transformer 915 is connected in the plate circuit of this oscillator as well as the primary of a transformer 914. The trunk circuit comprising conductors 911 and 912 is connected to the secondary of the transformer 914 and thence to the grid of the trunk 913. The primary and secondary windings of the transformer 914 are closely coupled together so as to form an oscillating circuit for the triode 913. The conductors 911 and 912 and the inductance 900 also provide means for varying the inductance of the grid circuit whereby the frequency of oscillation of the oscillator triode 913 may be altered. The secondary of the transformer 915 is connected across a number of alternating selecting relays of any usual or well-known type 925 to 934 inclusive. These relays are all connected to parallel, in series with the variable inductances 935 to 944, inclusive. The inductance of the various selecting circuits may thus be altered. The selecting relays 925—934, inclusive, are also connected in series with the variable condensers 960 to 965, inclusive so that the capacity of the various selecting circuits may be altered. The relays 925 to 934, inclusive, may thus be adjusted to respond to different frequencies of alternating current.

Having described the apparatus shown in the drawings, I shall now explain its detailed operation. In describing the operation of Fig. 1 it will be assumed that the operator at the control station desires to bring about the selection of the relay 17. In order to accomplish this result, he will operate the key K and will then momentarily depress the push button 2. As a result of the operation of the key K there is a circuit completed which extends from ground through the relay 14, conductor 12, springs of key K, springs 98, conductor 11 normally closed springs controlled by armature 48 to battery. The relay 14 is energized over this circuit and operates to remove the short circuit from the upper winding of the relay 13 at the normally closed springs controlled by armature 48, to connect battery to the mid points of the differential selecting relays 16 to 25, inclusive, at the front contact of this armature, to complete a circuit for the lower winding of the differential relay 16 at armature 49, and to connect ground to conductor 62 at armature 50. The relay 14 is now maintained energized over a circuit which extends from battery by way of front contact and armature 48, normally closed springs controlled by armature 51, mid-point of the differential relay 16, upper winding of relay 16, back contact and armature 55, upper winding of differential relay 13, conductor 11, springs 98, springs of key K, conductor 12, and relay 14 to battery. There is also a circuit for the lower winding of the relay 13 which extends from ground through said winding, armature 49 and its front contact armature 83 and its back contact, a portion of resistor 26, lower winding of relay 16, normally closed springs controlled by armature 51, and armature 48 and its front contact to battery. Since the re-

sistor 99 is not in the circuit of this kind neither the relay 13 nor the relay 16 is energized at this time. This is true because the conduction of the control circuit is equal to the conduction of the circuit through the lower windings of the relays 16 and 13. Now when the operator at the control station presses the push button 2 the springs 98 are opened and simultaneously a portion of the resistor 99 is included in the control circuit. This unbalances the relays 13 and 16. The relay, 13 upon operating, opens the point in the circuit of the relay 15 at armature 47. The relay 16, upon operating, extends the control circuit by way of the armature 55 to the upper winding of the relay 17, completes the circuit of the lower winding of the differential relay 17 at armature 56 and at armature 57 prepares a point in the circuit of the first selecting relay in the first group, namely No. 35. By this operation the relay 16 has increased the amount of resistance in the circuit of the lower winding of the differential relay 17 at the same time extending the control circuit to this relay. Since push button No. 2 is the one that is depressed the conductance of the control circuit will still be greater than the conductance of the circuit of the lower winding of the relay 17 and this relay will be operated to extend the control circuit to the differential selecting relay 18 at armature 59, to complete the circuit of the lower winding of the relay 18 at armature 60, and to prepare a circuit for the second selecting relay 36 in the first group at armature 61 and at this same armature to open a point in the circuit of the first selecting relay in the first group which is number 35. Because of the operation of the relay 17 the conductance of the lower winding of the relay 18 is less than the conductance of the lower winding of the relay 17 and since the push button 2 has been depressed the conductance of the control circuit equals the conductance of the path of the lower winding of the differential relay 18 and this relay is not operated. So long as the control circuit is unbalanced differential relay 13 which is included therein remains energized. However, as soon as the control circuit is balanced, that is as soon as the proper relay has been selected such as 18, the differential relay 13 is also balanced and this relay is deenergized to complete a circuit at armature 47 which extends from ground by way of said armature and its back contact, armature 58 and its front contact, back contact and armature 53, and upper winding of relay 15 to battery. Because of the relatively low resistance of the upper winding of the relay 15 only the armature 52 is attracted to complete a circuit for its lower winding. So long as the original circuit for the upper winding of the relay 15 is maintained, the circuit of the lower winding is shunted, and the armatures 83, 51 and 53 remain in their normal positions. However, when the circuit for the upper winding of the relay is opened both the upper and lower winding are energized in series and all the armatures of the relay become operated.

There is another circuit completed by the operation of the armature 47 in multiple with the one above traced which extends by way of armature 64 and its back contact and relay 32 to battery. Another result of the operation of the relay 13 is to complete a circuit which extends from ground by way of armature 47 and its back contact, armature 58 and its front contact, armature 57 and its front contact, armature 61 and its front contact, armature 63 and its back contact,

working contact of spring 68 and said spring and relay 36 to battery. The registering relay 36 is energized to close a locking circuit for itself at armature 70 to ground upon grounded conductor 62. The circuit of 33 is closed because relay 32 is energized to complete a circuit which extends from ground by way of armature 65 and its front contact, armature 66 and its back contact and switching relay 33 to battery. Switching relay 33 is energized to prepare circuit for the registering relays of the first group. Another result of the operation of the relay 32 is that at armature 67 there is a circuit completed which extends from ground upon ground conductor 62, armature 67 and its front contact, relay 31, and relay 32 to battery. The relay 31 is not energized at this time since it is short circuited by the original energizing circuit for the relay 32.

When the subscriber releases the push button at the control station, the relay 13 is again unbalanced as well as the relay 18. The operation of the relay 18 is without particular function at the present time. However, the relay 13 upon energizing opens the original energizing circuit of the relay 32 at armature 47, opens the original circuit of the registering relay 36 at this same armature, and in addition at this same armature opens the circuit for the upper winding of the relay 15. The relay 31 is immediately energized, since the short circuit is removed, to open the circuit of the switching relay 33 at armature 66, to open a point in the original energizing circuit of the relay 32 at armature 64, and to prepare a circuit for the relay 30 at the front contact of this armature. The switching relay 33 is deenergized to disassociate the first group registering relays from the selecting relays. The opening of the original energizing circuit of the relay 36 is without particular function since this relay is locked energized over the grounded conductor 62. Since the short circuit is removed from the lower winding of the relay 15, this relay is energized to attract its armatures 83, 51 and 53. The operation of the armature 53 opens a point in its original energizing circuit while the operation of the normally closed springs controlled by armature 51 opens the circuit of all the differential relays 13 and 16 to 25, inclusive and simultaneously completes another circuit for the relay 14 at armature 51 and its front contact. Another result of the operation of the relay 15 is at armature 83 a point in the circuit of the lower winding of the relay 13 is opened. The relays 16 and 17 are immediately deenergized, as well as the relay 18 if it has operated following the restoration of the push button 2 to normal. The selecting circuit is thus in its original condition since the relay 15 is deenergized to restore its circuits to normal following the deenergization of the relay 16.

It will be understood that the various differential relays 16 and 17 are energized and maintained energized through their lower winding as the control circuit is passed on from relay to relay.

It will be appreciated that the differential selecting relays can be operated at a high rate of speed; that is, that a large number can be operated successively in a short period of time. In fact, it is possible with the usual telephone type of relay to energize anywhere from 100 to 200 relays a second successively; that is, one energizing the other in a chain, depending upon their construction and adjustment. It will thus be seen that while the ordinary interval the subscriber will

take to operate the push button such as 1 to 10, inclusive, will be approximately a second, even if the push button is maintained for but a small fraction of a second that ample opportunity will be given for all differential selecting relays 16 to 25, inclusive, to become energized.

It will now be assumed that the operator at the control station desires to operate with this selecting relay in the second group. In order to accomplish this result the operator will depress the push button 5. By this operation a certain amount of resistance is included in the control circuit and the conductance of the circuit is altered. The differential selecting relay 16 as well as the differential relay 13 is thereupon unbalanced. The operation of the relay 13 serves to open a point in the circuit of the relay 30 at armature 47, as well as in the circuit of relay 15 at this same armature. The selecting relays 16, 17, 18, 19 and 20 will then be rapidly operated in sequence since with respect to any one of these relays when a circuit is closed, the conductance of the control circuit is less than the conductance of the circuit of the lower winding of each of these relays. However, the relay 21 is not operated since the conductance of the control circuit is equal to the conductance of the circuit of its lower winding. The relay 21 therefore remains deenergized. The sequential operation of the selecting relays then ceases. The relay 13 is immediately deenergized to complete a circuit for the upper winding of the relay 15 at armature 47 in multiple with the circuit for the relay 30 which extends over a path from ground by way of armature 47 and its back contact, armature 58 and its front contact, armature 64 and its front contact, armature 75 and its back contact and relay 30 to battery. The relay 30 is energized to complete a circuit for the relay 29 at armature 71 and to complete a circuit at armature 73 which extends from ground by way of said armature and its front contact, armature 76 and its back contact, and switching relay 34 to battery. The switching relay 34 is immediately energized to connect the second group of registering relays to the selecting relays 16 to 25, inclusive. There is now a circuit completed which extends from ground by way of armature 47 and its back contact, armature 58 and its front contact, armature 57 and its front contact, armature 61 and its front contact, armature 80 and its front contact, armature 81 and its front contact and armature 82 and its back contact, working contact of spring 76 and said spring and thence to the fifth registering relay of the second group. The fifth registering relay of the second group is immediately energized to establish a locking circuit for itself and to open its own energizing circuit.

When the operator at the control station releases the push button 5 the differential relay 13 is immediately unbalanced as is the relay 21 and there is a circuit completed so that the upper winding of the relay 15 becomes effective as well as the circuit of the relay 29. The relay 29 is energized to prepare circuit for the relay 28 at armature 75 and to open the circuit of the switching relay 34 at armature 76. The relay 34 is immediately deenergized to disassociate the second group of registering relays from the selecting relays. The relay 15 is immediately operated to open the circuit of all the differential selecting relays 16 to 25, inclusive, and also the relay 13. These relays are deenergized with the same results as before.

In this manner the selecting relays may be re-

leased and re-operated until any desired number of selections have been made. If the operator at the control station represents a subscriber at the sub-station of an automatic telephone system, this registration of the various selections corresponding to the digits dialed under present conditions will be effective to bring about the operation of the sending and translating equipment in the director, translator or register to control the establishment of connection. The manner of accomplishing these results will be apparent to those skilled in the art.

The proper number of groups of registering relays, such as 35 to 44, inclusive, and the proper number of switching relays such as 33 and 34, as well as the proper number of sequence controlling relays 27 to 32, inclusive, may be provided to take care of the registration of any number of digits. This will be obvious from the foregoing description.

It will be seen that when the push button 10 is operated that substantially all of the resistor 99 is placed into the control circuit, the selecting relays are, therefore, all operated in sequence until the relay 25 is energized. This relay is also energized since it remains deenergized for the digit 9 with the selecting relay 24 operated. The operation of the relay 25 serves to select the tenth registering relay of any group. It will be obvious that if there are a greater number of push buttons than ten that other selecting relays may be provided and that their operation will be substantially similar to that already described.

The release of all selecting equipment may be brought about by the operator at the control station restoring the key K to normal. By this operation the control circuit including the relay 14 is open and this relay is deenergized. The relay 14, upon deenergizing, opens the battery connection of all the selecting relays at the normally closed springs controlled by this armature, restores the battery connection to the conductor 11, opens a point in the circuit of the lower winding of the differential relay 13 at armature 49 and at armature 50 removes ground from grounded conductor 62. By the removal of ground from this conductor a point in the circuit of the relay 15 is opened, as well as the circuit from the relays 29, 30, 31 and 32. The circuits of the various registering relays which are energized are also opened by this operation and these relays are deenergized and thereby prepared for a new registration.

It will thus be seen that I have provided means for selecting any one of a plurality of devices over a single circuit by means of relays. It will be obvious that these relays are successively operated at a high rate of speed until the proper selection is made. This selection is governed by a change in an electrical characteristic of a control circuit. Though this selection occurs very rapidly as before stated, anywhere from one hundred to two hundred selections may be made in a second, it is successive selection rather than instantaneous selection and requires the operation of all the selecting equipment previous to it, to make the proper selection. That is, it is a new and very speedy type of step by step selection.

It will be obvious the great desirability of eliminating all the unnecessary operation which has been absolutely vital to selection heretofore and select directly without any intervening operation the position or electrical responsive device required.

I shall now describe the operation of my in-

vention shown in Fig. 2 in which it is possible to effect instantaneous selection. In order to prepare the selecting circuit for operation, the operator or other persons at the station at which the resistor 100 and the keys 101 to 110, inclusive, are located will operate the key K—1. The key K—1 remains in position until it is manually released. When the key K—1 is operated there is a circuit completed which extends from battery by way of the normally closed springs controlled by armature 151, conductor 112, resistor 100 thru the springs of key K—1, conductor 111 and relay 113 to ground. The relay 113 is energized over the circuit and operates to connect ground to one terminal of the resistors such as 126 of the various Wheatstone bridges at armature 150 and its front contact, to remove battery from the conductor 112 and to connect it to the point between the first and second arms of the bridges at armature 151, and to prepare a locking circuit for the registering relays 170 to 179, inclusive. The relay 113 is maintained energized over circuit which extends from battery through the first arm such as 124 of the various Wheatstone bridges in multiple, conductor 112, resistor 100 thru key K—1, conductor 111, and relay 113 to ground. There is also a current flow in the Wheatstone bridges over a path similar to the one that will be now traced which is associated with the selecting relay 114. This path extends from battery by way of front contact and armature 151, resistor 125, resistor 126 and front contact and armature 150 to ground. This last current flow is over the second and fourth legs of the bridge. The third leg of all the bridges is the line or control circuit including the resistor 100 and the relay 113. As mentioned before, the resistance such as 126 constituting the fourth leg of the various bridges are graduated. The push buttons 101 and 110 associated with the resistor 100 are adapted to alter the conductance of the third leg of the bridge so that the third leg may serve to balance any one of the Wheatstone bridges. However, the circuit for the third leg of the bridge extends through all of the resistor 100 and none of the Wheatstone bridges are balanced. There is therefore a current flow across the mid points of the various bridges to bring about the energization of the selecting relays 114 to 123, inclusive. The relay 114, upon energizing, opens a point in the selecting circuit at armature 154, and at armature 153 prepares the point in the selecting circuit for the various relays. The operation of the relay 115 performs similar results. The reason that the relays 114 and 115 both at armature 153 and 155, respectively, prepare selecting circuits is for the purpose of having selecting circuits prepared in the event that one or the other of these relays are selected. The operation of the other relays 116 to 123, inclusive, merely open a point in the various selecting circuits at the associated armature. Assuming that the operator at the control station desires to bring about the selection of the selecting relay 114 he will operate the push button 101. Immediately by this operation the conductance of the third leg including the line conductors 111 and 112 is altered. Since the operation of the push button 101 is calibrated so as to introduce sufficient resistance into the line circuit so that the current flow through the fourth leg of the bridge with which the relay 114 is associated is balanced by the current flow through the third leg of the bridge. The relay 114 is de-energized. All the other Wheatstone bridges are

unbalanced since the resistance of the fourth leg of the various bridges are graduated and the other selecting relays 115 to 123, inclusive, are energized. All of the selecting relays are energized except the relay 114 and there is a circuit completed which extends from ground by way of front contact and armature 155, armature 154 and its back contact normally closed springs controlled by armature 180, and relay 170 to battery. The relay 170 is energized to establish a locking circuit for itself at armature 180 and to open its original energizing circuit at the front contact of this armature through the normally closed spring. None of the other selecting relays are deenergized and consequently none of the registering relays 171 to 179, inclusive, are operated. The relay 170 is thus energized to register the selection desired by the operator at the control station. The relay 170 in the present instance may operate an annunciator or in fact may be an annunciator itself. The operation of the relay 170 completes the selecting operation.

In order to release the selection the operator at the control station will restore the key K—1 to normal. This opens the circuit of the third leg of the bridge and brings about the deenergization of the relay 113. The relay 113 upon deenergizing, opens the Wheatstone bridge selecting circuit at armatures 150 and 151, preparing an energizing circuit for itself at the normally closed springs controlled by armature 151, and opens the locking circuit of the registering relay 170 at armature 152. The registering relay 170 is therefore deenergized.

It will now be assumed that the operator at the control station desires to select the fifth selecting relay 118. In order to do this he will operate the key K—1 with the same results as before described and will then operate the push button 105. The operation of the push button 105 serves to introduce sufficient resistance into the third leg of the bridge to bring the current flow through into balance with the current flow thru the fourth leg of the bridge that is associated with the selecting relay 118. Since the Wheatstone bridge associated with the relay 118 is balanced this relay is deenergized while all the other relays 114 to 117, inclusive, and 119 to 123, inclusive are energized. There is a circuit now completed which extends from ground by way of the front contact and armature 153, armature 161 and its back contact, normally closed springs controlled by armature 184 and relay 174 to battery. The registering relay 174 is energized to establish a locking circuit for itself at armature 184. The registering relay 174 is the only one energized since all the selecting relays except the selecting relay 118 are operated. The restoration of the key K—1 to normal brings about the release of the selecting apparatus in the same manner as before described.

If the operator at the control station, as is assumed, operates the selecting relay 123 he will depress the key or push button 110, thereby altering the conductance of the third leg of the bridge so that it will balance the conductance of the fourth leg of the Wheatstone bridge associated with selecting relay 123. The selecting relay 123 is therefore deenergized, while all the relays 114 to 122 are operated. The relay 179 is therefore energized. In the manner above described it is possible for the operator at the control station to selectively operate any one of the relays 114 to 123, inclusive. Since the operation of each one of these relays depends upon the balancing of an

electrical circuit the selecting operation is very positive. In addition, it is to be noticed that any variation in the battery voltage will effect both the third and fourth legs of the Wheatstone bridge alike and this will have no effect upon the selecting action.

It is obvious that the selecting operation here set forth may be applied throughout the whole selecting field with great economy with reference to the apparatus needed to effect a given selection and speed of operation. In order that the operator may easily distinguish the different selections or perform any given operation the various push buttons such as 101 to 110, inclusive, may be definitely numbered. The operator may then perform the required operation in accordance with the number which he is given.

It will be obvious that while the system has been shown as selecting any one of ten operations that this number of selections is arbitrary and may be increased or decreased as desired. By increasing the battery voltage and the value of the resistance such as 100, the number of selections that may be made by using the principle disclosed is practically unlimited.

It is to be pointed out that irrespective of what relay is selected the speed of the selection of one relay is identically the same as the selection of another. This is highly desirable and altogether different from the usual time of selection where impulses are employed. When impulses are employed it is necessary to go over a chain of operations until the desired selection is arrived at. Thus, in the present case, the speed of selection is decreased in proportion with the number of selections made. In the present system this speed of selection is constant irrespective of the number of selections it is necessary to make over a single circuit.

Since an electrical balancing circuit is employed for selection it is obvious that instead of using a change in the amount of current flow as in the above case, that the system lends itself very readily to a balancing of voltages. The use of an electrical balancing circuit where at least two electrical forces are caused to interact in a plurality of different responsive devices and one of the electrical forces in each device commonly varied to bring about a balance of the forces in one particular device may be termed a zero method of selection. It is obvious, of course, that any number of selecting relays may be operated by pushing the various push buttons without releasing the key K—1 to normal in varying combinations or sub-combinations. By using this principle with the same number of selecting relays and operating them in the various combinations with the required number of registering relays to provide the combined selecting circuits it would be possible to select any one of a large number of devices very quickly and with a minimum of apparatus.

Referring now to Fig. 3, I shall describe the preferred embodiment of my invention.

In order to describe the operation in this case, it will be assumed that the operator at the control station desires to operate or select the relay 223. In order to accomplish this result, the operator will operate the key K—2 and will then depress the push button 210. By the operation of the key K—2 there is a circuit completed which extends from battery by way of the normally closed springs controlled by armature 250, conductor 212, resistor 200, springs of the key K—2, conductor 211, and relay 213 to ground. The

relay 213 is energized to disconnect direct battery from the conductor 212 and to connect it to one terminal of the resistors 224 and 227, to connect ground to the locking circuit of the registering relays 270 to 279, inclusive, at armature 251, and to connect ground to one terminal of the second leg of the Wheatstone bridge at armature 252. The relay 213 is maintained energized over a circuit which extends from battery by way of front contact and armature 250, resistor 224, conductor 212, resistor 200, springs of the key K—2, conductor 211, and relay 213, to ground. In order that the relay 223 may be selected, it is necessary that this relay be deenergized, while the relays 214 to 221, inclusive, are energized. In order that the relay 223 will be deenergized, it is necessary that the bridge be balanced. To simplify the description, it may be assumed that the bridge comprises the resistor 224, which is the first leg, the resistor 227, which is the fourth leg, the line conductor 212, the resistor 200, the conductor 211 and the relay 213, which is the third leg, and the resistor 225 from the point 228 plus the resistor 226 constituting the second leg of the bridge. In order to have the relay 223 deenergized, it is necessary that the proportion of the third leg of the bridge to the fourth leg of the bridge be the same as the proportion of the first to the second leg of the bridge; that is, the proportion of the resistance of the resistor 224 to the resistor 227 must be the same as the proportion of the line circuit with the controlling resistance 200 to the portion of the resistor 225 to the point 228 plus the resistor 226. This result is brought about when the push button 210 is depressed. Thus, when the push button 210 is depressed, the relay 223 is deenergized and the relays 214 and 222, inclusive, are energized. This result follows because, with respect to any other one of the selecting relays, the proportions of the bridge are altered and the potentials between the various points of the resistor are different and there is a current flow through these relays to energize them by reason of the potential difference between various points on the resistor 225. With the relay 223 deenergized and the remaining selecting relays operated, there is a circuit completed which extends from ground by way of armature 253 and its front contact, armature 254 and its back contact, normally closed springs controlled by armature 289, and registering relay 279 to battery. The registering relay 279 is energized to open a point in its original energizing circuit at the normally closed springs controlled by armature 289, and to establish a locking circuit for itself at the front contact of this armature. The relay 279 remains operated until the relay 213 is deenergized by the release of the key K—2 at the control station. When the push button 210 is released, the relay 223 is energized, as are all the relays 214 to 223, inclusive. By the operations of the operator at the control station, the relay 223 has been selected and operated, and this operation has been registered by the registering relay 279.

In order to release the registering relay 279, the key K—2 is restored to normal and the relay 213 is thereby deenergized to open the locking circuit of the relay 279 and to open the Wheatstone bridge selecting circuit.

It will now be assumed that the operator at the control station desires to bring about the selection of the relay 218. In order to accomplish this result he will operate the key K—2

with the same results as before, and will then operate the push button 205 momentarily. Since the relay 218 is the one to be deenergized, the conditions under which this will occur are, that the bridge must be balanced with respect to this relay; that is, the proportion of the resistor 224 to the resistor 227 plus that portion of the resistor 225 extending to the point 229 must be equal to the proportion of the conductors 211 and 212 with the portion of the resistance 200 cut into circuit by the operation of the push button 205 is to that portion of the resistor 225 extending from the point 229 plus the resistor 226. These conditions are brought about when the push button 205 is depressed. Since the points at which the other selecting relays are connected, all have different potentials, because they are all unbalanced, the relays 214 to 217, inclusive, and the relays 219 to 223, inclusive, are all energized. By the deenergization of the relay 218 there is a circuit completed for the relay 274. The relay 274 is the registering relay that is operated in response to the selection of the relay 218.

If it is desired to operate or select the relay 214, the operator at the control station will depress the push button 201, whereby the bridge circuit is altered so that the proportion of the first leg of the bridge, that is, of the resistor 224 to the second leg of the bridge, the resistor 225 is equal to the proportion of the third leg of the bridge comprising the conductors 211 and 212 and a portion of the resistor 200 to the resistor 226. Under these conditions the remainder of the bridge is unbalanced and the relays 215 to 223, inclusive, are all energized. The registering relay 270 is thereupon operated. The selection may be released by the restoration of the key K—2 with the same results as before.

It will be seen that this selecting circuit accomplishes substantially the same selecting result as that of Fig. 1. However, in this instance it is only necessary to have one Wheatstone bridge circuit for a large number of relays, and that the number of selections that may be obtained over a single circuit employing only one Wheatstone bridge circuit, is unlimited. Where one Wheatstone bridge is used for a plurality of relays, it will be seen that the Wheatstone bridge is automatically regulated to change the proportions of the circuit, depending upon the relay that it is desired to select. This regulation is an inherent functioning of the circuit itself. Thus, any number of selections are made with simply one operation and there is no sequential operation of the apparatus whatsoever. The function of this Wheatstone bridge circuit is not marginal in any sense of the word, but occurs through balancing of electrical forces to positively identify a particular selection. In this circuit also a zero method of selection is employed and the selection is secured by a balancing of electrical forces. Any one of the selecting relays 214 to 223, inclusive, may be selected by operating the corresponding push button at the control station. The separation between points to which the selecting relays are connected on the resistor 225 is governed by the amount of current required to operate the relay, the value of the resistance 225, and the electromotive force of the battery employed. The more sensitive the selecting relays, the closer they may be connected together on the resistor 225, for a given battery voltage. However, relays of any degree of sensitivity may be employed by sufficiently

spacing the connections of these relays on the resistor 225.

It is to be noted that the selection occurs instantaneously in response to the operation of a push button, and that this push button may be momentarily depressed and released and the corresponding registering relay will be operated. Selection occurs with a single operation instantaneously for any one of the selecting relays.

I shall now describe the modification of my invention shown in Fig. 4. In this instance differential relays are employed instead of the Wheatstone bridge selecting circuit. In order to describe the operation of the selecting system in this instance, it will be assumed that the operator at the control station desires to bring about the operation of the relay 314 or its selection. In order to accomplish this result, the operator will depress the key K—3 and will then operate the push button 301.

By the operation of the key K—3 there is a circuit completed which extends from battery by way of the normally closed springs controlled by armature 324, conductor 312, resistor 300, springs of the key K—3, conductor 311, and relay 313 to ground. The relay 313 is energized to disconnect the direct battery connection from the conductor 312 at the normally closed springs controlled by armature 324, and to connect battery to this conductor through the upper windings of the differential selecting relays 314 to 323, inclusive, in multiple. Other results of the operation of the relay 313 are, that at armature 325 a locking circuit is prepared for the registering relays 370 to 379, inclusive, and at armature 326 a circuit is completed for the lower winding of the differential selecting relays 314 to 323, inclusive. The operation of the selecting relays 314 to 323, inclusive, will first be considered when the lower windings of these relays have a graduated number of ampere turns in them; that is, the number of ampere turns in the lower windings of each of the selecting relays such as 314 will be different from the number of ampere currents in any other lower winding. This immediately sets up the fact that the current flow through the upper winding of each of the relays must be different in order that any relay may be balanced. Thus, when a selecting relay is selected the conditions of the circuit which brings about the selection of this relay will be different in this particular instance from the conditions that bring about the selection of any other relay and only one selecting relay will be deenergized or balanced at this time. Now when the push button 301 is depressed a certain amount of the resistor 300 is left in circuit with the conductors 311 and 312. Since it is desired to select the relay 314 the current flow through the upper winding of the relay 314 over the line conductor 312 a portion of resistor 300, through the push button 301, the conductor 311 and the relay 313 is of such nature that the magnetic field set up by the upper winding is equal in intensity but opposite in polarity to the magnetic field set up by the lower winding of the relay 314. Since this relay is differential, it is balanced and armatures 327 and 328 are retracted. However, under these conditions, the current flow through the upper windings of all the other relays 315 to 323, inclusive, is such that the magnetic field set up in each of these relays does not effect a balance with the magnetic field set up by their lower differential windings and these relays are all energized. A circuit is now

completed which extends from ground over armature 329 and its front contact, armature 328 and its back contact, normally closed springs controlled by armature 380, and relay 370 to battery. The registering relay 370 is thus operated to establish a locking circuit for itself at armature 380. It will then be seen that by this operation the operator at the control station has positively identified and selected the selecting relay 314.

The registering relay 370 may be released at any time by the restoration of the key K—3 to normal. If the key K—3 is not operated the selecting relays may, of course, be energized as before. Under these conditions the relay 313 in the selecting equipment, which is the release relay, may be eliminated. The various relays 314 to 323, inclusive, may then be operated by simply depressing the push buttons without any operation of a key such as key K—3. The only reason that the relay 313 is employed is to conserve the current flow in the battery and to not have a permanent circuit for the various differential windings.

It will now be assumed that the operator at the control station desires to bring about the selection of the relay 318. In order to accomplish this result, he will operate the push button 305. This operation alters the conductance of the circuit including the upper winding of the relay 318 so that the magnetic field set up by the upper winding is exactly equal and opposite of the magnetic field set up by the lower winding and this relay is balanced. Of course, the magnetic field set up by the upper windings of all the selection relays are simultaneously altered. However, it is only in the relay 318 that they are exactly equal and this is the only relay that becomes balanced and deenergized. The registering relay 374 is then the one operated.

If it is desired to operate or to select selecting relay 323, the operator at the control station will depress the push button 310. By this operation the current flow through the upper windings of the relay 323 is so altered that the magnetic circuit set up by this current flow is exactly equal to the magnetic field set up by the current flow in the lower windings and this relay is balanced to bring about the selection of the registering relay 379. Of course, the circuits of all the upper windings of the selecting relays 314 to 322, inclusive, are likewise altered. However, each one of these selecting conditions are different from the other and only in case or with respect to one relay are they adapted to create a balanced condition.

The selecting equipment may, of course, be released, as described before by releasing the key K—3.

Attention is directed to the fact that in this instance also where differential relays are employed instead of a Wheatstone bridge circuit or circuits, variation in the voltage or electromotive force of the battery has no effect whatever on the functioning of the selecting equipment. In this instance the balancing is secured by a magnetic interaction and when the resultant equal a predetermined quantity, which in this case is zero, the selection occurs. A zero method of selection is thus employed in this instance also.

Attention is directed to the fact that the magnetization curves of iron cores in the various relays have no effect upon the operation of this selecting system. This is true because the zero

method is employed throughout. That is, this selection is brought about by setting up two interacting magnetic fields in a plurality of electrical responsive devices and varying one of the magnetic fields in the devices until a balance is obtained and the magnetization curves of the iron in the cores of the various relays have no effect. This follows since the interacting magnetic fields are set up on the same cores. Since the selection is obtained when the result of the interacting magnetic field equal zero, we are not concerned with residual magnetism. For the same reason, neither are we concerned with the varying constants of the different magnetic circuits in each device. Thus by this zero method of selection all the difficulties that have been encountered with respect to the selection of any one of a large number of devices over a single circuit are eliminated. By employing this differential relay selecting circuit any number of selections may be obtained over a single circuit. The only limit to the number of selections is the voltage of the battery and the sensitivity of the relay. That is, the more sensitive the relay the greater number of selections that can be obtained with a given battery voltage.

It will, of course, be obvious that instead of having the lower winding of the differential relays graded, that is, each one different from the other, they may all be the same and the upper windings may be graded. If the upper windings are graded the same results are secured. This follows when it is considered that only with a particular resistance in the control circuit will there be a balanced condition set up with respect to one of the relays. For that matter, also both the upper and lower windings of the differential relays may be graded so long as they are not graded the same with respect to the same relay. All that is necessary is that where a plurality of electro-responsive devices are used, a magnetic circuit must be set up in each device which is different from the magnetic circuit of any of the other devices and providing a common control which can alter the magnetic circuit of all of the devices so to effect the balance or predetermined condition in any one of the devices. It will be seen that this selection employing differential relays is instantaneous and operates on a magnetic balancing principle instead of an electrical balancing principle as previously employed.

I shall now describe the modification of my invention shown in Fig. 5. In this instance the selecting circuit is designed to permit the selection of any one of a thousand selecting positions over a single circuit. The circuit employs the same principle as that described in connection with the selecting circuit of Fig. 3. This circuit is particularly adapted for use with the thousand point selecting switch developed by the Western Electric Company shown in the Patent 1,551,024 issued to Gooderham on August 25, 1925. This switch is of well known construction having three sets of ten cross bars. There are three sets of ten magnets for operating each of the three sets of ten cross bars. By operating a cross bar in each set it is possible to select a predetermined point out of the thousand.

In the present instance it will be assumed that the operator at the control station desires to make a certain selection. In order to accomplish this result he will operate the key K—4 and then depress one of the push buttons such as 401. By

the operation of the key K—4 there is a circuit completed which extends from battery by way of the normally closed springs controlled by armature 450, conductor 415, resistor 400, springs of key K—4, conductor 416 and relay 417 to ground. The relay 417 is energized to prepare the circuits of the differential relays 418 to 427, inclusive, 430 to 439, inclusive, and 440 to 449, inclusive. By operating the push button 401 the relay 418 in the first group of selecting relays is balanced and the relays 419 to 427, inclusive, are all energized. There is a circuit completed by way of ground by way of armature 452 and its front contact, armature 453 and its back contact and conductor 454 to one of the magnets in the cross bar switch. The conductors such as 454 from the first group of selecting relays 418 to 427, inclusive, extend thru the ten collecting magnets that operate the first ten cross bars in this cross bar selecting switch so that by the connection of ground to the conductor 454 one of these magnets is energized to position its associated cross bar. The resistor 400 is of such value that the operation of the push buttons 401 to 410 will operate any one of the selecting relays in the first group 418 to 427, inclusive. To operate or select the selecting relays in the second group of relays 430 to 439, inclusive, it is necessary to operate the push button 412 at the same time one of the push buttons 401 to 410, inclusive are operated. It will be seen that the operation of the push button 412 serves to connect a resistance 411 in multiple with the resistor 400 and this resistor acts as a multiplier. This resistance 411 so changes the functioning of the resistor 400 that the operation of the push buttons 401 to 410, inclusive serves to select any one of the selecting relays 430 to 439, inclusive, now, when the push button 402 is operated at the same time as the push button 412 the relay 431 in the second group of selecting relays is balanced and the relays 430 and 432 to 439, inclusive, are all energized. A circuit is thereby completed which extends from ground by way of armature 455 and its front contact, armature 456 and its back contact to conductor 457. The conductors such as 457 from the second group of selecting relays extend to the various selecting magnets of the cross bar switch in the second group. Thus the connection of ground to the conductor 457 brings about the energization of the second magnet in this group in the cross bar switch and the operation of the second cross bar in this group. The secondary selection in the cross bar switch is thus made. In order to bring about the balancing of a relay in the third group it is necessary that the push button 413 be operated at the same time one of the push buttons 401 to 410, inclusive, are operated. The resistance 414 acts as a multiplier and the values of the resistance 400 as effected by the operation of the push button 401 to 410, inclusive, are effectively changed so that only the selecting relays 440 to 449 may be selected. It will be assumed that the subscriber or operator at the control station operates the push button 413 and 403 at the same time. Under these conditions the relay 442 of the third group of selecting relays is the one balanced and all the relays 440 to 441 and 443 to 449, inclusive, are energized. A circuit is thereby completed which extends from ground by way of armature 459 and its front contact, armature 458 and its back contact, to conductor 460. The conductor 460 extends to one selecting magnet in the third group of selecting magnets

associated with the cross bar switch. The operation of the magnets serves to complete the connection, that is the three bars which have been displaced by the operation of the selecting magnet in the first group, the selecting magnet in the second group and the selecting magnet in the third group serve to select a particular one of a thousand possible devices.

It is to be understood that, when one of the push buttons 412 or 413 is operated, a particular one of the group of selecting relays is selected by this operation but when one of the push buttons such as 401 to 410, inclusive is operated that, while the relay that it is desired to select in the particular group is selected, all the other relays in that particular group are energized, as well as all the other selecting relays in the other groups. Consequently, only one selection is made. Therefore, it is possible with twelve push buttons to make any one of the thousand selections. When it is desired to release the equipment and restore the circuit to normal, the key K—4 is released to bring about the deenergization of the relay 417. The relay 417 is deenergized to restore the circuit of the selecting relays 418 to 427, inclusive, 430 to 439, inclusive, 440 to 449, inclusive, to their normal condition.

It will be seen from the foregoing that it is possible to select the predetermined device out of a large number with a minimum of apparatus in a substantial and negligible period of time. Since the differential form of selecting relays are employed in this case it will be appreciated that the statements with respect to the differential relays shown in the selecting system of Fig. 4 hold true with respect to these selecting relays. It will also be obvious that instead of employing the differential scheme of selection in this case that the Wheatstone bridge principle of selection may be employed. It is, of course, obvious that the winding of a differential relay may be graduated, that is, either the upper and lower windings of the differential relays may be graduated or both as stated before. In order to set each group of relays to work within particular limits it is only necessary to properly proportion their windings in accordance with the value of the resistor 400 alone with the resistor 400 and the resistor 411 in multiple, and the resistor 400 with the resistor 414 in multiple.

I shall now describe the modification of my invention as shown in Fig. 6. In order to do this, it will be assumed that the operator at the control station desires to bring about the selection of the relay 514. To accomplish this result he will operate the key K—5. As a result of this operation there is a circuit completed which extends from ground by way of relay 513, conductor 511 springs of key K—5, resistor 500, and normally closed springs controlled by armature 526 to battery. The relay 513 is energized over this circuit and operates to connect ground to one terminal of the resistor 524 at armature 525 to disconnect direct battery from the conductor 512 at the normally closed springs controlled by armature 526 and to connect battery to the mid-points of the differential relays 514 to 523, inclusive. As a result of the latter operation there is a new circuit established for the relay 513 which extends from battery by way of front contact in armature 526, to the mid-points of all the differential relays 514 to 523, inclusive, thence through the lower windings of these relays in multiple, conductor 512, resistor 500 springs of key K—5, conductor 511,

and relay 513 to ground. Relay 513 is maintained energized over this circuit.

Since all the resistor 500 is present in the control circuit, all the differential relays are unbalanced, it being understood that there is a circuit for each selecting relay which extends from battery that has been connected to their mid-points through their upper windings and thence through the resistor 524 to ground by way of front contact and armature 525. It will be seen that the upper windings of the various relays are connected to the resistor 524 at certain points. These connections are made at such points as will bring about a variation in conduction of a predetermined amount in steps between each relay. With all of the resistance 500 connected in the control circuit, all of these relays are unbalanced and are, therefore, energized. Now since the operator at the control station desires to bring about the operation of the relay 514, he will operate the push button 501. By this operation a certain amount of the resistance 500 is introduced into the control circuit while the remainder of it is short-circuited. This alteration of conductance in the control circuit brings about an alteration in the current flow therein and through the lower windings of all the selecting relays. In only one relay will the current flow through the lower winding equal the current flow through the upper winding, for to explain a little more clearly, in only one relay will the current flow through the lower winding set up the same intensity of magnetic fields as the current flow through the upper winding. In view of the connections of the various relays, the relay 514 is the only one in which this condition prevails. The relay 514 is thus balanced and is deenergized while the relays 515 to 523, inclusive are all operated. A circuit is now completed which extends from ground by way of armature 529 and its front contact, armature 528 and its back contact to conductor 540. The connection of ground to this conductor brings about the operation of a registering relay or any other device that may be desired.

As soon as the push button 501 is released all the selecting relays are again energized. When it is desired to restore the selecting circuit to normal, the key K—5 is released and the circuit of the relay 513 is opened. Relay 513 is deenergized to restore the selecting circuit to normal.

It will now be assumed that the operator at the control station desires to bring about the operation of the relay 523. To accomplish this result he will depress the push button 510. By this operation a certain amount of the resistance 500 is introduced in the control circuit and the current flow through the lower windings of the various relays is immediately altered. In only one relay, however, will this current flow set up a magnetic field which is equal to the magnetic field set up by the upper winding. This is in the relay 523. The relay 523 is then the only one deenergized. All the selecting relays 514 to 522 are thereby operated. A selecting circuit or operating circuit is now completed which extends from ground by way of armature 527 and its front contact, armature 535 and its back contact to conductor 549. The connection of ground to this conductor may perform any desired function such as the operation of a registering relay similar to those shown in previous figures.

It will be seen that in the present case, the differential relays may be all of the same construction with respect to their windings. The

characteristics of each relay are altered by the points on the resistor 524 to which they are connected. It will be seen that the circuit of Fig. 6 is very similar to the selecting circuit of Fig. 1 except that all the armatures are omitted but the selecting armature. That is, the selecting circuit of Fig. 6 is capable of instantaneous selection of any one of a plurality of devices over a single circuit and thereby eliminates all the unnecessary operations that were set up in connection with the circuit Fig. 1 when it was described. Thus with a simpler circuit, a much better and entirely different operation is secured.

I shall now describe the modified form of my invention shown in Fig. 7. The operation of this selecting circuit is identical with the operation of the circuit shown in Fig. 4. However, in this instance instead of the differential effect being secured by a second winding on the relay the effect is secured by permanent magnets of graduated strength positioned with respect to the cores of the relay 508 to 517, inclusive, so that the magnetic field set up by the respective associated permanent magnet interact with the magnetic fields set up by the windings of the relays 608 to 617. Any one of the relays may be selected by balancing the opposing magnetic forces. When the key K—6 is operated from the control station the relay 607 is energized and the relays 608 to 617, inclusive, are prepared so that they may be selected. Any one of these selecting relays may be deenergized by operating one of the push buttons such as 631 to 640, inclusive. To explain a little more fully, it will be assumed that the operator at the control station operates the push button 631. By this operation the current flow through the winding of the relay 608 is such as to set up a magnetic field which is of equal intensity and opposite polarity to the magnetic field set up by the permanent magnet 618. With this amount of resistance in the control circuit the magnetic field set up by the other windings do not create a balance and the armatures of the various other relays are attracted. A circuit is therefore completed which extends from ground by way of front contact and armature 650, armature 651 and its back contact to conductor 652. The connection of ground to conductor 652 may perform any desired operation.

In this manner it is possible to select any one of the selecting relays 608 to 617, inclusive. The selecting circuit may be restored to normal by restoring the key K—6 to normal position thereby opening the circuit of the relay 607. The relay 607 is deenergized to open the circuits of the various relays 608 to 617, inclusive, and these relays are deenergized.

The operation of the modification of my invention, shown in Fig. 8 is very similar to that already described in connection with Fig. 7. However, in this instance the permanent magnets are all of the same strength and the windings of the relays 714 to 723, inclusive, are graduated. If it is desired to bring about the operation of the relay 715 the operator at the control station will operate the key K—7 thereby completing a circuit for the relay 713. The relay 713 is energized to complete a circuit for the various relays 714 to 723, inclusive, at armature 730. The various selecting relays 714 to 723, are immediately energized. Their operation is, however, without function at this time. Now when the push button 704 is depressed sufficient resistance is introduced into the control circuit comprising the conductors 711 and 712 and a portion of the resistor 700 so

that current flow through the relay 715 is sufficient to create a magnetic field of the same intensity as that set up by the permanent magnet. Since the windings of all the other relays are different the amount of the resistor 700 that is inserted in the circuit at this time is different from that which would bring about the operation of any other of the selecting relays. Since the relay 715 is balanced the other relays 714 and 716 to 723, inclusive, are energized, there is a circuit completed which extends from ground by way of armature 731 and its front contact, armature 732 and its back contact, to conductor 733. The connection of ground to conductor 733 may perform any desired operation.

In order to restore the selecting equipment to normal, the operator at the control station simply releases the key K—7. By this operation the relay 713 is deenergized and the selecting circuit is restored to normal.

It is to be noted that where a permanent magnet is employed to set up the opposing magnetic field, that a variation in the voltage of the battery will effect the selecting operation. This is true because the magnetic field set up by the permanent magnet is inflexible and does not vary, whereas, the magnetic field set up by the winding of the relay depends entirely upon the amount of current going through the winding, which is governed by the battery voltage. However, the same general results may be secured by using a permanent magnet to create one of the magnetic fields that interact to give the resultant selection.

The modification of my invention shown in Fig. 9 is very similar to that shown in Fig. 4. However, in this case instead of the differential relays being connected in multiple, both windings are connected in series. From this it will of course be obvious that some windings may be connected in series and some in multiple, or either the upper and lower windings may be connected in series or in multiple, or a combination of both. So far as the operation is concerned, the functioning of this circuit is identically the same as that before described. That is, the operator at the control station by operating one of the buttons 801 to 810, inclusive, can bring about the selection of any one of the selecting relays 814 to 823, inclusive. In this instance, it will be noted that there is no key such as key K—5 or K—2. However, the operation is essentially the same. It will be assumed that it is desired to operate the selecting relay 818. In order to accomplish this result, the operator at the control station will operate the push button 805. By this operation a certain amount of resistance is included in the control circuit so that the conductance thereof is altered a sufficient amount to bring the current flow through the upper winding of the relay 818 to the proper amount so that the magnetic field created by the upper winding of the relay 818 is sufficient to balance the magnetic field created by the current flow through the lower winding. The lower windings of the differential relays are energized by the operation of the relay 813, which is in series with the circuit of the upper windings of these relays. The relay 813 is provided so as to reduce the amount of current consumed from the battery. It will be appreciated that while there is the same amount of current flowing in each circuit, that the balanced magnetic condition of the relay depends upon the number of ampere turns or, rather, upon the relative number of ampere turns of one relay as compared with another. By properly proportioning these

ampere turns, the same result can be accomplished as before, that is, it will be possible to select any one of an unlimited number of relays by simply altering the conductance of the control circuit, that is, an electrical characteristic thereof.

Returning now to the operation of the selecting circuit, since the magnetic field created by the windings of the relay 818 are equal and in opposition to one another, the armature 826 is retracted while the similar armatures of all the other relays 814 to 817, inclusive, and 819 to 823, inclusive are all energized and there is a circuit completed which extends from ground by way of armature 827 and its front contact, armature 826 and its back contact, to conductor 828. The connection of ground to the conductor 828 may perform any desired function.

It will be seen that the same results can be secured by connecting the windings of the selecting relays in series or in a series parallel arrangement as when they are connected in multiple, though the latter is probably the preferable way. This series arrangement is not effected by a variation in battery voltage, since both windings of the relay are supplied with the same battery, and it is not until a balance of magnetic forces is obtained that any relay is selected.

I shall now describe the modification of my invention shown in Fig. 10, in which alternating current is employed to control or govern the selection. In order to do this, it will be assumed that the operator at the control station desires to bring about the selection of the relay 925. To accomplish this result, the operator will depress the push button 901. By this operation the grid circuit of the oscillator 913 is completed with a certain amount of inductance 900 in the circuit. This grid circuit may be traced from the filament of the oscillator 913, conductor 911, a portion of the inductance 900, push button 901, line conductor 912, transformer 914, to the grid of the triode. The oscillating circuit is now complete and the triode 913 begins to oscillate at a frequency determined by the impedance of the grid circuit, which is controlled by the value of the inductance 900 that is cut into circuit. It will be obvious, of course, that instead of employing a variable inductance 900, a variable capacitance or impedance may be employed with substantially the same results. The frequency at which the triode 913 alternates or oscillates with the push button 901 depressed is the frequency at which the tuned circuit containing the alternating current relay 925 is adapted to respond. The operation of the relay 925 brings about the application of ground to conductor 950. The connection of ground to conductor 950 may perform any desired function.

It will be seen that, by operating any one of the push buttons 901 to 910, inclusive, that any one of the selecting relays 925 to 934, inclusive, may be separately and selectively operated, since there is a frequency of oscillation of the triode 913 for each push button 901 to 910, inclusive.

By this circuit arrangement, it is possible to bring about the selection of any one of a plurality of electro-responsive devices by governing the frequency of alternating current from a remote point to control the selection. The frequency of oscillation of the triode 913 is controlled absolutely from the control station, the alternating current flowing over the line conductors 911 and 912 and through that portion of the inductance 900 that is cut in the circuit.

It will be understood that, while I have illustrated and described my invention as resulting from and being secured by the effects of interacting electrical forces, this is not the only method of obtaining the desired results, and other methods of operation will be apparent to those skilled in the art.

From the foregoing, it will be observed that I have provided instantaneous and positive means for selecting any one of a plurality of devices over a single circuit in a cheap and highly satisfactory manner.

While I have shown my invention simply in its least complex form as a selecting system it will be understood that the invention is capable of use in a highly advantageous manner throughout the whole selecting field; for example, telephony, telegraphy, supervisory control, train control, fire alarms, printing telegraph systems, annunciator systems etc.

It will be understood that while I have shown certain specific embodiments of my invention, that I do not desire to be limited to these embodiments, but desire to secure and protect, by Letters Patent, such changes, modifications and departures as come within the scope of the appended claims.

I claim:—

1. In a selective signalling system, a Wheatstone bridge circuit including a first variable current leg permanently connected to a second variable current leg which includes a variable resistor and a relay, a first constant current leg permanently connected to the free end of said first variable leg, a second constant current leg permanently connected to the free end of said first constant leg and containing a plurality serially related sections, a plurality of electromagnetic relays, a common terminal for said relays permanently connected to the junction of said first and second variable current legs, connections between the free ends of said relays and said constant leg sections, a source of current, a normally closed connection between one terminal of said source and the junction of said first and second variable legs, a connection between the other terminal of the source and the free terminal of the relay a normally open switch in said second variable leg, closed to operate the relay in said second variable leg, means controlled by said relay for opening the normally closed connection between one terminal of said current source and the junction of said first and second variable current legs and for substituting a connection from said first terminal to the junction of said first variable and said first constant legs, and means simultaneously controlled by said relay for establishing a connection from the other terminal of said current source to the free end of said second constant leg to thereby energize said bridge circuit.

2. In a selecting system a plurality of selecting relays having one of their terminals connected to a common point, a resistance to spaced points of which the other terminals of said relays are connected, a second resistance connected between said common point and one end of said first resistance, a line wire connected to the said common point, a relay, a second line wire connected to one terminal of said relay, a source of direct current, a connection between one terminal of said source and said common point, a connection between the other terminal of said source and the other terminal of said relay, means for closing a circuit between said line wires to energize said relay, and

means controlled by the relay for erasing the connection between one terminal of said current source and said common point and for substituting a connection between that terminal of said current source and the junction of said first and second resistances to thereby prepare said selecting relays for selective operation over said line circuit.

3. In a selecting system a plurality of selecting relays having one of their terminals connected to a common point, a resistance to spaced points of which the other terminals of said relays are connected, a second resistance connected between said common point and one end of said first resistance, a line wire connected to the said common point, a relay, a second line wire connected to one terminal of said relay, a source of direct current, a connection between one terminal of said source and said common point, a connection between the other terminal of said source and the other terminal of said relay, means for closing a circuit between said line wires to engage said relay, means controlled by the relay for erasing the connection between one terminal of said current source and said common point and for substituting a connection between that terminal of said current source and the junction of said first and second resistances, and means also controlled by said relay for establishing a connection between said other terminal of said source and the free end of said first resistance, said relay controlled means together preparing said selecting relays for selective operation over said line circuit.

4. In a selecting system, a first station, a plurality of relays at said station, a second station, a number of keys at the second station corresponding in number to the number of said relays, a single circuit connecting said stations, a source of current at said first station, means at the second station for closing said circuit, means at the first station responsive to the closure of said circuit for connecting said source to said relays, and means operating at a substantially constant voltage as a result of the operation of any one of said keys at said second station controlled over said circuit and including said source of current for operating any predetermined one of said relays to the exclusion of the remainder.

5. In a selecting system, a first station, a plurality of relays at said station, a second station, a number of keys at the second station corresponding in number to the number of said relays, a single circuit connecting said stations, a source of current at said first station, means at the second station for closing said circuit, means at the first station responsive to the closure of said circuit for connecting said source to said relays, means responsive to such connection for energizing all of said relays and means operated as a result of the operation of one of said keys at said second station over said circuit including said source of current for de-energizing the relay corresponding to the key operated to the exclusion of the remaining relays.

6. In a selecting system, a first station, a plurality of relays at said station, a second station, a number of keys at the second station corresponding in number to the number of said relays, a single circuit connecting said stations, a source of current at said first station, means at the second station for closing said circuit, means at the first station responsive to the closure of said circuit for connecting said source to said relays, means responsive to such connection for energizing all of said relays and means operated as a result of the

operation of one of said keys at said second station over said circuit while said circuit is maintained closed including said source of current for de-energizing the relay corresponding to the key operated to the exclusion of the remaining relays.

7. In a selecting system, a first station, a plurality of relays at said station, a second station, a number of keys at the second station corresponding in number to the number of said relays, a single circuit connecting said stations, a source of current at said first station, means at the second station for closing said circuit, means at the first station responsive to the closure of said

circuit for connecting said source to said relays, means responsive to such connection for energizing all of said relays and means operated as a result of the operation of one of said keys at said second station over said circuit including said source of current for de-energizing the relay corresponding to the key operated to the exclusion of the remaining relays, said last named means being operated independently of individual voltage variation characteristics thereof, and means at said first station for registering the operation of the relay operated.

JOHN E. GARDNER.

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