Dec. 30, 1941. W. A. RHODES 2,267,950

TELEPHONE SYSTEM

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FIG. 1

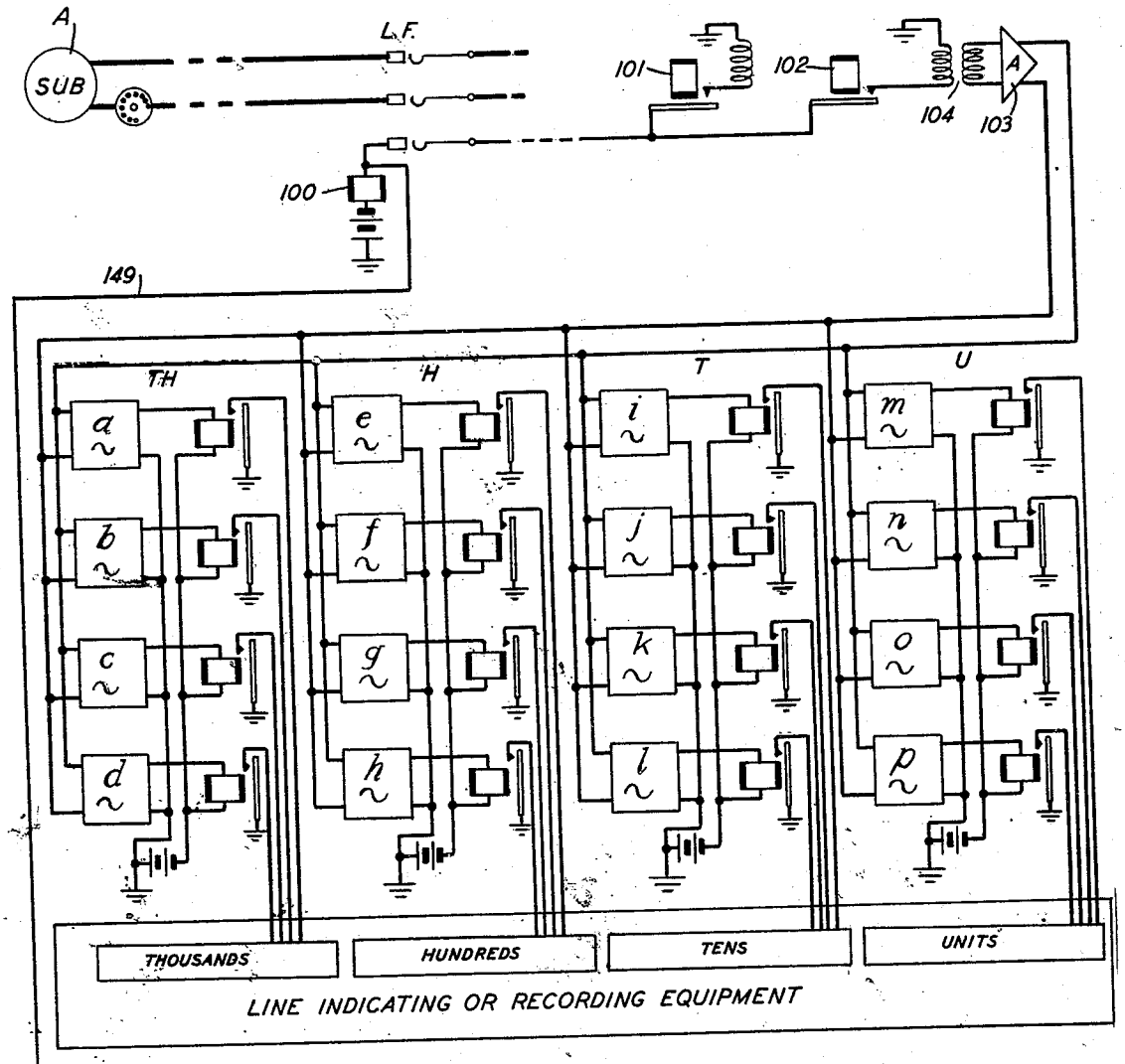

FIG. 1	FIG. 10		
FIG. 2	FIG. 3	FIG. 4	FIG. 5
FIG. 6	FIG. 7	FIG. 8	FIG. 9

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FIG. 2

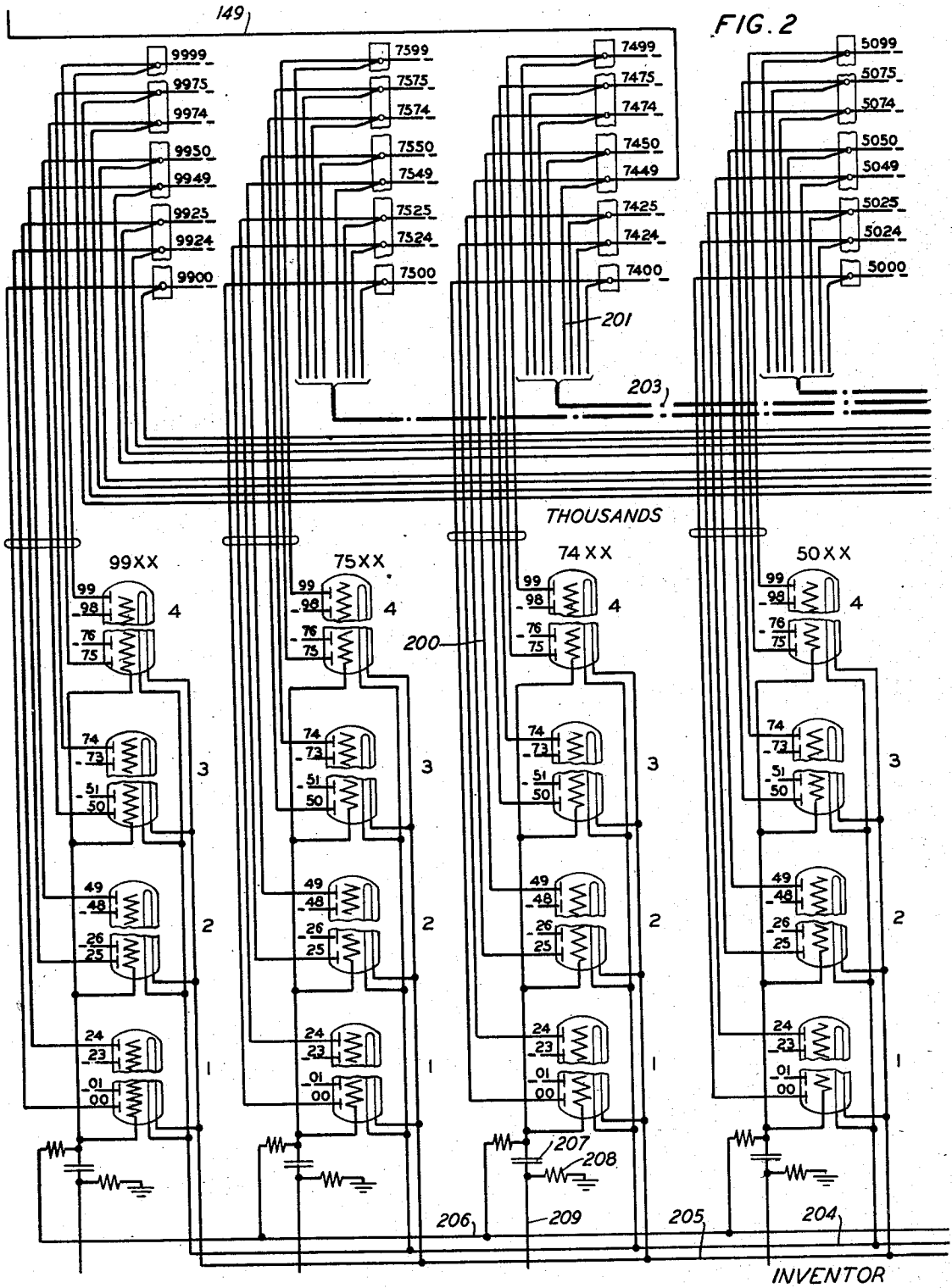

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FIG. 3

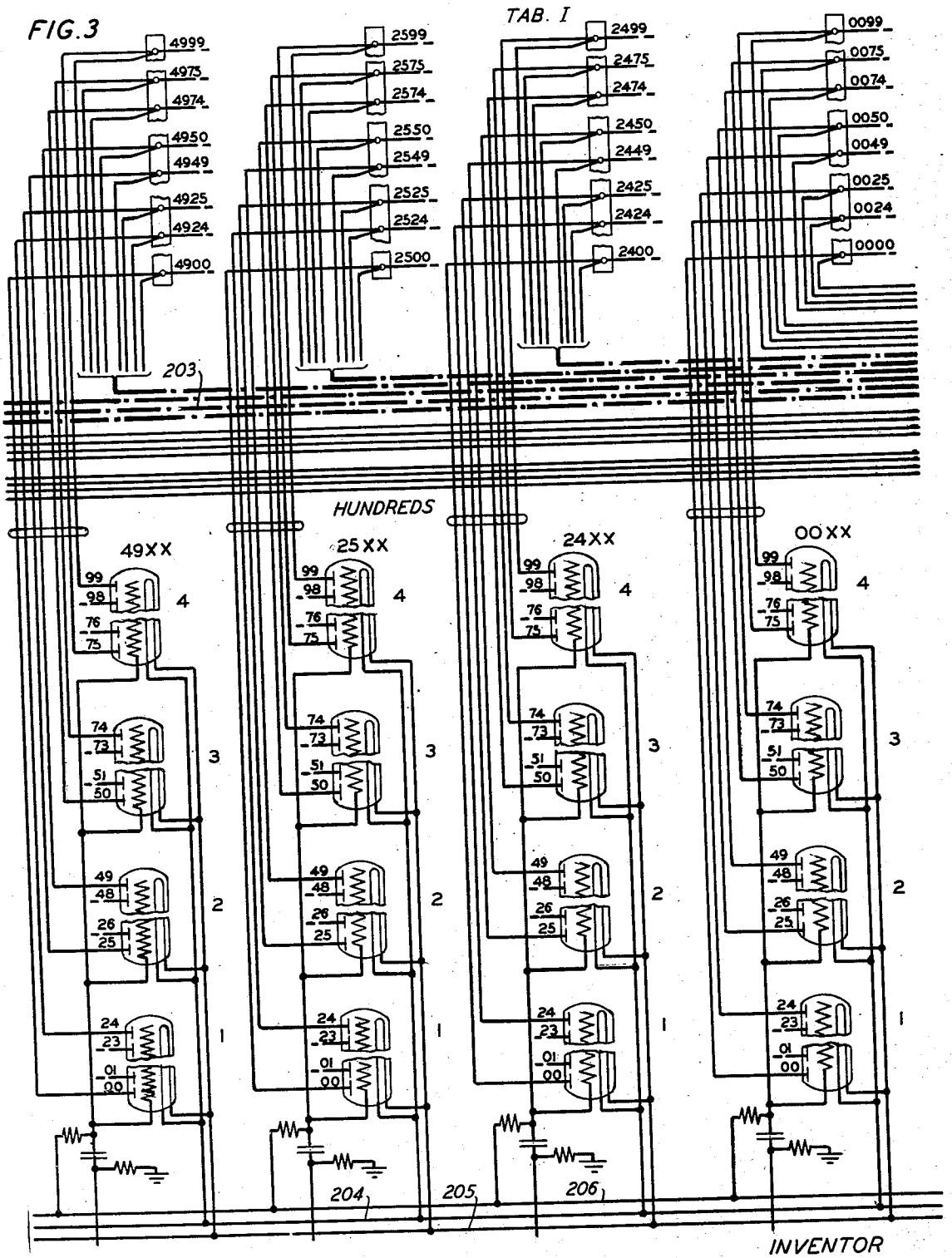

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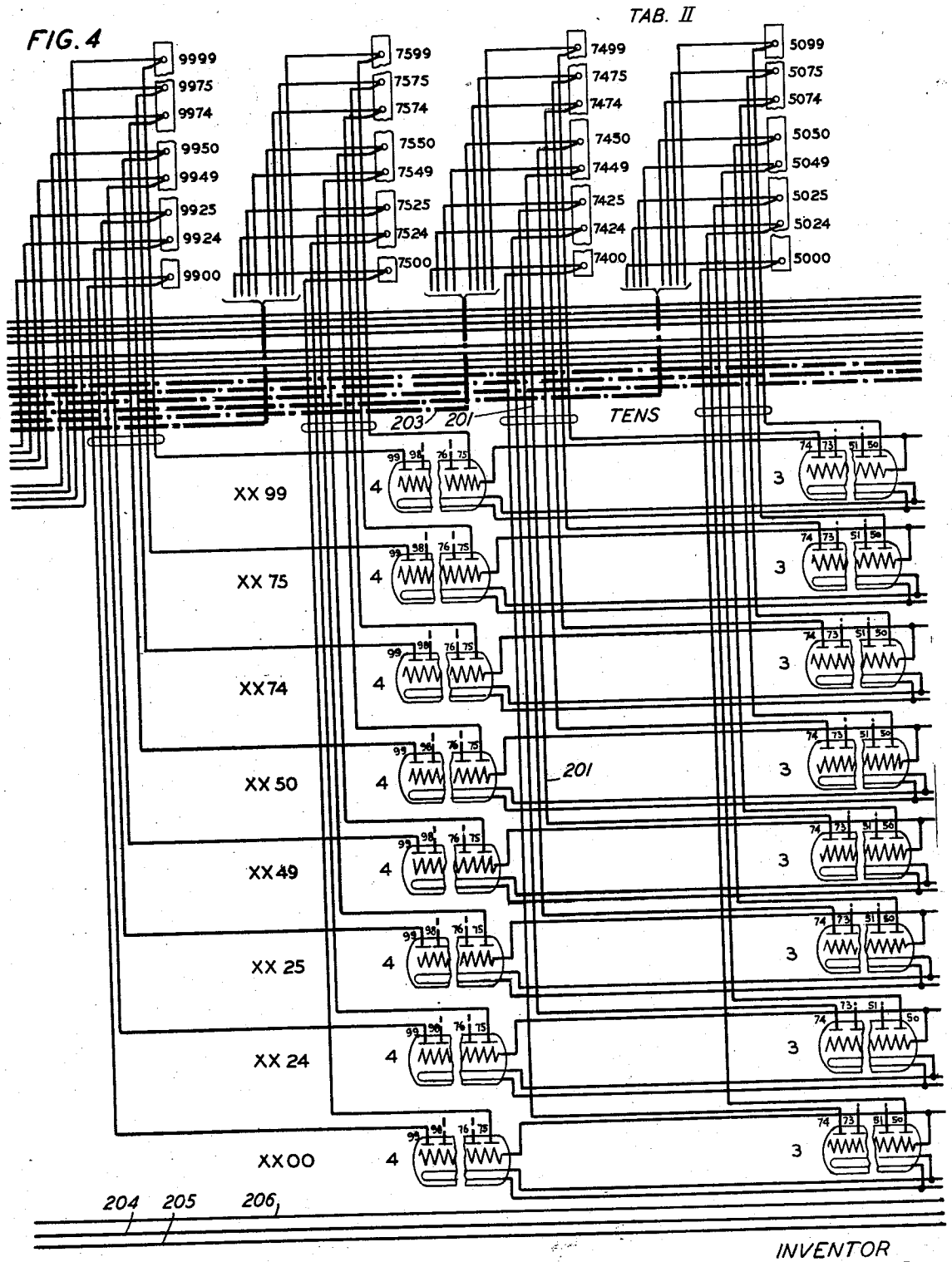
FIG. 4



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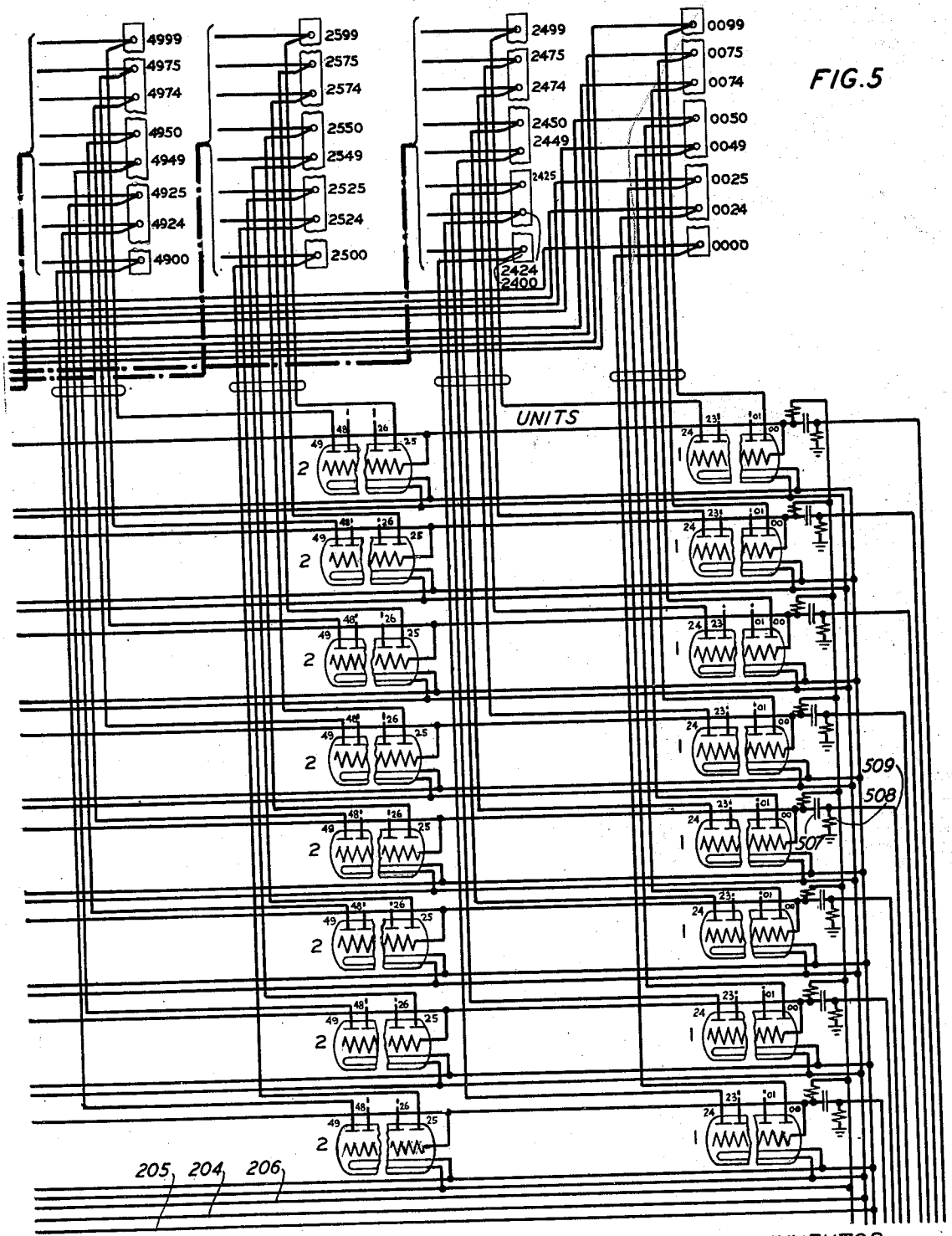

FIG.5

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FIG. 6

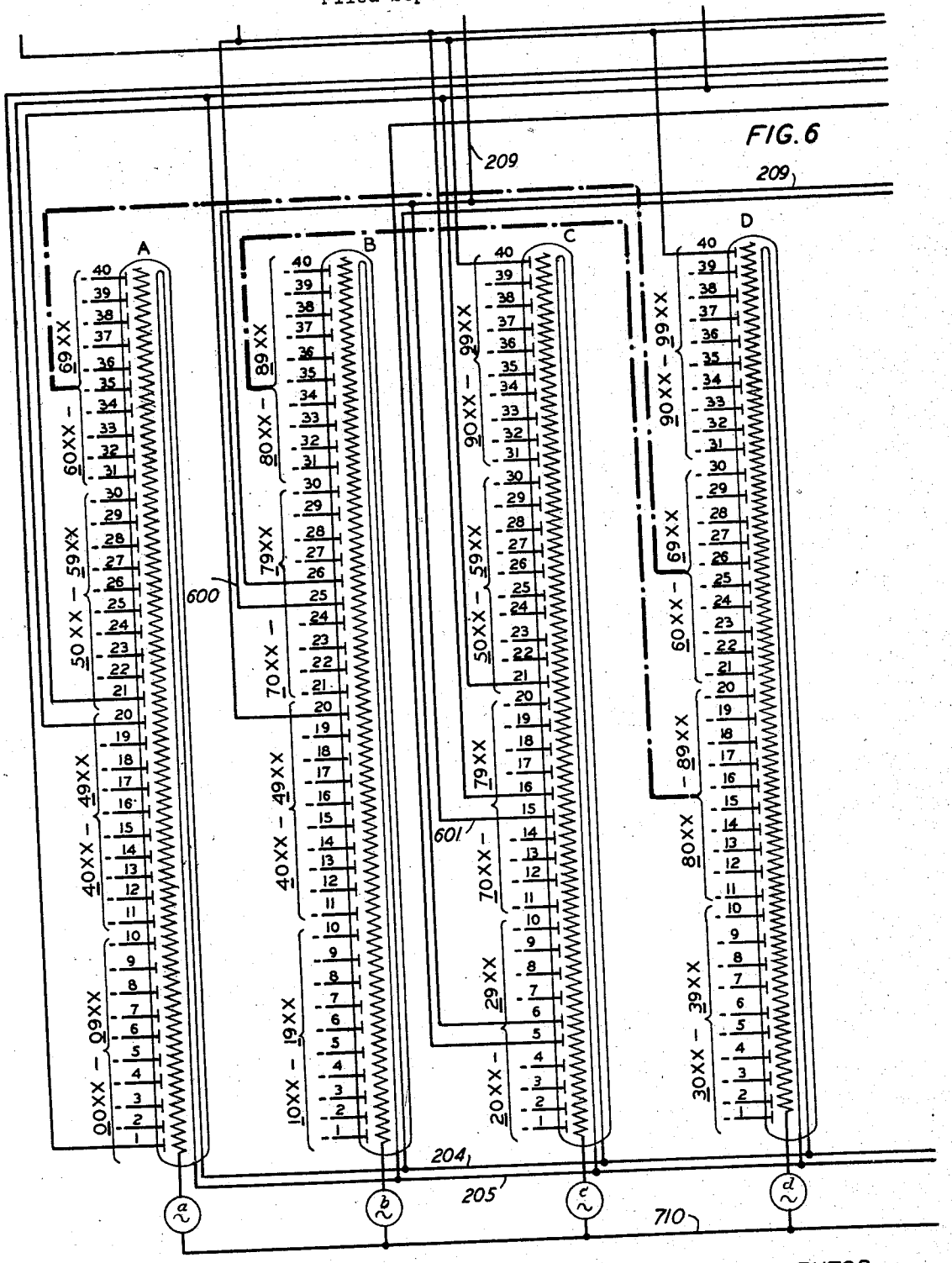

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FIG. 7

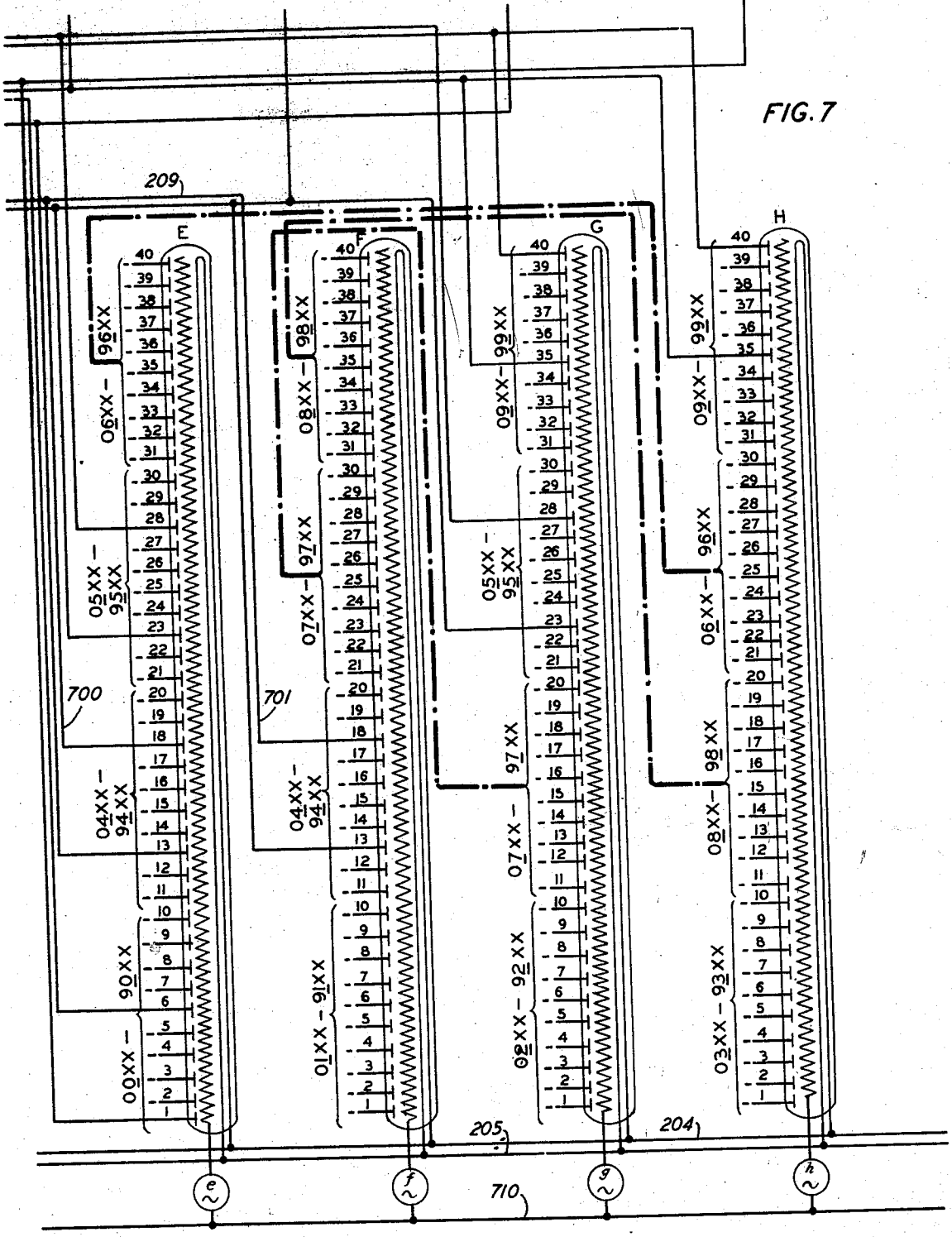

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FIG. 8

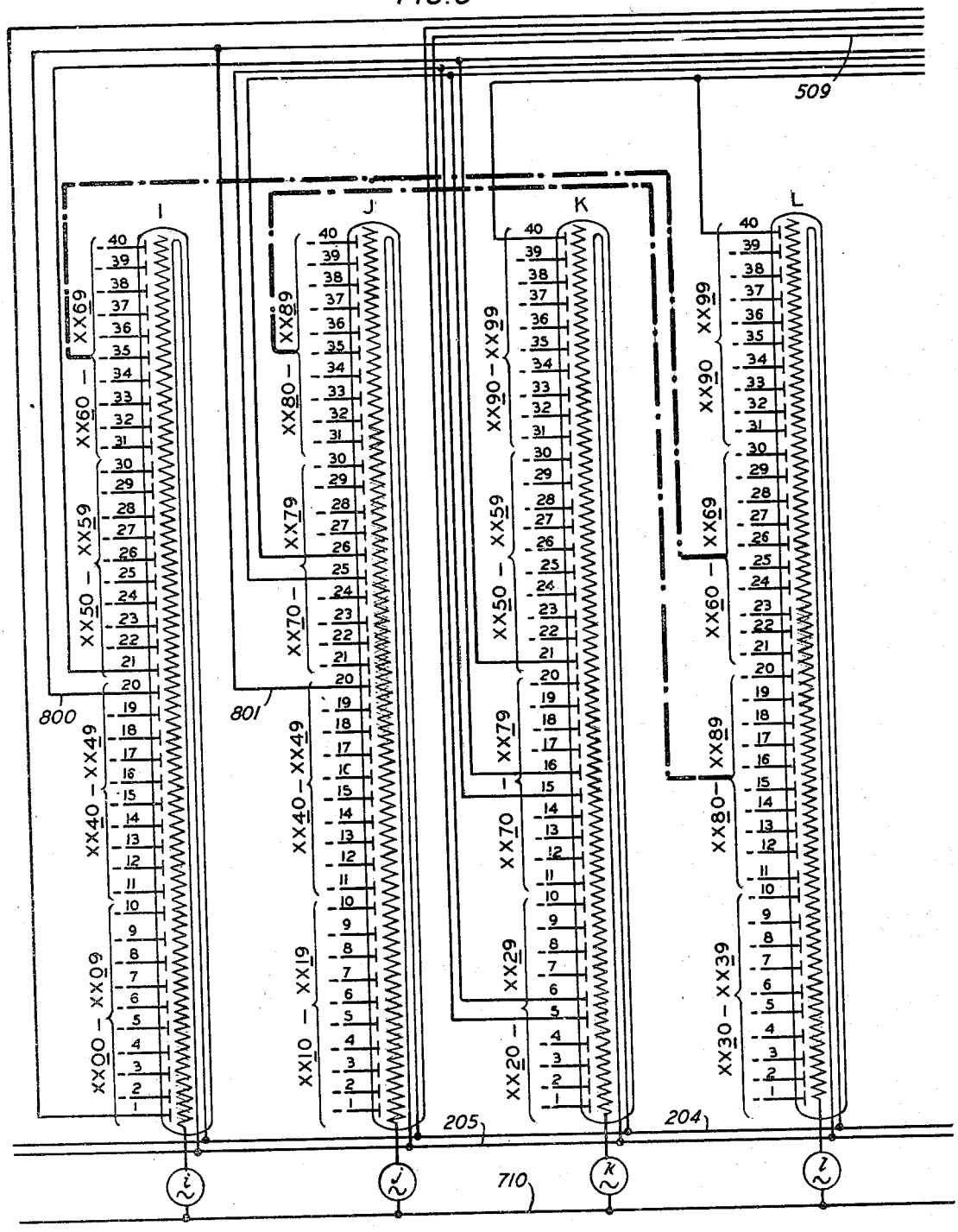

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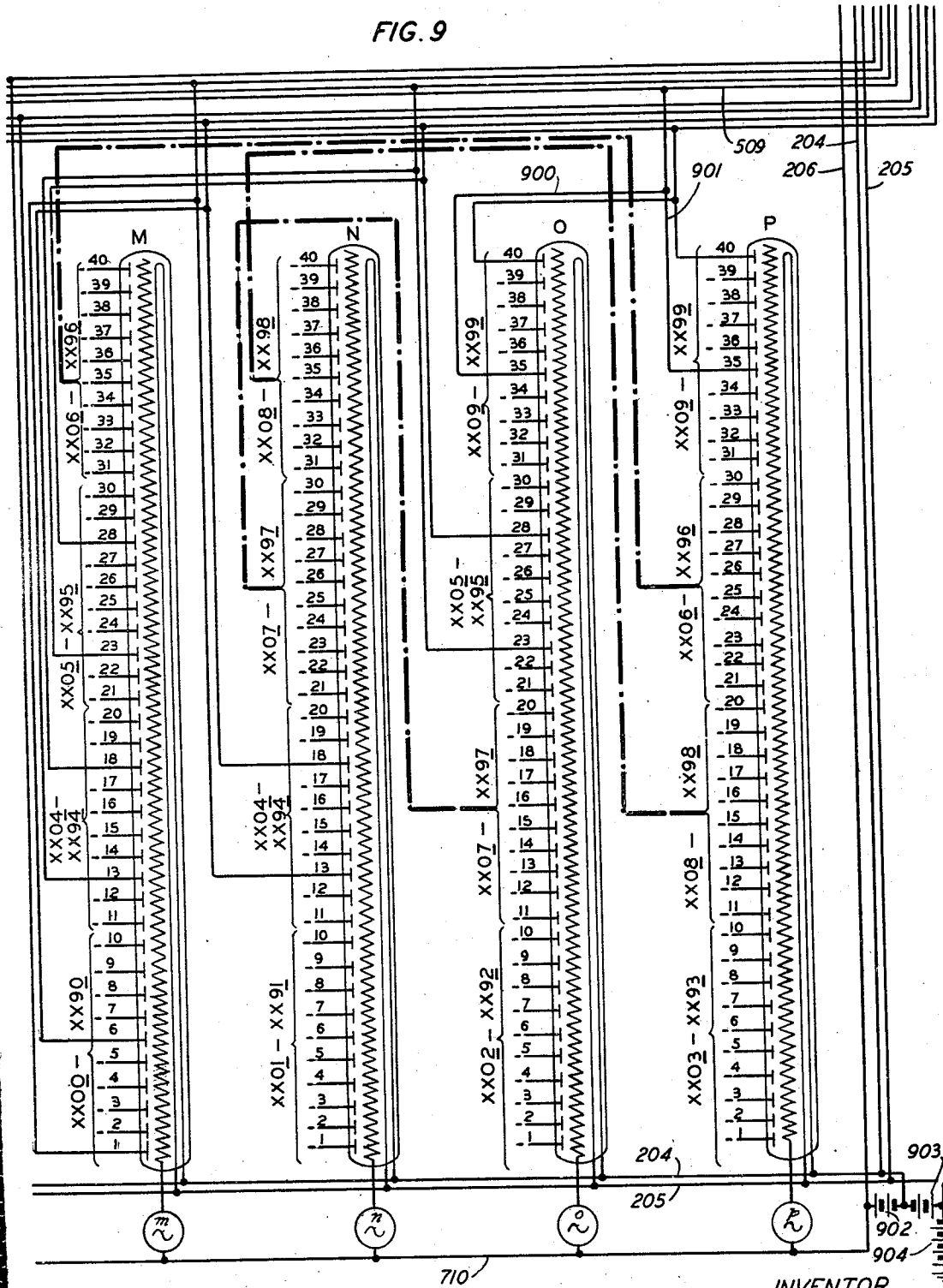
FIG. 9



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Patented Dec. 30, 1941

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UNITED STATES PATENT OFFICE

2,267,950

TELEPHONE SYSTEM

William A. Rhodes, New York, N. Y., assignor to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

Application September 20, 1940, Serial No. 357,518

10 Claims. (Cl. 179—27)

This invention relates to telephone systems and more particularly to those systems in which the numerical indication of a calling line is automatically determined and made available.

It is well known that in certain types of telephone connections such as those, for instance, in which the calling line is extended automatically or otherwise to some remote station, it is necessary to ascertain the number of the calling station in order that charges for the call may be properly assessed to said station. Such connections are known as toll or long distance connections and in some types of automatic telephone systems in which the calling line is routed to its destination via the position of a recording operator where, after the number has been communicated to the operator by the calling subscriber, said number is verified over a so-called checking multiple. This verification is made by touching the tip of a checking cord to that pin in a so-called checking multiple which is assigned to the given number and if the number as given by the calling party is correct, a tone circuit is completed over the checking cord which is heard in the operator's telephone set. On the other hand, if the number as given does not correspond to that of the pin to which the tip of the checking cord is touched, the tone circuit is not completed, and this fact indicates to the operator that the number given by the caller does not correspond to that of the station from which he is calling, in which event service may be denied until the discrepancy is rectified.

In automatic telephone systems, it is desirable to have the identity of the calling station ascertained and transmitted automatically to some point at which it may be recorded on settable registers for the visual display of the number, if the call is completed through an operator's position, or for automatic recording if the information is to be utilized for operating printing or other recording devices responsive to the setting of the registers.

My invention is principally concerned with the automatic identification of the calling line number and its principal feature is an arrangement of two main groups of vacuum tube devices and two auxiliary groups of vacuum tube devices which are arranged with respect to each other, respectively, to produce to coordinate translations of which the first provides an identification of each of the first two digits of the line number and the second provides an identification of each of the second two digits of the line number. According to one embodiment of my invention as adapted to provide identification for one or more lines in a ten thousand line capacity telephone office, I propose to use two main groups of four hundred vacuum tubes each having twenty-five anodes, with each line to be identified connected to one anode in a tube of each main group, and two auxiliary groups of eight other vacuum tubes, each having forty anodes with each anode connected to a source of positive potential and to the grid of a tube in the correlated main group according to alternating potentials of predetermined frequencies which are to activate the tubes in the two main groups to produce certain signal currents which are distinctive for the four digits of the twenty-five line numbers of the corresponding lines connected to the anodes of said tubes.

Each of the grids of the auxiliary tubes is connected to a source of alternating current of a specific frequency and since the cathodes are all connected to a source of filament current and their anodes to a source of positive potential in the known manner, said tubes are normally activated to modulate the anode potential with one or more frequencies, which potential is transmitted through appropriate coupling to the grids of the respective tubes in the main groups to which such anodes are connected. Inasmuch as the anodes of the tubes in each of the main groups are at negative potential when none of the lines connected thereto are calling, the potential to which the main tube grids are raised by the operation of the auxiliary tubes is productive of no effect. However, when a line calls, the potential of its anode in each tube in the two main groups of tubes to which such line is connected is changed from negative to positive and is of such a value that, with the grid potential determined by the operation of the auxiliary tube or tubes from which said potential is derived, the two tubes in the main groups are rendered conducting, thereby completing a current flow through their respective anodes which is determined by the frequencies that activate the auxiliary tubes from which the grids of the operated main tubes derived their activating potentials. Since each of the main tubes bears a digital coordinate relation to the twenty-five lines connected to its respective anodes, and since the connection between the grids of the main tubes and the anodes of the auxiliary tubes is determined by a certain frequency allocation to each numeral of a digit, there is present in the anode current of the two operated tubes in the main groups a plurality of distinct signals which singly

or in combination, designate the calling line number. These signals are, of course, amplified through suitable means and received upon suitable registers from which the number may then be displayed or recorded by appropriate apparatus provided for the purpose.

A clearer conception of the scope and purpose of the invention may be obtained from the following description, taken in connection with the appended claims and attached drawings, in which:

Fig. 1 shows a partial diagrammatic layout of an automatic telephone line extension and the receiving equipment of the line identification circuit;

Figs. 2 and 3 show, in part, one of the two main groups of tubes;

Figs. 4 and 5 show, in part, the other of the two main groups of tubes;

Figs. 6 and 7 show the eight vacuum tubes of that auxiliary group of tubes which is operatively associated with the main group of vacuum tubes shown in Figs. 2 and 3;

Figs. 8 and 9 show the eight vacuum tubes of the other auxiliary group of tubes which is operatively associated with the main group of tubes shown in Figs. 4 and 5; while

Fig. 10 shows the manner in which Figs. 1 to 9, inclusive, should be arranged with respect to each other in order to disclose the invention.

Referring now to the drawings, there are provided, in Figs. 2 to 5, inclusive, as indicated therein, a group of four hundred vacuum tubes in columns of four tubes each, namely, the one hundred columns of tubes indicated by the designations **00XX–99XX**, inclusive, for the thousands and hundreds digit designations of the various lines, and a group of four hundred other tubes in horizontal rows of four tubes each, namely, the one hundred columns of tubes indicated by the designations **XX00–XX99**, for the tens and units designations of said lines. Each tube in each group and row is of known construction and has twenty-seven elements, namely, a cathode, a grid and twenty-five anodes. There are, therefore, twenty thousand anodes in the two groups of tubes for the entire circuit which is to perform identifying operations for the calling lines of a ten thousand line telephone office.

Each line is provided with an identifying conductor as, for instance, conductor **149** that extends from the terminal side of the winding of the cut-off relay **100** of the line, the other side of said relay being connected to negative battery. The other end of said conductor is connected to a punching on the terminal assembly block TAB.I assigned to the line of which conductor **149** forms a part. Thus in Figs. 1 and 2, conductor **149** is connected to terminal punching **7449**, and line A is assumed to have the same numerical designation as the punching. It will be observed that the terminal assembly block TAB.I is arranged in vertical sections of one hundred punchings to the section, there being, for a ten thousand line office, one hundred such sections each allocated to a particular group of one hundred lines to the punchings of which are connected the identifying conductors of the related lines in the same manner as that already indicated for line A (**7449**).

From the other side of the punchings of terminal assembly block TAB.I extend two conductors. Referring more particularly to punching **7449** by way of example, one of the conductors at that punching extends to an anode in the second tube of column **74XX**, namely, tube **74XX—2** and the other to an anode in the third tube of row **XX49**, namely tube **XX49—3**, via a punching on terminal block assembly block TAB.II. The tube in each column and row to which each of said conductors is connected depends, in the case of the first group of tubes **00XX–99XX**, upon the thousands and hundreds numerical designation of the line and, in the case of the second group of tubes **XX00–XX99**, upon the tens and units designation of the line. Furthermore, since the twenty-five control anodes in each of the tubes of both groups are themselves numerically designated in consecutive order, the particular anode in each tube to which an identifying conductor is connected is made dependent upon the identity between the numerical designation of the anode and the numerical values of the two digits of the line number which are to be identified by a tube in the other main group. This arrangement is plainly shown by the anode designations of the two main groups of tubes in Figs. 2 to 5, inclusive.

Thus, punching **7449** which, at one side is connected to conductor **149**, is connected, on its other side, to conductors **200** and **201**, the latter included within bracket line **203**. The line **7449** has a thousands-hundreds digit designation of "74" and since the column of four tubes **74XX** is reserved for the identification of all the one hundred lines having the numerical designation **74**, conductor **200** is extended to an anode in tube **74XX—2** and particularly to the anode labeled **49** therein, anode **49** having been selected because it bears the same numerical designation in the consecutive line-up of the one hundred anodes of the four tubes in the column as the tens-units designation of the line. In the same way, conductor **201** extends to terminal punching **7449** in the terminal assembly block TAB.II (which is identical to terminal assembly block TAB.I) and from thence is connected to an anode in tube **XX49—3** and particularly to the anode **74** therein. Here again the particular anode selected for connection to conductor **201** may be determined by the thousands-hundreds designation of the line number which, in the case of line number **7449** (line A), requires that conductor **201** be connected to the anode labeled **74**.

The identifying conductor of every line in a ten thousand line office is thus similarly extended to an anode in a tube in that column of tubes in the group **00XX–99XX** which is reserved for the thousands-hundreds identification of the particular one hundred lines identified by the column, and to an anode in the particular tube in that row of tubes in the group **XX00–XX99** which is reserved for the tens-units identification of said hundred lines. It is obvious that the operation of a tube in each group, each having one of its anodes connected to an identifying conductor of a line through its extension from the punchings on terminal assembly blocks TAB.I and TAB.II, may be utilized to identify the two digits reserved for each row and column in each group, respectively, if the current produced through the anode circuit of each operated tube is of alternating character and made up of one or more components of specific frequencies reserved for the identification of each of the digits designated by the tubes in a column or row.

To provide these frequencies an auxiliary group of eight forty-anode vacuum tubes is provided for each main group of tubes **00XX–99XX**

and XX00–XX99. These tubes are designated A to H, inclusive, for the group of eight tubes which is operatively associated with the thousands-hundreds tubes 00XX–99XX, and I to P, inclusive, for the group of eight tubes which is operatively associated with the tens-units tubes XX00–XX99. The grid of each tube in each of the auxiliary groups is connected to one side of an alternating potential source of a specific frequency which is designated by the small letter of its associated tube designation while the other side of all the separate sources of potential are connected to the positive side of battery 902 via conductor 710. Since the cathodes of all tubes in the auxiliary as well as the main groups are all connected permanently to the filament battery source 903 via conductors 204 and 205, the grids of the auxiliary tubes are all permanently activated to produce an alternating current flow between the cathode and any one or more anodes in their respective tubes as soon as a positive potential of the required value is applied to said anode or anodes, the frequency of said current being, of course, the same as that of the source connected to the grid.

Now the grids of all the tubes in each column and row of the two main groups of tubes are connected via a separate low resistance for each column and row, to conductor 206 and thence to the positive side of battery 902. On the other hand, each separate group of grids in a column or row of tubes is connected via a condenser coupling to an anode in one or two of the tubes in the auxiliary group associated with one or the other, respectively, of the main group of tubes. The order of connection is four grids in a column or row in a main group of tubes to an anode in one or two of the tubes in the associated auxiliary group whose grids are connected, respectively, to the frequency sources which, singly or in combination of two, will identify the two digits characterized by the column or row of tubes in the two main groups according to the following code:

Numeral frequency code table

Digit	Thousands	Hundreds	Tens	Units
0	*a*	*e*	*i*	*m*
1	*b*	*f*	*j*	*n*
2	*c*	*g*	*k*	*o*
3	*d*	*h*	*l*	*p*
4	*ab*	*ef*	*ij*	*mn*
5	*ac*	*eg*	*ik*	*mo*
6	*ad*	*eh*	*il*	*mp*
7	*bc*	*fg*	*jk*	*no*
8	*bd*	*fh*	*jl*	*np*
9	*cd*	*gh*	*kl*	*op*

Thus, as an illustration of the connections between the grids of the tubes in the two main groups and the anodes of the tubes in the two auxiliary groups, consider, for example, the column of tubes 74XX to an anode of the second tube 74XX—2 of which is connected conductor 200 and the row of tubes XX49 to an anode of the third tube XX49—3 of which is connected conductor 201. These conductors, it will be recalled, are extensions of the line identifying conductor 149 of line 7449. Now the column of tube 74XX identifies the thousands-hundreds digits 74 and, according to the above table, the thousands digit 7 requires currents of frequencies *b* and *c* for its identification while the hundreds digit 4 requires currents of frequencies *e* and *f* for its identification. Accordingly, the grids of the four tubes in the column 74XX are all multipled and connected to the condenser 207 the other side of which is connected to grounded resistance 208 and conductor 209. Conductor 209, on the other hand, has four branches. The first, branch 600, is connected to anode 25 in tube B whose grid is connected to frequency source *b*; the second, branch 601, is connected to anode 15 of tube C whose grid is connected to frequency source *c*; the third, branch 700, is connected to anode 18 of tube E whose grid is connected to frequency source *e*; and the fourth, branch 701, is connected to anode 18 of tube F whose grid is connected to frequency source *f*. It is obvious that, under proper conditions of activation as described below, anode 49 of tube 2 in the column 74XX will have a current passing through it composed of frequencies *b*, *c*, *e* and *f* in identification of the thousands-hundreds digits 74.

In the same manner, the grids of the four tubes comprising row XX49 are multipled and connected to condenser 507 the other side of which is connected to grounded resistance 508 and conductor 509. Since, according to the above table, tens digit 4 is identified by the frequencies *i* and *j* and the units digit 9 by the frequencies *o* and *p*, conductor 509 likewise has four branches, the first of which, branch 800, is connected to anode 20 of tube I connected to frequency source *i*; the second, branch 801, is connected to anode 20 of tube J connected to frequency source *j*; the third, branch 900, is connected to anode 35 of tube O connected to frequency source *o* and the fourth, branch 901, is connected to anode 35 of tube P connected to frequency source *p*. As in the previous case, under proper conditions of activation, anode 14 of tube 3 in row XX49 will pass a current consisting of frequencies *i*, *j*, *o* and *p* in identification of the tens and units digits 49.

As noted from the above code, the four auxiliary tubes A to D are reserved for the four frequencies assigned to the thousands digit; the four tubes E to H are served for the four frequencies assigned to the hundreds digit; the four tubes I to L are reserved for the four frequencies assigned to the tens digit; and the four tubes M to P are reserved for the four frequencies assigned to the units digit. As further noted by the numbering of the anodes of the auxiliary tubes, each anode in a group of ten consecutive anodes counting from the bottom upward, is connected to the grids of a column or row of tubes in the main groups which characterizes one of the digits identified in whole or in part by the frequency connected to the grid of the auxiliary tube. Since four primary frequencies are used singly or in combinations of two to identify each numerical value of each of the four digits, it is clear that each auxiliary tube need not have more than forty anodes.

The receiving equipment is only schematically indicated in Fig. 1 since all its parts are well known and commercially available. It comprises a relay 101 adapted in any suitable manner to ground the winding side of the line cut-off relay 100, a relay 102 which may be operated in any suitable manner when line identification is to be obtained, and a transformer 104 having the input side of an amplifier 103 connected to its secondary winding. The output side of the amplifier is connected to four groups of four filtering rectifying circuits of any suitable de-

sign, one for each digit, and each circuit feeds its output into a registering relay with contacts extending into an indicating or recording circuit adapted to respond to the operation of the relays to produce a visual, oral or permanent record of the digits indicated by the operated relays.

Having described the structural arrangement of my invention, its manner of operation will now be set forth in some detail.

When a subscriber such as A, for instance, initiates a call for which line identification is necessary, the line is extended to some central point by means of line-finder switch LF and other line extending switches which are not shown but which, for example, may be of the Strowger step-by-step type or the panel type or of cross-bar type. In fact, the manner in which the connection is extended is of no controlling importance to this invention other than the fact that whatever means are used will include a relay **101** which will be caused to operate and close a circuit that operates the cut-off relay **100**.

It will be observed that the identifying conductor **149** has negative potential applied thereto through the winding of the cut-off relay CO. This potential is, of course, further applied to the anodes **49** and **74** in the two tubes **74XX—2** and **XX49—3**. The cathode potential from battery **903**, however, is maintained at slightly less negative value than that applied to the identifying anodes of the various lines, when idle, through the winding of their respective cut-off relays **100** so that, normally, when the lines are idle, no current will flow through any of the tubes in the main groups. When, however, a line calls, such as line A for example, and ground is applied to conductor **149** by the operation of relay **101**, the potential at anodes **49** and **74** is raised. Since the auxiliary tubes are always activated, the grids of the tubes in column **74XX** and those in row **XX49** are raised to the point where they will cause current to flow between the cathode and any anode in any tube in said column and row which has had its potential raised by the operation of the correlated cut-off relay. Hence the tube **2** in column **74XX** operates to pass a current between its cathode and such anode, modulated to the combined frequencies of *b*, *c*, *e* and *f* and completed via conductor **200**, terminal **7449** on TAB.I, conductor **149**, to ground on the contacts of relay **101**. In the same way, tube **3** in row **XX49** is operated to pass a current between its cathode and such anode, modulated by frequencies *i*, *j*, *o* and *p* and completed via conductor **201**, terminal **7449** of TAB.II, conductor **201** in bracket line **203**, conductor **201**, terminal **7449** of TAB.I and thence as traced to ground (or resistance ground) over the contacts of relay **101**.

When the line indication is desired, relay **102** is operated and relay **101** is released, whereupon the primary winding of transformer **104** is connected in circuit to hold the cut-off relay **100** operated and to transfer the circuit over which the line indicating current flows, through the primary winding of said transformer. This current, made up of frequencies *b*, *c*, *e*, *f*, *i*, *j*, *o*, and *p* is induced into the secondary of transformer **104**, then passes and is amplified through amplifier **103** and fed into the four parallel branches of the four filtering rectifying units, one for each digit of the line number. Each rectifying unit selectively operates on the frequency to which it is tuned and results in the operation of the relay individual to the unit. The number of relays operated in each digit group will depend, of course, upon the number of frequencies present for the digit and for the code given, will be two for each digit. These relays, in operating, ground signaling conductors connecting with suitable indicating, oral or recording, equipment in which suitable apparatus operatively responds to the grounded signaling conductors to register the line designation.

It will be observed that, in my invention, there is no limit to the number of simultaneous line identifications which can be made. Since the auxiliary tubes are always activated and since all the tubes of the two main groups can all become activated immediately upon the raising of one or more of their respective anode potentials by the grounding of the identifying conductors respectively connected to them, it is obvious that, so far as the line identification circuit itself is concerned, there can be as many simultaneous identifying operations going on as there are anodes in a main group of tubes, each operation taking place over the separate line identifying conductor of a calling line.

When line identification operations are completed to the extent that a record of the line is registered in the visual, oral or recording equipment, relay **102** is released, negative battery is again applied to anode **49** of tube **2** in column **74XX** and anode **74** of tube **3** in row **XX49** causing these tubes to cease conducting. The line identification circuit is now in the normal condition prevailing when no lines are calling.

While I have described the principle of my invention in connection with its specific application to a typical telephone connection and with reference to a specific arrangement of vacuum tube devices, it is to be understood that various other applications and embodiments thereof may be made by those skilled in the art without departing from the spirit of the invention as defined within the scope of the appended claims.

What is claimed is:

1. A calling line identification circuit for the lines of a telephone system comprising a plurality of electronic devices having control elements connected to said lines according to their numerical designation, and means responsive to the application of a potential to the control elements of calling lines for operating the associated electronic devices to produce an indication of the identity of each of said lines.

2. A calling line identification circuit for the lines of a telephone system comprising a plurality of vacuum tubes having anode elements connected to said lines according to their numerical designation, and means responsive to the application of a potential to the anode elements of calling lines for operating the associated vacuum tubes to produce an indication of the identity of each of said lines.

3. An identification circuit for the lines of a telephone system comprising in combination a plurality of vacuum tubes disposed coordinately relative to the lines of a telephone system whereby a potential applied to any one of said lines causes the operation of any two of said coordinately related tubes to produce a numerical identification of the line to which said potential was applied.

4. An identification circuit for the lines of a telephone system comprising in combination two groups of electronic devices normally adapted to apply an alternating potential of a specific frequency to a plurality of electrodes thereof, two other groups of electronic devices disposed co-

ordinately relative to the numerical designations of the lines of the system and electrically coupled to the electrodes of the devices of said first two groups, means for applying a signaling potential through one of said lines when calling to an electronic device in each of said other two groups of devices whereby said devices are rendered conducting to produce an alternating current of the frequencies determined by the electrodes coupled to said devices, and means selectively responsive to each of the frequencies present in the current produced by the operation of said devices for identifying the numerical designation of said calling line.

5. An identification circuit for the lines of a telephone system comprising in combination two groups of vacuum tubes each having a plurality of anodes, a grid and a cathode with each grid adapted to modulate a current flow between the cathode and all anodes in accordance with a specific frequency, two other groups of vacuum tubes disposed coordinately relative to the numerical designation of the lines of the system and having their respective grids electrically coupled to the anodes of the vacuum tubes of said first two groups, means for applying a signaling potential through one of said lines when calling to an anode of a tube in each of said two other groups of tubes whereby said tubes are activated to produce an alternating current of the frequencies determined by the grids of the tubes in said first two groups coupled to said activated tubes, and means selectively responsive to each of the frequencies present in the current produced by said activated tubes for identifying the numerical designation of said line.

6. A calling line identification circuit for the lines of a telephone system comprising two main groups of electronic devices having electrodes connected to said lines, two auxiliary groups of electronic devices for each of said main group of devices having electrodes connected to the grids of the devices in the associated main group and adapted to apply a potential of specific frequency to the grids thereof, means responsive to the application of a potential to the electrodes of the devices in the two main groups for operating said devices whereby an alternating potential having a plurality of frequencies is produced, and means selectively responsive to each frequency for indicating the numerical designation of said calling line.

7. A calling line identification circuit for the lines of a telephone system comprising in combination two main groups of electronic devices having electrodes connected to said lines, two auxiliary groups of electronic devices for each of said main group of devices having electrodes connected to the grids of the devices in the associated main group and adapted to apply a potential of specific frequency to the grids thereof, means responsive to the application of a potential to the electrodes of the devices in the two main groups for operating said devices whereby in response to the alternating potential on their respective grids, an alternating potential is produced through said electrodes, and circuit closing means including settable registers selectively responsive to each of the frequencies in said alternating potential for operating said devices and setting said registers to indicate the identity of said line.

8. A calling line identification circut for the lines of a telephone system comprising in combination two main groups of electronic devices having electrodes connected to said lines, two auxiliary groups of electronic devices for each of said main group of devices having electrodes connected to the grids of the devices in the associated main group and adapted to apply a plural frequency alternating potential thereto, means responsive to the application of a potential to the electrodes of the line initiating a call for causing the associated electronic devices to become operative in producing an alternating current of the plural frequencies applied to the grids thereof, and means selectively responsive to the frequencies present in said current for identifying the calling line to which said potential was applied.

9. An identification circuit for the lines of a telephone system comprising in combination an identifying conductor for each line, two groups of electronic devices disposed in coordinate pattern in relation to the numerical designation of each of the lines in the system, each electronic device in each group having a plurality of electrodes connected to as many line identifying conductors for identifying two digits of the associated line number and to an electrode in a device of the other group for identifying two other digits of the same line number, means for applying a signaling potential to the identifying conductor of one of said lines when calling and, therethrough, to the electrode in a device in each group connected thereto whereby said devices are activated, to pass a current therethrough, means for modulating said current to a plural frequency current in accordance with a frequency allocation to each numeral of a digit in each of the four digits of a line number, and means selectively responsive to said alternating potential for identifying the numerical designation of the line to whose identifying conductor the signaling potential was applied.

10. An identification circuit for the lines of a telephone system comprising in combination with an identifying conductor for each line, a first pair of electronic devices for a group of said lines, each of said devices having an electrode for each line in the group connected to the identifying conductor thereof, a plurality of other electronic devices each having an electrode connected to the grid of a device in said first pair and adapted to apply a potential of specific frequency thereto in accordance with a frequency allocation to the digits of the line numbers, means responsive to the application of a signaling potential to the identifying conductor of a calling line in the group and, therethrough, to the electrodes of the first pair of devices connected to said conductor for operating said pair of devices to produce an alternating current having the same plural frequencies as the potential on the grid thereof, and means responsive to the operation of said first pair of devices for identifying the conductor to which said signaling potential was applied.

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