Oct. 13, 1942. N. I. HALL 2,298,695

SELECTING SYSTEM

Filed Feb. 8, 1941 3 Sheets-Sheet 1

FIG. 1

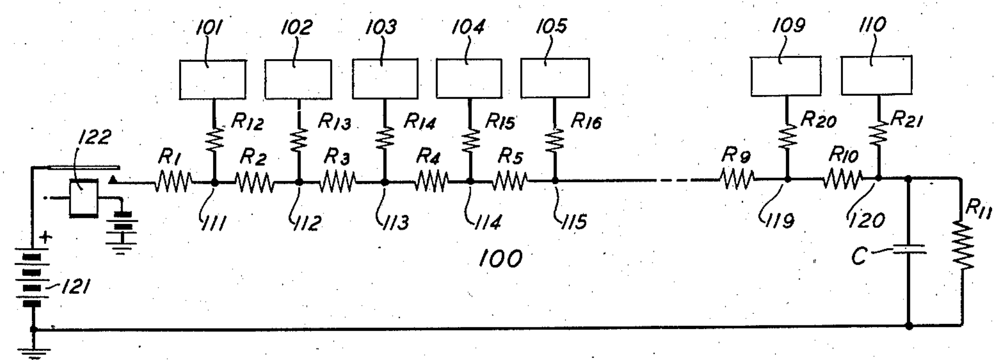
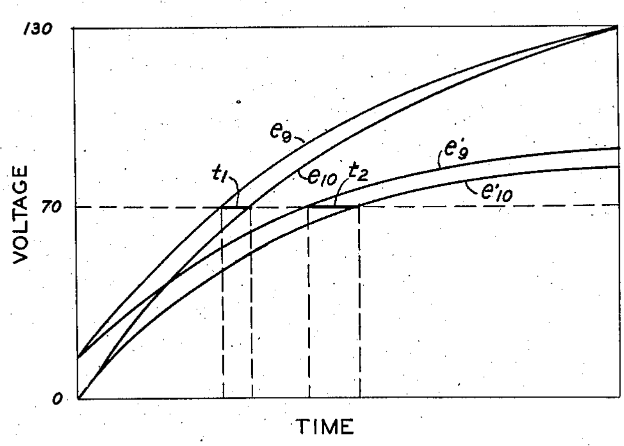


FIG. 4



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SELECTING SYSTEM

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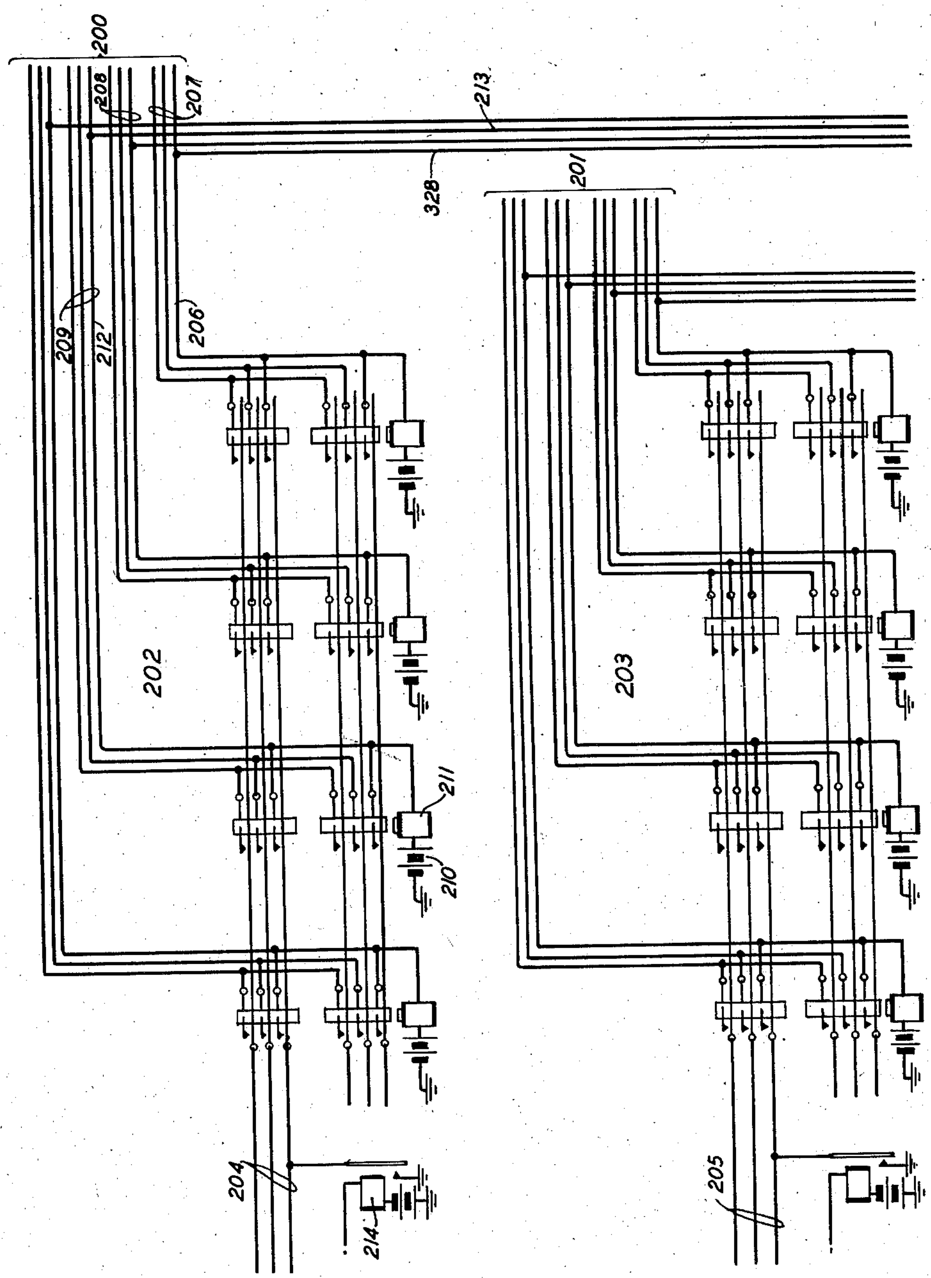
FIG. 2



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SELECTING SYSTEM

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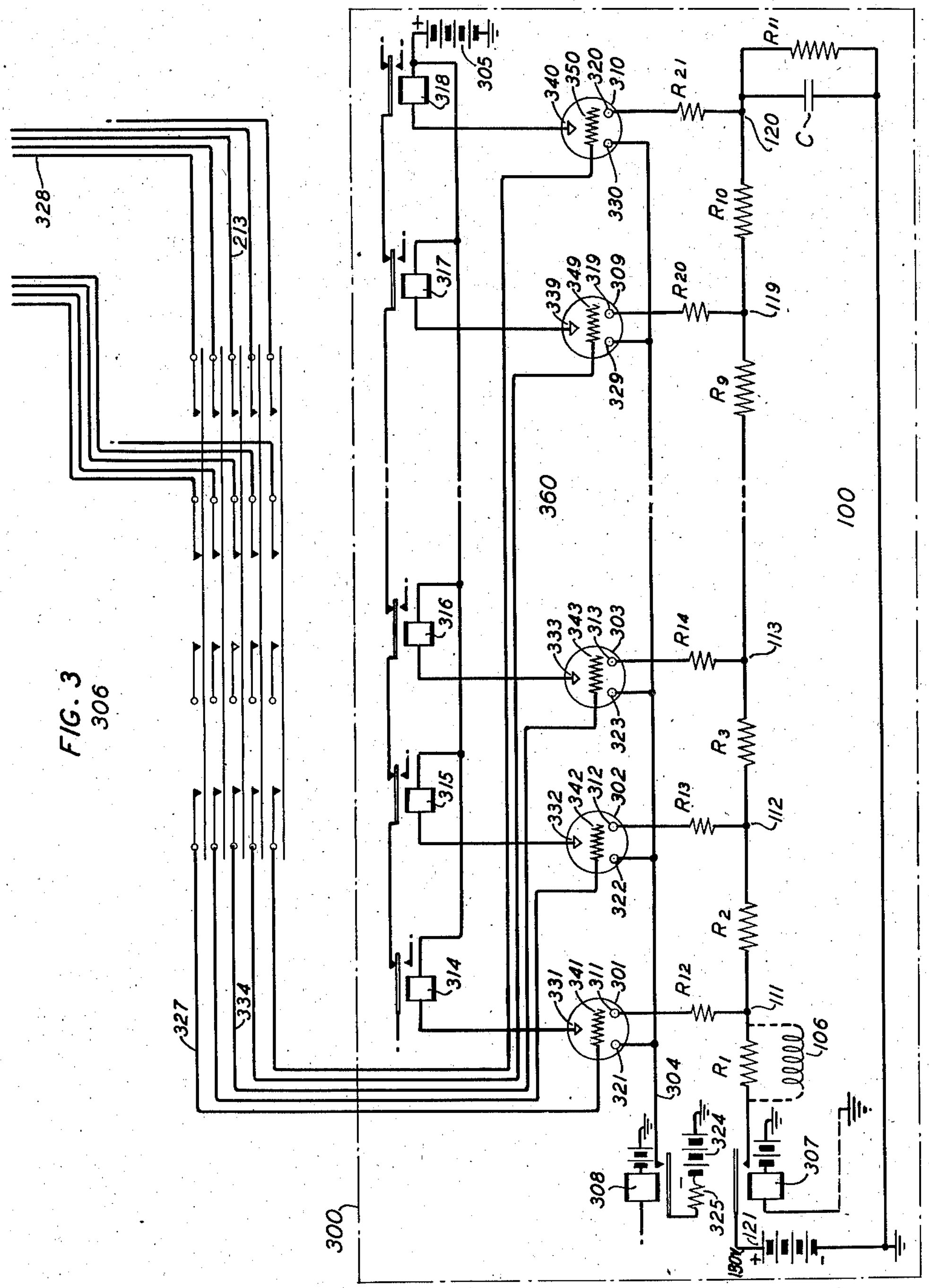

FIG. 3
306

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UNITED STATES PATENT OFFICE

2,298,695

SELECTING SYSTEM

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Application February 8, 1941, Serial No. 377,995

10 Claims. (Cl. 179—18)

This invention relates to selecting systems and particularly to systems in which the selective operations are performed automatically.

An object of the invention is to control the propagation of electric waves and to utilize these waves for selecting lines, trunks or other electrical circuits or devices.

Another object is to obtain greater uniformity in the rate at which these waves are propagated and consequently greater accuracy in the selecting operation.

Another object is to obtain a more useful spacing of the voltage values along the circuit on which the waves are propagated.

Another object is to simplify and otherwise to improve voltage controlled selecting circuits.

In accordance with this invention the foregoing and other objects are realized by means of a selecting system in which the lines, trunks, circuits or other devices of a group are tested in succession by a series of space-discharge devices or tubes which are rendered effective successively by propagating a voltage wave along an electric circuit and utilizing the progressing wave to ionize the tubes one after another. The tubes are connected respectively to the lines or other devices being tested; and, when each tube in turn is ionized by the voltage wave, a test is made of the associated line to determine its condition. When the first idle line is reached by this progressive test, the corresponding tube discharges, the line is chosen, and the remaining tubes are rendered unresponsive to the voltage wave, thereby preventing the testing and selection of a second line in the group.

A feature of the invention is a selecting system in which the voltage propagation circuit includes a plurality of resistors, one for each tube, connected in series with each other and in series with a common condenser. When the source of voltage is connected to this circuit, current flows through all of the resistors in series to charge the condenser. As the condenser charges a voltage of a predetermined value moves along the circuit from one resistor to the next, finally reaching the condenser. If the resistors are chosen at substantially equal values, the differences in voltage between successive resistors along the circuit will be substantially equal. This means that the successive tubes will receive their operating voltages consecutively and that no tube will be permitted to operate until after operating voltage has been applied to the preceding tube.

Another feature is a voltage propagating circuit in which a common resistor is connected in shunt to the common condenser. When so connected the common resistance shunts some of the current flowing through the series resistors, the remainder of this current serving to charge the condenser. Hence the rate of change, cause by the charging of the condenser, of the total current flowing through the series resistors is reduced by the presence of the shunt resistor. This increases correspondingly the time intervals required for the voltage wave to move from one tube to the next, the maximum effect taking place in the sections nearest the condenser where the voltage and time differences between sections tend to be smallest. These increased intervals are highly desirable since they afford adequate time for each tube to function before full operating voltage is applied to the succeeding tube.

These and other features of the invention will be discussed more fully in the following detailed specification.

In the drawings accompanying the specification:

Fig. 1 is a voltage propagating circuit including certain features of the present invention;

Figs. 2 and 3 disclose a testing and selecting system incorporating the voltage propagating circuit and other features and illustrating one of the numerous useful applications of the present invention; and

Fig. 4 is a graph showing certain relations existing in the voltage propagating circuit.

Systems have been proposed heretofore for the propagation of voltages along a series of circuit elements, such as resistances. These prior systems, however, are usually subject to certain disadvantages which detract from their effectiveness when employed for selecting voltage operated devices. For example, it is difficult in these prior systems to maintain uniform differences of voltage along the propagation circuit. In other words, the differences between successive points in one part of the circuit are less than those existing between corresponding points in another part of the circuit. Again it is difficult to obtain a uniform time rate of change of voltage along the propagation circuit. That is to say, the interval required for the voltage to rise to a given value at one point following the instant it reached said value at the preceding point in the circuit will vary in different parts of the circuit. With these disadvantages in a voltage propagating circuit it follows that responsive devices, such as space-discharge tubes, may operate falsely either because the voltage differences between successive tubes are not sufficient to insure the proper sequence of operation or because the rate of propagation of the operating voltage is so rapid that one tube in the series does not have sufficient time in which to operate before the operating voltage is applied to the next succeeding tube.

These advantages are overcome in the present system by means of the voltage propagating circuit above mentioned, which includes a single condenser connected in series with a plurality of resistance elements and a shunt resistance connected across the common condenser. The advantage of this circuit, as will be explained more fully hereinafter, is that a substantial voltage difference is maintained between all sections of the circuit and that the rate of propagation of the voltage wave is substantially uniform in all parts thereof.

Referring to the drawings, and first to Fig. 1, the voltage propagation circuit 100 comprises a plurality of resistors R_1, R_2, R_3, R_4, R_5 . . . R_9 and R_{10}, a condenser C, and a shunt resistance R_{11} connected across the terminals of the condenser C. While there may be any desired number of resistance elements in the series, it is assumed in the present disclosure that there are ten of these elements. The values of the resistors R_1 to R_{10} may be chosen to obtain the desired relation between the voltages present at the successive junction points 111, 112, 113, 114, 115, 119 and 120. Since the voltages at these junction points are utilized to operate voltage responsive devices 101, 102, 103, 104, 105, 109 and 110 it is desirable to maintain a substantial difference between the voltages at any two junction points, particularly as these voltages approach the value at which the responsive devices operate. The reason for maintaining a definite spacing of the voltage values from one resistance to the next is to enable the selection of any one of the voltage operated devices by testing these devices in sequential order. In particular, if the voltage operated devices 101 to 110, inclusive, are space-discharge tubes, it is desirable to maintain a certain difference of voltage between consecutive tubes so that the voltage applied to any tube is well below the operating value at the time operating voltage is being applied to the adjacent tube. For example, at the instant the voltage at the junction point 113 reaches the operating value of the tube 103 the voltage of junction point 114 should be sufficiently less than the operating value of tube 104 to insure against the false operation of the latter tube. This difference of voltage depends, of course, upon the value of resistance R_4 and the value of the current flowing therethrough at the time.

Since it may be assumed that the operating voltages of the devices 101 to 110 will in actual practice vary substantially, it is important that the voltage differences between successive devices should be maintained at a value sufficient to insure against false operation. With this end in view good results may be obtained by assigning the same resistance value to each of the intervening resistances R_2 to R_{10} and by making this value sufficiently high to safeguard against the false operation of any one of the devices 101 to 110. The value of the initial resistor R_1, which lies between the positive pole of the battery 121 and the first receiving device 101, is chosen with regard to the voltage of the source 121 and the operating voltage of the responsive devices. If, for example, the operating voltage of the devices 101 to 110 is substantially less than the full voltage of the battery 121, it may be necessary to make resistor R_1 high as compared with the resistors R_2 to R_{10} in order that the voltage applied to the responsive device 101 be somewhat below its operating value the instant after relay 122 is operated.

The purpose of the condenser C is to produce a diminishing flow of current in the circuit 100 following the closure of the relay switch 122. Upon the closure of this switch current flows through the resistors R_1 to R_{10} in series, whereupon it divides, part of it flowing into the condenser C, and the remainder flowing through the common resistor R_{11}. At the first instant following the closure of the circuit, condenser C being fully discharged, current of maximum value flows through the series resistors, and voltages of minimum values appear at the successive junction points 111, 112, 113, etc. However, as the condenser C accumulates its charge the current flowing in the circuit diminishes correspondingly, and the voltages at the successive junction points rise correspondingly. In effect, therefore, a voltage wave progresses along the series resistors, increasing at the successive junction points as the condenser C becomes charged. A voltage amplitude necessary to operate the responsive devices reaches the junction point 111 shortly after the circuit is closed and progresses from one resistor to the next until it finally reaches the junction point 120 shortly before condenser C assumes its fully charged condition. Since the resistors R_2 to R_{10} are equal in value a substantially equal voltage difference is maintained between junction points for different values of current flowing in the circuit. Although this voltage difference decreases as the condenser C charges, it is maintained sufficiently high by selecting the proper value for the series and shunt resistors to insure against false operation of the voltage responsive devices.

The common resistor R_{11} plays an important part in the voltage propagating circuit in that it approximately equalizes the voltage and time spacing in the various sections. Without resistor R_{11} the voltage and time differences between sections of the circuit decrease as the wave approaches the condenser. However, resistor R_{11} limits the final condenser voltage and thereby reduces the charging rate, the effect becoming greater as the charge increases. This in turn increases the voltage and time spacings in the end sections, and the result of these two opposing factors is that the spacing is nearly uniform in all sections of the circuit.

The effect of the common resistor R_{11} on the end section may be seen more clearly from the graph of Fig. 4. In the figure the curves e_9 and e_{10} represent the voltages at the junction points 119 and 120, respectively, when the common resistor R_{11} is omitted. These voltages increase with time until they reach the limiting value of the circuit. As these curves reach the ordinate value 70, which may be assumed to be the operating voltage of the responsive devices 109 and 110, they are separated by a time interval represented by the horizontal line t_1. When, however, the common resistor R_{11} is added, the curves e'_9 *and* e'_{10}, which also represent the voltages at junction points 119 and 120, respectively, rise at a substantially lower rate and approach a limiting value depending upon the resistances in the circuit. In this case the curves e'_9 and e'_{10} are separated by a substantially larger time interval t_2 at the instant they reach the ordinate value 70. The advantage of increasing the time spacing from t_1 to t_2 is that a longer interval is afforded for one voltage responsive device to operate before operating voltage is applied to the next succeeding device.

It will be noted that resistors R_{12}, R_{13}, R_{14}, R_{15}, R_{16}—R_{20}, R_{21} are included in circuit with responsive devices 101 to 110. These resistors serve to prevent lockouts or other interference with the operation of the responsive devices, particularly when discharge tubes are used.

Referring now to Figs. 2 and 3, a description will be given of the invention when applied to a system for testing and selecting lines, trunks or other circuits. Two groups of lines 200 and 201 are illustrated. The lines of these groups may be selected by corresponding switches 202 and 203, which may be switches of the well-known cross-bar type, or of any other type, to extend connections from incoming lines, such as the lines 204 and 205. The lines of the groups 200 and 201, and other groups not shown, are tested and selected by a common mechanism 300 which includes a circuit 100 for propagating a voltage wave for operating a series of test tubes 360. The voltage propagating circuit 100, which is the same as the one disclosed in Fig. 1, includes a source of potential 121, a series of resistors R_1, R_2, R_3—R_9 and R_{10}, and the common condenser C and resistor R_{11}. The successive junction points 111, 112, 113, 119 and 120 are connected through resistors R_{12}, R_{13}, R_{14}, R_{20} and R_{21} to the control electrodes 311, 312, 313, 319 and 320 of the discharge tubes 301, 302, 303, 309 and 310 of the group 360. The cathodes 321, 322, 323, 329 and 330 of these tubes are connected to the common cathode conductor 304. The anodes 331, 332, 333, 339 and 340 of said tubes are connected through the respective register relays 314, 315, 316, 317 and 318 to the common source of anode supply voltage 305. The control grids 341, 342, 343, 349 and 350 of the tubes 301, 302, 303, etc., are connectable to the test conductors of the groups of lines 200, 201, etc., undergoing test.

A connector 306 is provided for the purpose of connecting the common testing and controlling mechanism 300 to the desired group of lines. In any well-known manner the connector 306 may be operated at the desired time to connect the control grids of the series of tubes 360 to the test or sleeve conductors of the desired group, such as the group 200.

Following the operation of the connector 306 to connect the tubes 360 to the lines of the desired group 200, or at any suitable previous time, the relay 308 is operated to connect the negative pole of battery 324 through resistor 325 to the common cathode conductor 304. Also at any suitable time relay 307 is energized to close the voltage propagating circuit 100, and current flows through the series resistors R_1, R_2, R_3, etc., and into condenser C and through the common resistor R_{11}. As soon as current begins to flow in this circuit a positive potential appears at the junction point 111 which is added to the voltage of battery 324 to produce a voltage difference across the starting gap 311—321 of the first tube 301. As the condenser C continues to charge the voltage of the junction point 111 continues to rise until the voltage across the starting gap of the tube 301 reaches the ionizing value. Thereupon the starting gap ionizes, the tube is now in condition to transfer its ionization to the main anode 331 provided the proper potential exists on the control grid 341. It will be noted that the control grid 341 is connected over conductor 327 through the connector 306, conductor 328 to the test conductor 206 of the first line 207 of the group 200. If this line 207 is busy, it has the usual ground potential thereon, which may be applied from the closed contacts of relay 214 through the contacts of switch 202 to the test conductor 206. This ground potential is extended over the conductor 328 through contacts of connector 306 and over conductor 327 to the control grid 341 of the tube 301. Therefore, the ionization does not transfer to the main anode 331, and no current flows in the anode circuit to operate the relay 314 individual to this particular tube.

A moment later the voltage of junction point 112 rises to a value such that the voltage applied across the starting gap 312—322 is sufficient to ionize the tube 302. Similarly, if the second line 208 is busy ground potential appears on the control grid 342, and the tube 302 fails to discharge.

Assume, however, that the next line 209 is idle. Therefore, battery potential is applied from the positive pole of battery 210 through the winding of magnet 211, test conductor 212, conductor 213, connector 306, conductor 334 to the control grid 343 of the tube 303. When, therefore, the voltage of the junction point 113 rises to the proper value and the starting gap 313—323 ionizes, the tube 303 discharges its main gap, and current flows from the positive pole of battery 305 through the winding of relay 316, anode 333, cathode 323, conductor 304, contacts of relay 308, common resistance 325 to the negative pole of battery 324. Relay 316 operates in this circuit to register the idle condition of the line 209 in the group 200. The flow of current in the common resistor 325 alters the potential of the cathodes of all of the remaining tubes in the group 360 so that none of these tubes will ionize its starting gap in response to the voltage wave as it progresses along the circuit 100. Hence the first idle one of the lines in the group 200 is selected, and the remaining lines are protected against selection by rendering the tubes 360 unresponsive to the voltage wave. The operated relay 316, identifying the selected line 209, may serve in any well-known manner to cause the operation of switch 202 to seize the selected line.

In case all lines in the group 200 are found busy when the test is completed the circuit will wait until one of the lines subsequently becomes idle, after which the tube associated with this line immediately operates.

After the line has been selected and the switch 202 operated, or when the allowable time for testing has expired without finding an idle line, the connector 306 may be released to free the common mechanism 300 for use in testing other groups of lines.

A still further improvement in the time and voltage characteristics of the propagating circuit 100 may be had by connecting an inductance 106 of suitable value in parallel with the resistor R_1 as indicated in Fig. 3. When the circuit is first closed the inductance 106 presents a high impedance so that the value of the current which flows at the time of circuit closure depends upon the resistances in the circuit. However, as the rate of change of current diminishes with the charging of condenser C the inductive impedance of the element 106 correspondingly diminishes, and, since the resistance of this element is low when compared with the resistor R_1, more and more current is permitted to flow in the circuit 100. This increasing rate of current flow due to the decreasing impedance of the path through the element 106 serves to compensate for the condenser charging component, which becomes less and less as the condenser assumes its full charge. Therefore, the rate of change of the total current flowing through the series resistors is reduced correspondingly with the result that the voltage separation between successive resistors and the time rate at which the voltage wave is propagated are both improved substantially.

While the voltage propagating circuit has been illustrated herein in connection with the testing and selecting of lines, such as those used in telephone systems, it will be understood that this circuit may have a wide number of useful applications in systems whenever it is desired to utilize a voltage wave for operating responsive devices.

For a better understanding of the cross-bar switches illustrated herein and of the manner in which these switches are controlled and operated in telephone systems reference is made to the patent to Reynolds, No. 2,021,329 of November 19, 1935, and to the patent to Carpenter, No. 2,093,117 of September 14, 1937.

What is claimed is:

1. The combination in a selective system of a voltage propagating circuit, a plurality of resistors connected in series in said circuit, a source for causing current to flow through said resistors in series, a single condenser in said circuit chargeable by said current and serving to cause a voltage wave to progress along said series of resistors, and a series of responsive devices connected respectively to said resistors, said wave serving to apply an operating voltage to the successive devices as it moves along said resistors.

2. The combination in a selective system of a voltage propagating circuit, a plurality of resistors connected in series in said circuit, a source for causing current to flow through said resistors in series, a single condenser in said circuit chargeable by said current and serving to cause a voltage wave to progress along said series of resistors, the values of said resistors being selected to obtain a definite relation between the voltages at the successive junction points of said resistances, and a series of responsive devices connected respectively to said junction points, the voltages at the successive junction points rising progressively to the operating value of said devices as the voltage wave is propagated.

3. The combination in a selective system of a voltage propagating circuit, a plurality of resistors connected in series in said circuit, a source of causing current to flow through said resistors in series, a single condenser in said circuit chargeable by said current and serving to cause a voltage wave to progress along said series of resistors, the values of said resistors being equal to obtain equal voltage differences between adjacent resistors, and a plurality of voltage responsive devices connected respectively to the successive resistors, said voltage wave rising to the operating value of the successive devices as it moves along said resistors.

4. The combination in a selective system of a voltage circuit, a plurality of resistors connected in series in said circuit, a source for causing current to flow through all of said resistors in series, a single condenser in said circuit chargeable by the current flowing through said resistors and serving to cause a progressive reduction in the flow of said current as it becomes charged, said diminishing current flow serving to cause a voltage wave to progress along said series of resistors toward said condenser, and a series of voltage responsive devices connected respectively to the junction points of said resistors, said wave serving to apply an operating voltage to the successive devices as it moves along said resistors.

5. The combination in a selective system of a voltage circuit, a plurality of resistors connected in series in said circuit, a source for causing current to flow through said resistors, a condenser in said circuit chargeable by the current flowing in said resistors and serving to cause a voltage wave to progress from one resistor to the next, a resistor common to said plurality of resistors for controlling the rate of change of current flow in said circuit as said condenser becomes charged, and a plurality of responsive devices connected respectively to the resistors of said series, said voltage wave serving to operate said responsive devices.

6. The combination in a selective system of a voltage circuit, a plurality of resistors connected in series in said circuit, a source for causing current to flow through said resistors, a condenser in said circuit chargeable by the current flowing in said resistors and serving to cause a voltage wave to progress from one resistor to the next, a resistor connected in shunt of said condenser for controlling the rate of change of current in said circuit to maintain a uniform time rate of change of the voltages between consecutive resistors in said series, and a plurality of responsive devices connected respectively to the resistors of said series, said voltage wave serving to operate said responsive devices.

7. In combination, a group of elements to be selected, a voltage circuit, a plurality of resistors connected in series in said circuit, a series of discharge tubes connected respectively to the successive junction points of said resistors, means for connecting said tubes respectively to the elements of said group, a single condenser connected in said circuit, a source for charging said condenser through said resistors in series to cause a voltage wave to progress along the resistors of said series, said voltage wave serving to apply an operating voltage to the successive tubes of said series, and means dependent on the condition of any one of the elements of said group for causing the corresponding tube to operate in response to said voltage wave.

8. In combination, a group of elements to be selected, a voltage circuit, a plurality of resistors connected in series in said circuit, a series of discharge tubes connected respectively to the successive junction points of said resistors, means for connecting said tubes respectively to the elements of said group, a single condenser connected in said circuit, a source for charging said condenser through said resistors in series to cause a voltage wave to progress along the resistors of said series, said voltage wave serving to apply an operating voltage to the successive tubes of said series, means dependent on the condition of any one of the elements of said group for causing the corresponding tube to operate in response to said voltage wave, and means effective when any one of said tubes operates for preventing any other tube from responding to said voltage wave.

9. The combination in a selective system of a voltage circuit, a plurality of resistors connected in series in said circuit, a source for causing cur-

rent to flow through said resistors, a condenser in said circuit chargeable by the current flowing in said resistors and serving to cause a voltage wave to progress from one resistor to the next, impedance means common to said resistors for controlling the rate of change of current flow in said circuit to maintain uniform voltage spacings between successive resistors and uniform speed in the propagation of said wave, and voltage responsive devices associated with the successive resistors.

10. The combination in a selective system of a voltage circuit, a plurality of resistors connected in series in said circuit, a source for causing current to flow through said resistors, a condenser in said circuit chargeable by the current flowing in said resistors and serving to cause a voltage wave to progress from one resistor to the next, inductive means common to said resistors for controlling the rate of change of current flow in said circuit as the condenser charges to maintain uniform voltage spacings between consecutive resistors, and voltage responsive devices connected respectively to the succeeding resistors in said circuit.

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