

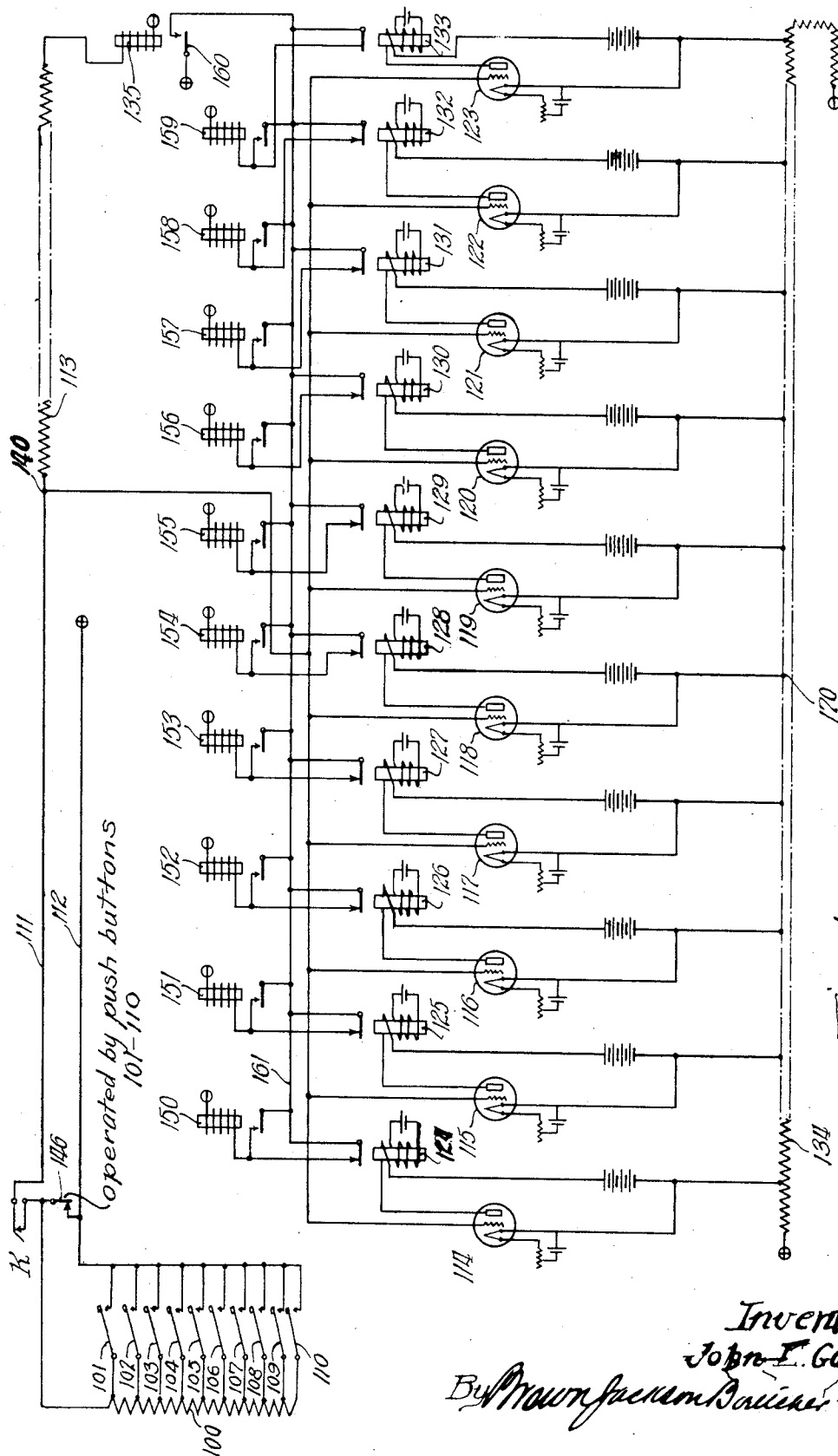
Nov. 27, 1934.

J. E. GARDNER

1,982,290

SELECTING SYSTEM

Original Filed Dec. 24, 1927 2 Sheets-Sheet 1



Inventor
John E. Gardner
By *Wm. J. Baker* Attorney
Attys

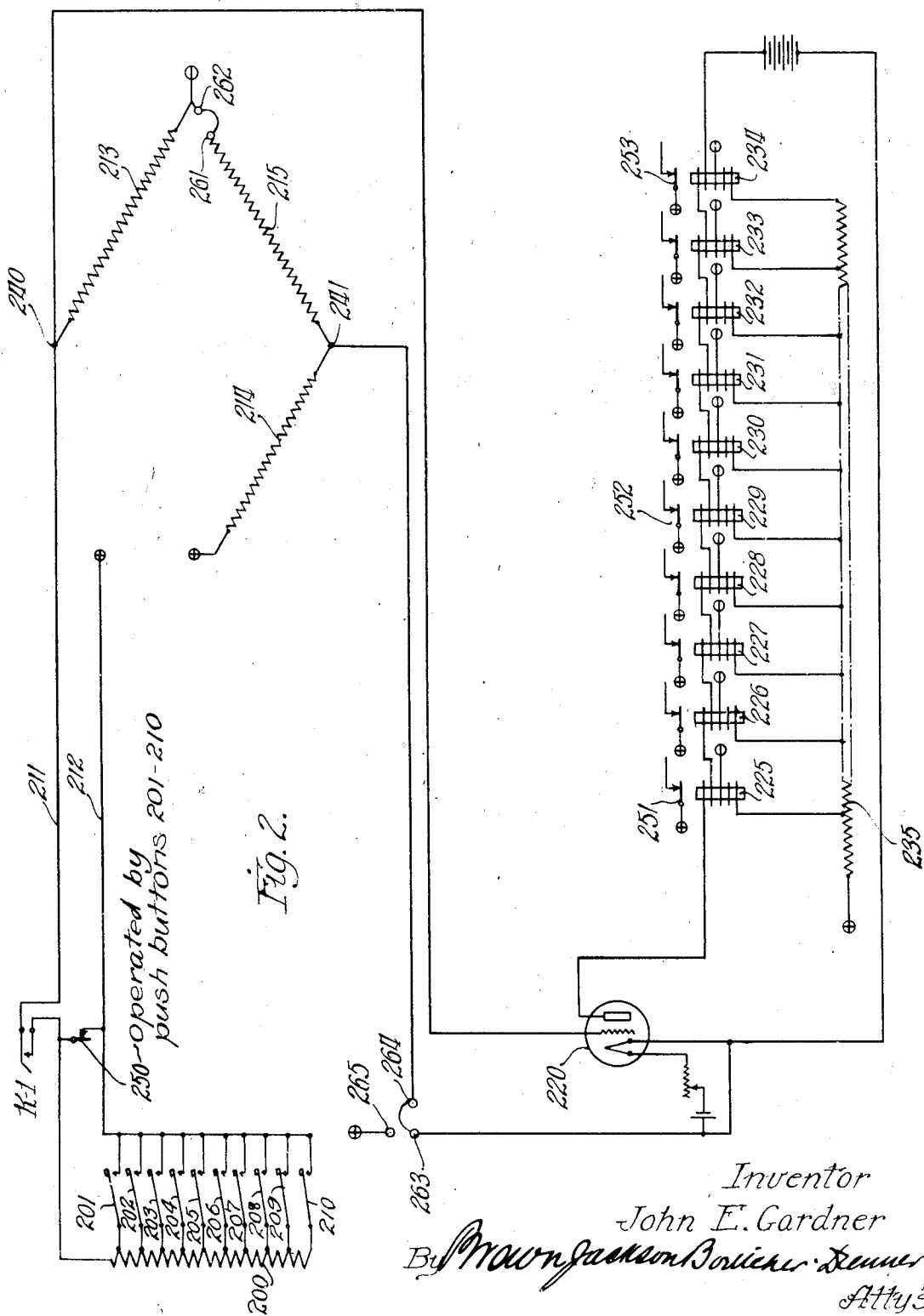
Nov. 27, 1934.

J. E. GARDNER

1,982,290

SELECTING SYSTEM

Original Filed Dec. 24, 1927 2 Sheets-Sheet 2



UNITED STATES PATENT OFFICE

1,982,290

SELECTING SYSTEM

John E. Gardner, Chicago, Ill.

Application December 24, 1927, Serial No. 242,485

Renewed June 16, 1933

5 Claims. (Cl. 177—353)

My invention relates in general to selecting systems.

One of the objects of my invention is to provide a method of instantaneous selection over a single circuit employing the voltage drop in that circuit.

Another object is to provide a method of instantaneous selection over a single circuit that may be employed over long distances.

Another object is to provide a method of instantaneous selection over a single circuit whereby a number of selecting devices may be connected into the circuit indiscriminately without any interacting effect of one on the other.

Another object is to provide a method of instantaneous selection which may be applied without change to any of the selecting arts such as automatic telephony, printing telegraphy, remote control of power apparatus, remote measuring, etc.

There are other objects of my invention which, together with the foregoing, will be described in the detailed specification which is to follow taken in conjunction with the accompanying drawings forming a part thereof.

In my prior invention disclosed in my copending application, Serial No. 211,101 filed August 6, 1927, I have disclosed a method of making a positive selection instantaneously over a single circuit.

In this prior application a variation in the conductance of the circuit is made use of and the amount of current flowing in the circuit determines the selection. In a system of this character, the selecting devices cannot be added into the selecting circuit indiscriminately since the addition of any selecting device alters the whole circuit. Thus, if there are ten selecting stages and an additional selecting stage is added, the addition of the last makes it necessary to modify the controlling device so as to compensate for its inclusion into the circuit. In the present instance selecting devices may be added into the circuit without any appreciable effect of one upon the other being produced. This result is secured in the present

instant by employing a variation in potential in the electric circuit instead of the variation in current. Obviously in said prior application since a change or variation in the electrical characteristics of the circuit is used to control the selecting devices more particularly the conductance, the amount of current flow in the circuit changes. Since the selecting devices are operated directly by this current flow, the addition of any new selecting device into the circuit changes the circuit so that the whole selecting circuit must be modified

to enable the various selecting devices to work harmoniously together. In the present instance the instantaneous selection is secured by a change in electrical characteristics of the circuit, namely, the conductance, the same as before. However, a function of this change in conductance is the voltage drop or variation. Potential operated selecting devices are employed. Consequently, all that is necessary is to secure a variation in potential. Since no current is consumed from the controlling circuit as many selecting devices may be individually operated or controlled as is necessary or desirable. The present invention makes use of a similar principle of selection wherein opposing electrical forces are set up and the main circuit is variously controlled so that the opposing forces may be equalized selectively to produce the proper selection.

Referring now to the drawings comprising Figs. 1 and 2, I have shown by means of the usual conventional diagrams sufficient apparatus and circuits to enable my invention to be readily explained and understood.

In Figure 1, in the upper left hand corner of the sheet is shown a resistor 100, which is connected to a series of ten push buttons, ten push buttons representing ten selections. Each push button is adapted to insert a predetermined amount of resistance in the circuit comprising the conductors 111 and 112 extending to the point at which the selection may be made which might be termed the central station. At the central station a Wheatstone bridge circuit is employed. This bridge is made up of the resistor 113, the resistance of the winding of the relay 135, the line conductors 111 and 112 and whatever portion of the resistor 100 that is included in the circuit and the resistor 134. Thermionic devices 114 to 123 are provided and have their control or grid circuits all connected in multiple. The filament circuit of the thermionic devices is energized from a plurality of batteries. The output circuit of each of these thermionic devices includes the upper winding of the selecting relays 124 to 133, inclusive, the lower winding of these differential relays being completed by means of a local circuit. The current flow in the lower winding of all these relays is identically the same or substantially so. The current flow through the lower windings of these relays is equal and opposite in direction to the current flow through the upper winding of the relays when there is zero difference in potential between the filament and grid of the respective thermionic devices with which they are associated. The purpose of this differ-

ential winding is merely to provide a zero point in the circuit. That is, considering the operation of a thermionic tube when there is zero potential difference between the grid or control electrode and the filament a certain amount of electrons pass from the filament to the plate or output electrode of the device. When the grid potential is negative with respect to the filament, lesser number of electrons pass from the filament to the plate while when the grid circuit is positive with respect to the filament, a greater number of electrons flow from the filament to the plate. In the present circuit the thermionic devices are so constructed that the tubes or devices operate on what is known as a straight part of the curve, that is, the current output of the tube is directly proportional to the potential positive or negative impressed upon the grid. It will be seen that the filaments of the thermionic devices are connected at various points along the resistor 134. This is for the purpose of biasing the grid of the various thermionic devices as will be explained.

In Fig. 2 a somewhat different form of potential operated selecting device is employed. In the upper left hand corner of the sheet is shown a resistor 200 corresponding to the resistor 100 previously described. Push buttons 201 to 210, inclusive, are associated with this resistor. A key K—1 is employed associated with this resistor at the sending station to close the line circuit. This key may be of any usual or well known type and locks in the position to which it is operated. The line conductors 211 and 212 extend to the central office where a Wheatstone bridge circuit is connected to the line conductor. This Wheatstone bridge circuit comprises the resistors 213, 215, 214 and the line conductors 211 and 212 and whatever portion of the resistor 200 is connected in the circuit. Across the mid points of the Wheatstone bridge is connected a thermionic device 220. This thermionic device may be of any usual or well known type. It will thus be seen that whatever potential difference exists between the points 240 and 241 on the bridge will be impressed upon the grid circuit of the thermionic device 220. A plurality of differential relays 225 to 234, inclusive, have their upper windings included in a series circuit and are connected to the output circuit of the thermionic device 220. The lower windings of these relays 225 to 234, inclusive, are connected at various points along a resistor 235. These relays unlike the relays 124 to 133 of Fig. 1, each has a different amount of current flow through their lower winding. The number of selections depends upon the output capacity of the thermionic device, the current variation of the device along a straight line curve and the sensitivity of operation of the differential selecting relays 225 to 234, inclusive. Having briefly described the apparatus shown in the drawings, I shall now explain its detailed operation with respect to Fig. 1.

While in the drawings a plurality of batteries have been shown, it will be understood that the energy may be derived from a common source in any usual or well known manner.

It will be seen that the selecting circuit includes the resistor 113 and the resistor 134 at the central station. The selecting devices or thermionic devices 114 to 123, inclusive, are bridged between the resistors 113 and 134. Considering the thermionic device 123, it will be seen that there is zero difference of electrical potential between the grid and the filament when the proportion of the

resistor 113 to that portion of the resistor 134 to which the filament of the thermionic device 123 is connected is the same as the proportion of the resistance of the conductors 111 and 112 plus a portion of the resistor 100 is to the portion of the resistor 134 extending from the connection of the thermionic device 123 to the positive side of the battery. Under these conditions, it will be seen that a Wheatstone bridge is formed with the resistor 113 forming the first leg, a portion of the resistor 134 extending to the thermionic device 123 constituting the second leg, the line circuit comprising conductors 111 and 112 and whatever portion of the resistor 100 is included in the circuit comprising the third leg and that portion of the resistor 134 extending from the thermionic device 123 to positive battery comprising the fourth leg. Thus with respect to the thermionic device 122 there is zero potential difference between the grid and the filament when the proportion of the resistor 113 to that portion of the resistor 134 extending to the filament connection of a thermionic device 122 is equal to the proportion of the conductance of the control circuit extending to the sending device to that portion of the resistor 134 extending from the connection of the filament of the triode 122 to positive battery. In a like manner zero potential difference can be obtained between the grid and the filament of any one of the thermionic devices 114 to 123, inclusive. It is to be noted, however, that the proportions of the bridge to secure the zero potential values are different. Consequently when the potential difference between the grid and the filament of any one thermionic device is zero, the remaining thermionic devices are all different either having a positive or negative potential applied to the grid with respect to the filament. The thermionic devices 114 to 123, inclusive, are essentially voltage operated and controlled, that is, the potential of the grids controls the current flow through them, there being substantially no current flow from the filament to the grid. Thus obviously other thermionic devices such as 114 may be added without effecting the control circuit extending to the said sending base. In fact, as many duplicate sets of ten selecting devices might be inserted into the circuit as desired without there being any inter-action between them. It will be seen that the upper winding of each of the selecting relays 124 to 133, inclusive, is included in the output circuit of one of the thermionic devices. The lower winding of these relays all have permanently a certain amount of current flowing through them in the opposite direction to the current flow in their upper winding. This differential current flow in their lower windings is for the purpose of securing a positive and negative operation. That is, in a thermionic device output circuit the current flow is essentially in one direction, the grid or controlling element merely modifying it. That is, to explain more fully, when there is zero potential difference between the filament and the grid, there is a certain normal current flow. When the grid potential is positive the current flow is greater. When the grid potential is negative the current flow is less. The purpose of this differential winding in each of the relays then is merely to balance out this normal current flow. So if when there is negative potential on the grid and less than normal current flow through the upper windings of these relays, the relays will attract their armature. By this arrangement, the relay operation occurs on both sides of the zero point. Since the normal

current flow through all the thermionic devices is substantially equal, the differential current flow through these relays is substantially the same.

It will be seen that the thermionic devices 114 to 123, inclusive, really have at all times a differential biasing potential upon the grid circuit more or less in the nature of the bias put upon the grid by the usual C battery. The number of selecting devices, each selecting device comprising a thermionic device and its associated relay, that may be independently operated over a circuit of this nature depends entirely upon the capacity of variation of the thermionic device and also upon the sensitivity of the relay employed.

The number of push buttons employed at the sending station depends entirely upon the system of selection used in addition to the number of selections permitted by the type of thermionic device employed and the sensitivity of the associated selecting relays. Ten push buttons have been selected in the present instant merely for the purpose of illustration as in some systems of selection such as those employed in automatic telephony, the decimal system of numbering is made the basis of the selection.

The points on the resistor 100 to which various push buttons are connected is determined entirely by the manner in which the thermionic devices 114 to 123, inclusive, are connected, that is, the push button 101 is so connected to the resistor 100 that when it is depressed, the relative proportions of the bridge are changed so as to bring about a zero potential difference between the filament and the grid of the thermionic device 123. Obviously the absolute value of the resistance of this connection might vary within a wide range. This variation is controlled by the proportions of the resistor 100 that is cut into the circuit to the resistor 113 and also by the voltage of the battery employed. In a like manner, the push button 109 is so connected that the amount of resistance of the resistor 100 connecting into the circuit is such as to balance the said selecting circuit with respect to the thermionic device 122. The other push button connections are similarly made. Of course, it is desirable that these various thermionic devices be spaced in equal steps from each other in order to maintain the proper difference of selection. The potential of the point 140 to which the multiplied grids of the various thermionic devices are connected is determined entirely by the relative proportions of the resistor 100 and the resistor 113, as well as by the voltage of the battery in this circuit.

In order to describe the operation of this selecting circuit, it will be assumed that the operator at the sending station desires to bring about the selection of the selecting relay 124 and its associated registering relay 150. In order to accomplish this result, the operator at the sending station will depress the push button 101 after operating the key K. By the operation of the key K there is a circuit completed which extends from battery relay 135, the resistor 113, conductor 111, springs of key K, spring 146 and its resting contact and conductor 112 to ground. The potential at the point 140 depends upon the relative value of the resistance of the line loop circuit comprising conductors 111 and 112 and the resistor 113. It will be seen that the filaments of the various thermionic devices 114 to 123, inclusive, are connected along the resistor 134. The resistor 134 is connected directly across the battery and there is a certain potential drop along

the resistor. There is thus a certain potential impressed upon the filament of the various thermionic devices which is different in the case of each device. Since the resistor 134 is bridged across the terminals of the same battery that supplies current to the line loop circuit and the resistor 113, there is an electrical potential difference impressed between the grid and filament of various thermionic devices 114 to 123, inclusive. It is to be noted that the potential impressed upon the grids of all the various thermionic devices is the same while the potential impressed upon the filaments vary. As a result of this, the effective potential difference between the filaments and the grids of the various thermionic devices vary also. Under the present conditions with none of the resistors 100 included into the controlling circuit, substantially all the potential drop occurs across the resistor 113 and the potential at the point 140 is relatively high, the potential impressed upon the various filaments of the thermionic devices 114 to 123 all being lower. All the selecting relays 124 to 133, inclusive, are thus energized since the current flow in their upper winding is greater than the current flow in their lower winding, there being a positive potential impressed upon all the various grids and a greater current flow in the output circuits of the thermionic devices than normal when there is zero potential difference between the grid and the filament. The selecting relays 124 to 133, inclusive, are energized to attract their associated armatures whereby various points in the circuits of the registering relays 150 to 159, inclusive, are opened. The operation of the relay 135 serves to connect positive battery at armature 160 to the armatures of the various selecting relays 124 to 133, inclusive.

Now, when the push button 101 is depressed a certain portion of the resistor 100 is connected in the control circuit since the spring 146 is moved away from its resting contact by the operation of the push button 101 in any well known or approved manner. By the introduction of this portion of the resistor 100 into the control circuit, there is zero potential difference between the filament and the grid of the thermionic device 114. This is true since under these conditions, the relation of the resistor 113 to that portion of the resistor 134 extending to the filament connection of the thermionic device 114 is the same as the relation of that portion of the resistor connected into the circuit is to that portion of the resistor 134 extending from the positive side of the battery to the filament connection of the thermionic device 114. This relation is different with respect to all the other thermionic devices 115 to 123, inclusive. Since there is now zero potential difference between the filament and the grid of the thermionic device 114 the current in the plate or output circuit of this device becomes normal. Consequently the current flow in the upper winding of the differential relay 124 is the same though it flows in an opposite direction to the current flow in the lower winding of this relay and this relay is immediately deenergized. All the other differential selecting relays 125 to 133, inclusive, maintain their armatures attracted. This is true because the current flow through their upper windings is different from the current flow through their lower windings, which merely compensates for the normal current flow on zero voltage between the grids and the filaments of the various thermionic devices. The selecting circuit is now completed which extends

from ground by way of armature 160 and its front contact, armature of the selecting relay 124 and its back contact and relay 150 to battery. The relay 150 is thus operated to establish a locking circuit for itself through the conductor 161. When the push button 101 is restored to normal, the grid potential of the various thermionic devices is again altered to what it was when the key K was first operated and the selecting relay 124 again attracts its armature to open the point in the original energizing circuit of the relay 150. The latter relay is not deenergized until the key K is restored to normal at the sending station thereby opening the circuit of the relay 135.

It will now be assumed that the operator at the sending station desires to bring about the selection and operation of the registering relay 159. Since this occurs under the control of the selecting relay 133, the operator at the sending station will depress the push button 110. As a result of this operation, all of the resistor 100 is included into the line or control circuit. The potential at the point 140 is thereupon lowered to a value determined by the proportion of the control circuit to the resistor 113 and the relay 135. As a result of the operation of a push button 110 the constants of the selecting circuit are so changed that the relation of the resistor 113 to that portion of the resistor 134 extending to the connection going to the filament of the thermionic device 123 is the same as the relation of the resistor 100 to that portion of the resistor 134 extending from positive battery to the filament connection of the thermionic device 123 thereon. This brings about the establishment of zero potential difference between the grid and filament of a thermionic device 123 whereby the current flow in its plate or output circuit is brought to normal. The relation of the selecting circuit with respect to all the other thermionic devices 114 to 122, inclusive, is different and there is a difference of potential in each instant between the respective grids and filaments. Since the current flow in the plate or output circuit of the thermionic device 123 is restored to normal, the relay 133 is deenergized while all the other selecting relays 124 to 132 are maintained with their armatures attracted. There is a selecting circuit now completed for the registering relay 159 which extends from ground by way of armature 160 and its front contact, armature of the relay 133 and its back contact and relay 159 to battery. The registering relay 159 is energized to establish a locking circuit for itself to ground upon conductor 161.

It will now be assumed that the operator at the sending station desires to bring about the operation of the registering relay 154. In order to accomplish this result, he will operate his push button 105, after operating the key K. By the operation of the key K, the relay 135 is energized as are all the selecting relays 124 to 133, inclusive. The operation of the relay 135 serves to prepare such selecting circuits as before. Now when the push button 105 is depressed, a certain portion of the resistor 100 is included in the control circuit and the potential of the point 140 is again modified, so that there is zero potential difference between the filament and the grid of the thermionic device 118. This follows since the relation of the resistor 113 to that portion of the resistor 134 extending to the point 170 at which the filament of the thermionic device 118 is connected is the same as the relation of the conductors 111 and 112 including that

portion of the resistor 100 in the circuit is to the portion of the resistor 134 extending from positive battery to the point 170. Since there is zero potential difference between the grid and the filament of the thermionic device 118, the plate or output current is altered so that it is normal and the relay 128 is deenergized. Since the potential of all other filament connections are different the current flow in the output circuit of all the other thermionic devices 114 to 117, inclusive, and 119 to 123, inclusive, are different than normal and all relays 124 to 127, inclusive and 129 to 133, inclusive, maintain their armatures attracted. A selecting circuit is now completed for operating the registering relay 154 which extends from ground by way of armature 150 and its front contact, armature of selecting relay 128 and its back contact, and relay 154 to battery. The relay 154 is energized to establish a locking circuit for itself and to close any other selecting circuits such as that leading to an annunciator or other indicating device, or in fact, to cause any operation that is necessary or desired.

When the key K is released, the relay is deenergized and the selecting circuit restored to normal.

In this manner any one of the selecting relays 124 to 133, inclusive, can be operated independently of any other relay instantaneously. It will be seen that under certain conditions, the current flow in the output circuit of certain of the differential selecting relays is less than the current flow in their lower windings and it is sometimes the current flow in the lower windings that maintains the armatures of the relays attracted. For the best operation, it is desirable that the various selecting relays be constructed so that they are as sensitive as possible, in order to make a large number of selections at a given battery voltage. Since these relays are differential relays, it is also desirable that the winding be what is known as twin windings; that is, the wires of each winding being wound parallel on each relay. This form of construction practically does away with any danger of leakage effecting the operation. In fact by this construction, there is substantially no magnetic leakage.

Attention is directed to the fact that no current is consumed from the Wheatstone bridge testing circuit by any of the thermionic devices 114 to 123, inclusive, and their associated selecting relays 124 to 133, inclusive. The operation of this selecting circuit depends entirely upon a variation in potential. The amount of current flowing through the resistor 113 and the control circuit extending to the sending station is of no consequence except as it affects the potential at point 140. This potential is not dependent upon the absolute amount of current flowing in the control circuit but is only dependent upon the relative values of the resistor 113 and that portion of the resistor 100 that is connected into the circuit. This makes the selecting system very flexible and any value may be given the resistors 113 and 100 as are found desirable. The operation of the system is by potential drop only. In a like manner, the value of the resistance 134 is of no consequence since its only function is to place varying potentials upon the filaments of the different thermionic devices and these potentials are independent of current flow, depending entirely upon the points along the resistor to which the filaments of the various triodes are connected.

The number of selecting devices that may be operated independently of one another instantaneously over a single circuit is controlled entirely by the voltage of the battery included in the circuit of the resistor 113 and the control circuit and bridged across the resistor 134, the amount of current that can be obtained from the thermionic devices such as 114 that are employed and the sensitivity of the selecting relays 124 to 133, inclusive. The exact voltage difference impressed between the filaments and the grids for performing the selection, depends entirely upon the sensitivity of the relay employed for selection and the output capacity of the tube. For example, with one type of thermionic device, it may be found that a difference of one volt in grid potential will be sufficient to positively bring about the operation of the various selecting relays, this one volt difference in potential causing a considerable current change in the plate or output circuit. Thus the voltage would change from minus 5 volts to plus 5 volts which gives a 10 volt variation and 10 stages of selection at intervals of one volt each.

Particular attention should be directed to the fact that this selecting circuit is entirely voltage operated and no current is consumed from the control circuit. Thus, this selecting circuit is ideal for operation over long lines. In addition, the points along the resistor 100 to which the various push buttons 101 to 110 are connected may be separated by large values of resistance so that any variation in line resistance will have no effect on the circuit. The value of the resistor 100 is governed entirely by its relative value with respect to the resistor 113.

Particular attention should also be directed to the fact that as many more thermionic devices may be added as is desirable simply by connecting them in the same manner as shown. In this instance, of course, the resistor 134 would be extended as would the resistor 100. However, in this case, it is not necessary to change the setting of any one of the selecting devices that are in the circuit at the present time. This follows because there is no current used from the control circuit.

Sometimes it may be desirable to operate a plurality of these selecting circuits in parallel. In this instant it will be assumed that it is desirable to make the same selection to different points. This condition very often arises in printing telegraph work. In this instance, of course, the same operation is performed at different points. However, different operations may be performed as a result of the operation of the second selecting circuit if it is so desired. Since the thermionic devices are responsive to a change in potential, the addition of another set of selecting devices connected in parallel with the one shown will have no effect on the present circuit. When a push button is depressed at the sending station, the thermionic device and its associated selecting relay that corresponds to this push button will be operated to perform the proper selecting operation in both instances. In like manner as many more selecting circuits in parallel with the one shown may be used as is necessary or desirable.

It is also possible by so proportioning the relative values of the resistors 100 and 113 to add another selecting circuit and its corresponding resistors 113 and 134 to the control circuit without an appreciable effect on the one shown.

It will thus be seen that this method of selection is particularly advantageous since it is ex-

tremely flexible and various selecting devices may be employed without any interacting effect since the whole operation is controlled by a change in potential. It will be appreciated that this selecting operation is instantaneous as any one of an infinite number of devices can be instantaneously operated independent of the rest over a single circuit in a highly positive manner.

In Fig. 2 I have shown a preferred embodiment of my invention in which a single thermionic device is employed. However, while in this circuit a single thermionic device is employed and the same general results secured, the system of selection described in this figure is somewhat more flexible and may be desirable in many instances.

Referring now to Fig. 2, it will be seen that the resistors 213, 215, 214 and 200 together with the resistance of the line or control circuit comprising conductors 211 and 212 comprise a Wheatstone bridge. The thermionic device 220 which may be the usual type of vacuum tube is bridged between the points 240 and 241. From this arrangement it will be obvious that a positive or negative potential difference can be applied between the grid and filament of the thermionic device 220. By properly proportioning the relative values of the resistors 200 and 213 and 214 and 215, the range of variation of potential differences that may be applied between the grid and filament of the thermionic device 220 can be made substantially anything that is desired. The resistor 200 is connected to ten push buttons 201 to 210, inclusive, in such manner that when one of the push buttons is depressed a certain amount of the resistance 200 is included into the line or control circuit. The points along the resistor 200 to which these push buttons are connected is governed by the value of the desired potential differences to be impressed between the grids and filaments of the thermionic device 220. Ten selecting relays corresponding to the ten push buttons 201 to 210, inclusive, are connected in the plate or output circuit of the thermionic device 220. These ten selecting relays are the relays 225 to 234, inclusive. The relays 225 to 234, inclusive, are of the differential type having two windings, the current flow in one winding adapted to set up a magnetic field that opposes the current flow in the other winding. In order to minimize leakage these relays should be constructed in the same manner as the relays 124 to 133 previously described, that is, with so-called twin windings. It will be noted that the lower windings of these relays are permanently energized by being connected in circuit with the resistor 235, each winding being connected at a different point on the resistor. These connections determine that the current flow through the lower windings of these relays alters in steps, which for best operation should be equally spaced. For example, if there are one hundred milliamperes of current flow through the lower winding of the relay 225 and ninety milliamperes of current flow through the lower winding of the relay 226, the current flow in the lower windings of the remaining relays should go down in ten milliamperes steps. It will be seen that the upper windings of these selecting relays are all connected in series, while the lower windings are connected in what might be termed a parallel arrangement. This arrangement is merely arbitrary and may be changed as desired depending entirely upon which type of connection whether series parallel combinations or parallel combina-

tions give the best results in a given instance.

While the circuit has been shown as being constantly supplied with batteries at all times, it will be appreciated that a relay may be connected in a manner similar to that shown in Fig. 1 to energize the bridge testing and selecting circuits in the same manner as before described.

In the circuit shown with the key K—1 in an open position, it will be seen that there is a certain potential difference between the grid and filament of the thermionic device. This will cause a certain current flow in the plate or output circuit which includes the upper winding of the selecting relay. This might be described as the normal current flow. This current flow should be different than the current flow flowing in the lower winding in any of the selecting relays, so that they will all remain energized at this time. If necessary, one selecting space may be left blank at this point of normal current flow and another one added to make up the number of stages of selection required. In this type of selecting circuit, the points to which the push buttons 201 to 210, inclusive, are connected are so calculated with respect to the resistor 213 and to the resistors 214 and 215 that the potential impressed between the grid and filament by the operation of the push buttons in sequence are such that the current flow in the output circuit including the upper windings of the selecting relay vary so that the current flow in the upper winding of the first selecting relay 225 is exactly equal to the current flow in the lower winding of this relay and with the second push button 202 depressed exactly equal to the current flow in the lower winding of the relay 226. When these conditions are met, one of the selecting relays will be deenergized whenever the corresponding push button is depressed while all the other selecting relays will remain with their armatures attracted. These selecting relays may complete circuits for registering relays in the same manner as shown on Fig. 1 or may perform any other desired selecting function.

In order to describe the operation of the selecting circuit it will first be assumed that the operator at the control or sending station desires to bring about the operation of the relay 225 instantaneously and independent of any other of the selecting relays. In order to accomplish this result the operator at the control station will depress the key K—1 which locks in position. By this operation, there is a circuit completed so that the Wheatstone bridge selecting circuit becomes effective. That is, as soon as the key K—1 is depressed there is a circuit extending from positive battery to negative battery through the resistor 213 and a certain potential difference is impressed between the grid and the filament. Until this time there is no potential between the filament and the grid since there is no potential upon the point 240 except the negative potential of the battery. This potential brings about a certain alteration in the current flow in the output circuit of the thermionic device. However, this current flow should meet the same requirements as the normal current flow meets, that is, in none of the selecting relays should the current flow in the upper windings under these conditions be the same as the current flow in the lower windings.

Now, when the operator at the sending station depresses the push button 201, the springs 250 are opened and the resistor 200 has a portion of itself included in the circuit. By this operation

a certain potential difference is impressed between the filament and the grid because the electrical potential at the point 240 is changed while the potential at the point 241 remains constant. The difference between these two potentials whether positive or negative places a positive or negative potential difference between the filament and the grid and alters the current flow in the output circuit of a thermionic device 220 so that the current flow in the upper winding of the relay 225 is exactly the same and in opposite direction to the current flow in the lower winding of this relay. The relay 225 is immediately deenergized. Under these conditions the current flow in the upper windings of the various other selecting relays is the same as in the upper winding of the relay 225, while the current flow in the lower windings of the various other selecting relays are all different and the remaining selecting relays 226 to 234 all maintain their armatures attracted. A selecting circuit may be completed by the deenergization of the relay 225 by way of armature 251 and its back contact to accomplish any desired results. When the push button 201 is released the control circuit is restored to normal and the selecting relay 225 is again operated and maintains its armature in the same energized condition as all the other selecting relays.

It will now be assumed that the operator at the sending station desires to bring about the selection of the selecting relay 234 independent of any of the relays 225 to 233, inclusive. To accomplish this result, the operator depresses the push button 210. As a result of this operation the potential at the point 240 is again altered with respect to the point 241, so that there is a certain potential placed upon the grid of the thermionic device and the current flow in the plate or output circuit is altered so that the current flow through the upper winding of the relay 234 is exactly equal and opposite to the current flow through the lower winding of this relay. The relay 234 is immediately deenergized while the other selecting relays 225 to 233, inclusive, being unbalanced maintain their armatures attracted. The operation of the relay 234 brings about the retraction of the armature 253 and the completion of a selecting circuit at this armature and its back contact which may be used to accomplish any desired function. When the push button 210 is released the potential between the grid and the filament of the thermionic device 220 is again altered as is the current flow in the plate or output circuit including the upper windings of the selecting relays 225 to 234, inclusive. All the selecting relays are immediately energized to attract their armature, that is to say, the armature 253 is again attracted and the armatures of the remaining relays 225 to 233 remain in the same condition as they were before.

It will now be assumed that the operator at the sending station desires to bring about the selection of the relay 229. In order to accomplish this result, he will depress the push button 205. This operation changes the potential to point 240 so that the current flow through the upper winding of the relay 229 is exactly equal and opposite to the current flow in its lower winding. In all the other selecting relays 225 to 228, inclusive, and 230 to 234, inclusive, the unbalanced condition prevails and these relays maintain their armatures attracted. The relay 229 retracts its armature 252 to complete a selecting circuit at its back contact which may perform any desired function.

When the push button 205 is released the normal conditions of the circuit are restored with the armatures of all the selecting relays energized.

In this manner it is possible to operate any one of the ten selecting relays individually in an instantaneous and positive manner by pressing the corresponding push buttons at the sending station.

It will be obvious that as many stages of selection may be employed as is desired. In fact, the number of stages of selection that may be made in this manner is governed only by the voltage of the battery in the Wheatstone bridge testing circuit, the capacity of the tube and the values of the resistors such as 200, 213, 214 and 215 comprising the selecting circuits.

Since this selecting circuit is purely a potential operated device so far as the Wheatstone bridge testing circuit is concerned, a plurality of these thermionic devices such as 220 with their associated selecting relays may be connected in multiple between points 240 and 241 without effecting the operation in any way except that when one push button is depressed there will be corresponding operation in the selecting relays associated with the various thermionic devices that are connected between the points 240 and 241. Also because this selecting circuit is a potential operated one the only function of the resistor 200 and its associated push buttons is to alter the potential of the point 240. So depending upon the relative values of the resistor 213 and the resistor 200 and its associated control loop the points of the resistor 200 to which the push buttons 201 to 210, inclusive, are connected may be as widely separated as desired, so that any change in resistance in the line loop brought about by the natural changes that always occur will have no effect upon the selecting operation. Of course, it is possible to connect other resistors and similar push buttons in parallel with the resistor 200 and the push buttons 201 to 210, inclusive, at different points to control the selecting circuit. The selecting circuit may then be controlled separately from the different points in the same manner as already described. Of course, it is also possible to accomplish the same results with respect to the selecting circuit shown in Fig. 1.

It will be appreciated also that more selecting relays may be employed in the output circuit of the thermionic device 220 without effecting the resistance connections for the push buttons 201 to 210, inclusive. It being only necessary to add more resistors to bring about the proper current flow in the output circuit for the additional relays. The reason that more relays can be added in this circuit without effecting the operation of the other relays is because of the very high impedance of the tube as compared with the impedance of the relays.

While the resistor 235 connects and limits the current flow in the windings of the selecting relays in Fig. 2, it will be understood that it is probably most desirable to employ separate resistors of the proper value in the lower winding of each relay. When separate resistors are employed in the lower winding of each relay, other relays may be added in the circuit without any effect, though with one resistor employed, the addition of other relays drawing current through the one resistor reduces the amount of current flowing in the lower windings of the other relays proportionately. For this reason, it is desirable to employ a separate resistor in series with the lower

winding of each relay. Similarly resistor 134 of Fig. 1 may also be composed of separate individual units if desired.

In the circuit shown in Fig. 1, it will be seen that in order to bring about the proper selection, the Wheatstone bridge selecting circuit is balanced so that there is zero potential difference between the filament and the grid, while in the circuit shown in Fig. 2, no balance occurs. In the selecting circuit of Fig. 2, it is only necessary to bring the potential between the grid and filament of the triode 220 to the proper value in order to bring about the desired selection. That is, during the various steps of selection, the circuit is unbalanced at all times. Since the circuit shown in Fig. 2 is governed merely by the potential of the point 240, the resistors 214 and 215 in the above circuit may be entirely eliminated since it is possible to control the potential of the point 240 with respect to the battery simply by means of the resistor 200 and its associated push buttons.

In this instance, the connection between the terminals 263 and 264 would be removed and the terminal 263 would be connected to the terminal 265. In addition, the connection between the terminals 261 and 262 would be opened. Since the filament of the thermionic device 220 is connected to the positive terminal of the exchange battery which supplies energy to the control circuit, the potential of the point 240 with respect to the positive terminal of the battery will control the electromotive force impressed upon the grid of the thermionic device. The selecting circuit then no longer constitutes a Wheatstone bridge circuit, but is merely one in which the potential of the point 240 is altered. The operation of the selecting system in this instance is identically the same as that that has been described heretofore. The selecting relays 225 to 234, inclusive, having the current flow in their lower windings modified so that upon the different potentials impressed between the filament and the grid, there will be a balance obtained in a particular one of the selecting relays while all the other relays will be unbalanced. The potential of the point 240 is governed merely by the relative values of the resistor 213 and the portion of the resistor 200 that is connected into the control circuit comprising the conductors 211 and 212. The range of potential variation with respect to the point 240 is, of course, governed by the characteristics of the thermionic device 220 in an obvious manner. It will be seen that in this aspect of the invention, no balancing occurs at all. The electromotive force impressed upon the point 240 being the determining factor as it controls the amount of current in the output circuit of the thermionic device 220. In the previous form of the invention shown in Fig. 1, it was necessary to balance a bridge, while the present selection is obtained as a result of a variation in potential.

In order to make the maximum number of selections over a single circuit by using the selecting circuit shown in Fig. 2, it is desirable that the differential selecting relays 225 to 234, inclusive, be as sensitive as possible, so that they will maintain their armatures attracted on a small current unbalanced in their two windings. Better operation of these relays may also be secured if their cores are laminated.

It will be seen that the selecting system just described whereby it is possible to select a definite one of an infinite of selecting devices instan-

taneously and positively over a single circuit by means of potential variation in response to a modification in an electrical characteristic of the circuit is one capable of wide use in the selecting art. It will be obvious to those skilled in the various arts where the same may be advantageously applied.

Attention is directed to the fact that in Fig. 1 the method of selection consists in setting up in a plurality of relays 225-234 opposing electromagnetic forces and varying one of these forces, namely the forces produced by the relay coils that are in series with the plate circuit, to produce a balanced condition in the relay that it is desired to select. This is not exactly true in Fig. 2 since only the potential of the grid and filament circuits of the thermionic device 220 is controlled and this is accomplished by means of a variation in electrical potential between them. However, in this selecting circuit including the selecting relays, the method of selection consists of setting up the opposing forces as before.

Attention is also directed to the circuit of Fig. 2 wherein it will be appreciated that the filament of the thermionic device might be connected to an intermediate point on the battery instead of to its positive terminal. This is determined by the range of operation of the tube and the range of variation of electromotive force applied to the point 240.

It will be understood that while I have described certain specific embodiments of my invention that many changes, modifications, departures and deviations may be made without departing from the spirit and scope thereof, and I desire to protect by Letters Patent all such changes, modifications, departures and deviations as come within the scope of the appended claims.

I claim:—

1. In a selecting system, a plurality of differential relays, each having a plurality of windings, a multi element thermionic device associated with each relay, means for setting up equal potential differences between two elements in each of said devices, said means including a circuit extending through a second winding of the associated relay, a local circuit closed through a second of the windings of each relay to magnetize it, a circuit common to said devices, means for closing said circuit, and means controlled over said circuit for applying an electrical potential to a third element of each of said devices while said common circuit remains closed to cause a predetermined one of said devices to pass sufficient current through the first winding of the associated relay to balance the magnetization produced by the current in the local circuit of the relay and thereby effect an independent operation of that relay.

2. In a selecting system, a plurality of three element thermionic devices, a relay connected between two elements of each of the devices, means

for establishing a potential difference between each of said two elements of that device, means for applying a potential to the second elements of said devices which potential is different for each device, means for simultaneously applying a potential to the third elements of said devices, said potential balancing the potential on the second element of one of said devices to operate its relay to make a selection.

3. In a selecting system, a plurality of thermionic devices each having a filament, a grid and a plate, a differential relay for each device having one winding connection to the plate of the device, means for energizing the second windings of said relays to unvarying strength, said first and second windings being proportioned to balance each other magnetically when the grid of the associated device is adjusted to zero potential with respect to its filament, means for applying a different potential to the filament of each device, and means for applying the same potential to all of said grids simultaneously to thereby bring the potential of one of them to zero difference with respect to its filament.

4. In a selecting system, a fixed resistance, a variable resistance, a battery, a pair of line wires, a line circuit extending from one pole of said battery serially through said fixed resistance, the first of said line wires, said variable resistance and the second of said line wires to the opposite pole of said battery, a plurality of selective devices, an open circuit connection from said devices to the junction of said fixed resistance and first line wire, means for closing said line circuit, means including said variable and fixed resistances for altering the potential gradient in said line circuit to thereby impress a certain potential on said open circuit, and means responsive to the presence of that potential on said circuit for operating one of said selective devices.

5. In a selecting system, a relay, a fixed resistance, a variable resistance, a battery, a pair of line wires, a line circuit extending from one pole of said battery serially through said relay, said fixed resistance, the first of said line wires, said variable resistance and the second of said line wires to the opposite pole of said battery, a plurality of selective devices, an open circuit connection from said devices to the junction of said fixed resistance and first line wire, means for closing said line circuit, means including said variable and fixed resistances for altering the potential gradient in said line circuit to thereby impress a certain potential on said open circuit, means responsive to the presence of that potential on said circuit for operating one of said selective devices, and means controlled by said relay for maintaining said selective device operated.

JOHN E. GARDNER.