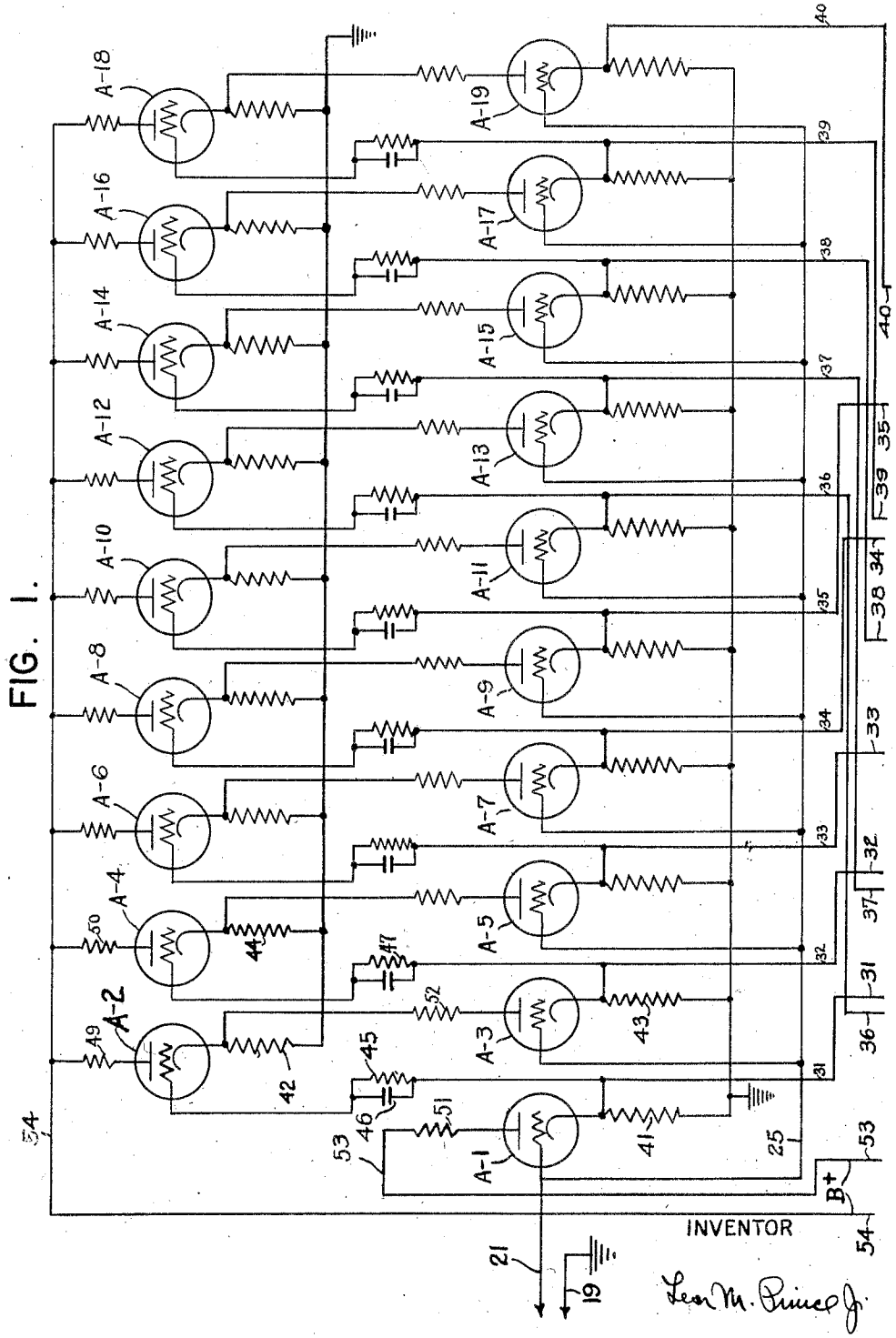
Jan. 19, 1943. L. M. PRINCE, JR 2,308,778

AUTOMATIC TELEPHONE SYSTEM

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FIG. 1.



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AUTOMATIC TELEPHONE SYSTEM

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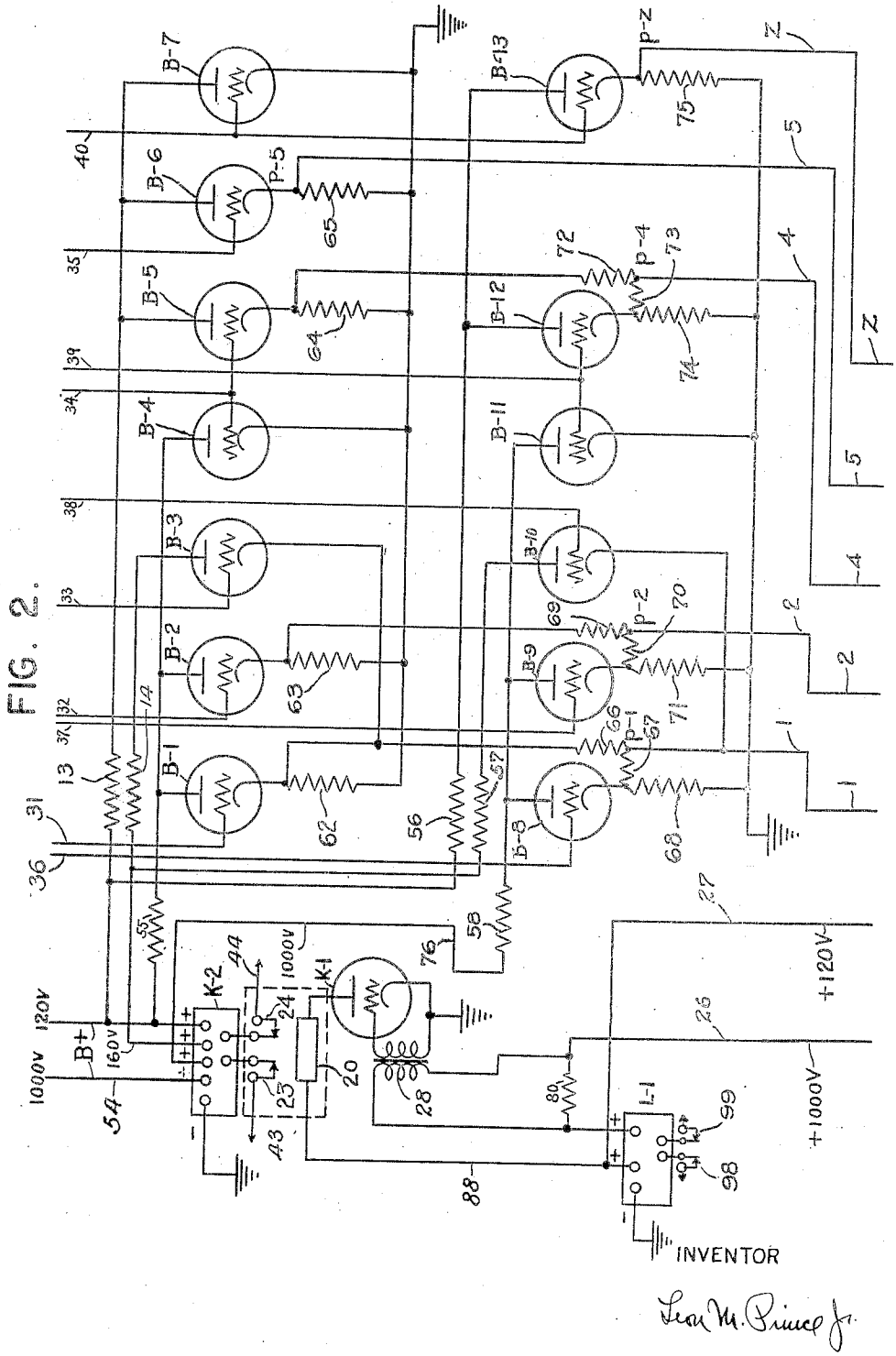


FIG. 2.

Leon M. Prince Jr.

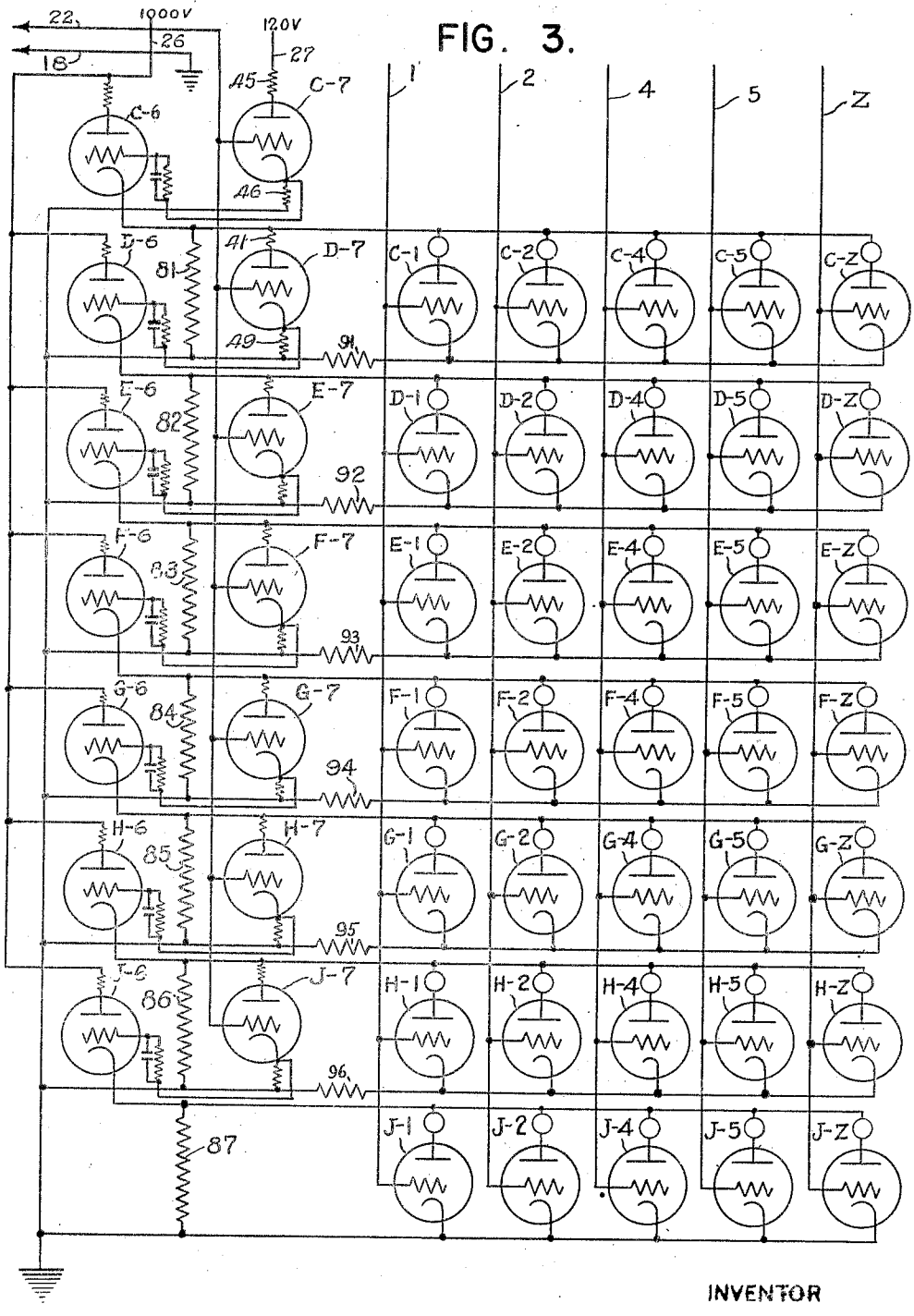
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FIG. 3.



INVENTOR

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UNITED STATES PATENT OFFICE

2,308,778

AUTOMATIC TELEPHONE SYSTEM

Leon M. Prince, Jr., New York, N. Y.

Application September 11, 1939, Serial No. 294,230

14 Claims. (Cl. 179—18)

This invention relates to electronic control circuits and more specifically to application of such circuits to automatic telephone systems.

The accompanying Figures 1, 2 and 3 represent an all-electronic register circuit for a panel sender of a dial telephone system. It is designed for use with telephone numbers comprised of seven units, e. g., the numbers used in New York city. The circuit is subdivided into three main circuits and two auxiliary control circuits. The first main circuit, Figure 1, is called the "counting circuit" and is comprised of tubes A—1 to A—13. The second main circuit, Figure 2, is called the "differentiating circuit" and consists of tubes B—1 to B—13. The third main circuit, Figure 3, is called the "register circuit" and is comprised of tubes C—6, C—7, C—1, C—2, C—4, C—5, and C—Z . . . . . J—6, J—7, J—1, J—2, J—4, J—5, and J—Z. Auxiliary reset circuits are comprised of apparatus K—1, K—2, and L—1, shown in Fig. 2.

For the purpose of illustrating the cooperation of the three circuits a brief description of a typical automatic telephone dialing system is included. When a telephone subscriber wishes to dial a number, e. g. Endicott 2-7769, he places his finger in the opening of the dial showing the letter E and pulls the dial around to the stop bracket. When the dial is released the dial clicks off three signals. Next, he places his finger in the opening showing N and again pulls the dial around to the stop bracket. Upon releasing it, the dial clicks off six signals. Then he dials the number 2 and the dial clicks off two signals. This is repeated for the numbers 7, 7, 6, and 9 in order, and each time the dial clicks off signals corresponding to the number dialed.

Each of these clicks is transformed into an electrical impulse and it is the purpose of my counting circuit, Fig. 1, to count each one of these impulses. Thus, on the first series of impulses corresponding to the letter E, the counting circuit will record 3. It is there reset, as it is after each successive series of impulses. Upon the second series of impulses corresponding to the letter N it will record 6. Upon the third series of impulses, corresponding to 2, it will record 2. This will be continued until all the numbers are counted. After counting each series of impulses, the counting circuit sends its count to the differentiating circuit, Fig. 2, which actuates circuits corresponding to the count which in turn actuate the register circuit, Fig. 3, to record the result and cause the number to be connected. The counting circuit and the differentiating circuits are then cleared and are ready to receive the next series of impulses. The register circuit is not reset until the whole series of numbers have been recorded and retransmitted to an automatic switching apparatus (not shown) which, as is well known in the automatic telephone art, is suitably operated to connect the proper subscriber circuit to the trunk line.

In order to save duplication of equipment in the register circuit, Fig. 3, the telephone company uses only a few of the numbers from 1 to 0. Just five units are used in this code but these five units are made to do the work of ten. These units are 1, 2, 4, 5, and *z*, the latter representing the character 0. The dialing of the number 1 or a letter corresponding to it is represented by 1; the dialing of the number 2 or a letter corresponding to it is represented by 2; the dialing of the number 3 is represented by 2 and 1 in combination; the dialing of 4, by 4; the dialing of 5, by 5; the dialing of 6, by 5 and 1; the dialing of 7, by 5 and 2; the dialing of 8, by 5, 2 and 1; the dialing of 9, by 5 and 4; and finally the dialing of 0, by *z* alone.

The counting circuit, Fig. 1, counts out the total number of impulses in each series of clicks as the dial sends them out. The function of the differentiating circuit, Fig. 2, however, is to take these dialed impulses and codify them so that the output circuit of the differentiating apparatus actuates the proper lines of the five lines corresponding to the numbers 1, 2, 4, 5, and *z* of the code. These lines in turn will supply operating potential for the grids of each set of tubes in the register groups, Fig. 3. For example, on the second dialing operation corresponding to the letter N, six impulses will be received by the counting circuit shown in Fig. 1. This will operate six odd-numbered tubes in the counting circuit which in turn will operate corresponding tubes in the differentiating circuit shown in Fig. 2 so as to put operating potential on lines 5 and 1 of its output circuit.

As a result, tubes D1 and D5 in the second group of tubes in the register circuit shown in Fig. 3, will be operative, indicating that the second unit of the telephone number dialed is N (or 6). In the same way, the operation of tubes C1 and C2 in the first register group indicates that the letter E (or 3) is the first letter of the number dialed. The operation of tube E2 in the third register group indicates that the number 2 is the third number dialed. This continues down the line until tubes 15 and 14 in the bottom group of tubes operate to indicate that 9 was the final number dialed. How these results are accomplished by my circuit is described in greater detail hereafter.

D. C. potential is suplied to the plates of all tubes. In the present arrangement gas-filled tubes are used having operating characteristics such that a plus bias of 20 volts on the grids is required to render them operative. Any tubes with similarly suitable characteristics may, of course, be substituted.

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Referring to Figure 1, it is the purpose of the counting circuit to count the impulses of the dial and to transmit the results of this counting to the differentiating circuit. This circuit is composed of a series of pairs of tubes A—1 and A—2, A—3 and A—4, through A—17 and A—18, and the single tube A—19. Each pair is comprised of a primary and secondary tube, the secondary tube in each instance acting to prepare the following primary tube for operation. The single tube A—19 does not require a secondary tube because it is the last tube in the line and therefore has no corresponding secondary tube to prepare for operation. All the odd numbered tubes in group A are primary tubes and the even numbered are secondary tubes. The grids of all the primary tubes are in parallel and connected with input line 21, 19. This input line 19, 21 is arranged to respond to the dialed number by temporarily raising the potential of the common primary grid line 25 from ground potential to some higher value, i. e., 20 volts, for each dial click received over line 19, 21. This grid potential impulse is timed by a suitable time constant circuit to die out in a predetermined time interval before the next dial click is received. Thus the grid line 25 will receive a series of sharp transient impulses, i. e., a series of 20-volt pulses, spaced in a predetermined manner, the number of which impulses will correspond to the number of dial clicks received, i. e., to the digit dialed.

Thus, upon the first impulse of a given series corresponding to a given number from 1 to 0 which is dialed, the grid of tube A—1 will lose control. Current will then flow from source of potential of 120 volts at power supply K—2 of Figure 2 through line 53, through current limiting resistor 51, tube A—1, and cathode resistor 41 to ground. As a result line 31 will assume a potential of 20 volts instead of its original potential of zero. One of the results of this change in potential is to charge the condenser 46 through resistor 45 which, after a time delay commensurate with values of said condenser and resistor, will cause the grid of tube A—2 to lose control. Operation of tube A—2 permits current from source of potential of 1000 volts at power supply K—2 in Figure 2 to flow through line 54, current limiting resistor 49, tube A—2, and cathode potentiometer 42 to ground. The IR drop across potentiometer 42 raises the cathode-anode potential of tube A—3 from zero to approximately 120 volts. But by this time the first impulse on line 25 has died out since the time delay in condenser 46 and resistor 45 is so adjusted that tube A—2 will operate some time after the first impulse occurs but before the second one. Therefore, A—3 cannot operate on the first impulse. Before the second impulse occurs, howevers, the IR drop across resistor 42 is sufficient to supply A—3 with a plate potential of 120 volts and therefore A—3 is ready to operate if and when the second impulse occurs. When the grid of tube A—3 loses control as a result of a second impulse on line 25, current flows from the 120 volt source of potential across the cathode potentiometer 42 of tube A—2 through a current limiting resistor 52, tube A—3, and cathode resistor 43 to ground. As before, tube A—4 does not operate until after the second impulse has subsided and before the third one begins. Thus, the potentiometer 44 in the cathode circuit of tube A—4 does not supply tube A—5 with plate voltage until just after the second impulse dies out. Thus tube A—5 cannot operate on the second impulse but is ready to respond to a third impulse.

In this fashion each successive pair of tubes will operate as long as the dial sends out impulses. The value of resistor 51 in the plate circuit of tube A—1 controls the current in resistor 41 so that the IR drop is 20 volts, or more. Resistor 52 in the plate circuit of tube A—3 performs the same function for resistor 43, as do all the other resistors in the plate circuits for the resistors in the cathode circuits of the primary tubes. The value of resistor 49 in the plate circuit of tube A—2 controls the current in cathode potentiometer 42 so that the IR drop equals approximately 120 volts. Similarly, resistor 50 in the plate circuit of tube A—4 performs the same function for cathode potentiometer 44 as do all the resistors in the plate circuits for the cathode potentiometers of the secondary tubes.

After each series of impulses corresponding to a single number of the telephone number to be dialed, the currents in the plate circuits of the A tubes are temporarily interrupted by means of relay contacts 22 and 24 in Figure 2, and they are all reset and immediately ready to operate again. The sequence of events resulting is this operation will be hereinafter described in connection with the circuits shown in Figure 3. In addition to supplying grid control potential for their corresponding secondary tubes, these potentiometers, i. e., the resistors in the cathode circuit of the primary tubes, also control the grid circuits of tubes B—1 through B—13, shown in Figure 2, to which they are connected by lines 31 through 43.

As an example of the actual operations of the circuits just described in connection with Figure 1 let us dial the telephone number Endicott 2–7769. Translating this telephone number into figures it becomes 3—6—2—7769. In accordance with this sequence of numbers, the counting circuit will first operate so that a potential of 20 volts will be on lines 31, 32, and 33. After the dial returns to rest, relay contacts 23 and 24 will operate interrupting the plate circuits and resetting all tubes in the counting circuit (and in the differentiating circuit, Fig. 2, as will hereinafter be explained). The next series of impulses is 6, so lines 31 to 36, inclusive, will have operating potential on them. After the next interruption, lines 31 and 32 will possess operating potential. After the next two interruptions lines 31 to 37, inclusive, will possess operating potential. After the next interruption, lines 31 to 38, inclusive, will possess operating potential. Finally, after the next interruption, lines 31 to 39, inclusive, will possess operating potential. Upon the dial's return to rest after this final signal, the plate circuits will be interrupted once more, clearing the group A tubes for a new incoming call.

The function of the differentiating circuit shown in Figure 2 is to record the results of the counting circuit shown in Fig. 1 in such a way as to make these signals available for use in the register circuit lines 1, 2, 4, 5, and z connecting the differentiating circuit of Figure 2 with the register circuit of Figure 3. The tubes in this differentiating circuit are, in a sense, arranged into six groups. They are (1) tubes B—1, B—2, and B—4, whose plates are connected together to a single series resistor 55 and thence to a 120 volt source of potential; (2) tube B—3, the cathode of which is connected to the cathode of tube B—1 but through its own plate resistor 14 to approximately 160 volts at source K—2; (3) tubes B—5,

B—6, and B—7, whose plates are all connected to series resistor 13 thence to 120 volts at source K—2; (4) tubes B—8, B—9, and B—11, whose plates are connected together and receive plate potential through series resistor 58 and line 76 from a plus 1000 volt source at K—2; (5) tube B—10 the plate of which is connected through resistor 57 to a plus 160 volt source of potential at K—2 and the cathode of which is connected to the cathode of tube B—3 through resistor 67; and (6) tubes B—12 and B—13 whose plates are connected together and obtain plate potential of 120 volts through series resistor 56. Within each group, as each successive tube operates, the IR drop across the series resistor reduces the potential at the cathode by an equal amount. In any group therefore, an operating potential on line 1, for example, is reduced to a non-operating potential through the decrease in current flowing through resistor 62 of tube B—1 when tube B—2 or B—4 operates. The same principle applies throughout the six groups. When it is desired to lower the operating potential on all the cathodes of any one group, a tube, such as B—4, is shorted through the series resistor to ground. This increases the IR drop through the series resistor to a value far below that required by the various cathodes to supply operating potential to the output lines of the circuit. The operation of the differentiating circuit will now be traced. When the grid of tube B—1 loses control as a result of potential on line 31 due to a first impulse of any number of a dialed telephone number, current flows from the plus 120 volt source of potential at power supply K—2 through series resistor 55, tube B—1, and through cathode potentiometer 62 to ground, and also through resistors 66, 67 and 68 to ground, but not through line 1, the grids of —1 tubes in Figure 3 to ground, as none of these grid to cathode paths are yet open. The result is to raise the potential of point *p*—1 from zero to 20 volts, placing 20 volts on line 1. If no further impulses are received this grid potential will be sufficient to operate tube C—1 in the first group of the register circuit (Fig. 3). Upon the operation of tube B—2 as a result of potential on line 32 due to a second impulse of any number of a dialed number, current flows in resistor 63, the value of which is greater than resistor 62 through a path parallel to the path of current through tube B—1. As a result, point *p*—2 assumes a potential of plus 20 volts through resistor 69, as does also line 2. This potential will operate tube C—2 in the register group (Fig. 3), providing no further impulses are received. The current through resistors 62 and 63, however, also goes through the series resistor 55 with the result that, upon the operation of B—2, the current through 62 is reduced and thus the voltage of point *p*—1 and so of line 1 drops to a value less than 20 volts, rendering this line incapable of operating tube C—1. In this way the counting and differentiating circuits will function so as to only render operative tube C—2 of the first register group as a result of the second dialed impulse. Upon the operation of tube B—3 as a result of potential on line 33 caused by a third impulse, current flows in resistor 14 from a source of 160 volts potential at K—2, through tubes B—3, and through resistors 62 and 66, 67 and 68 to ground. The result is to raise the potential of *p*—1 and line 1 to 20 volts again. Thus, when three impulses have been recorded by the counting circuit, lines 1 and 2 out of the differentiating circuit are in a condition to render operative the register tubes (Fig. 3) connected to them, both C—1 and C—2.

When line 34 receives potential due to a fourth impulse, tubes B—4 and B—5 operate. The operation of tube B—4 draws so much current through resistor 55 as to greatly increase the IR drop across it. This affects the drop across resistors 62 and 63 which in turn reduces the potential of points *p*—1 and *p*—2 and so of lines 1 and 2 to below 20 volts, at which value they are incapable of rendering operative the register tubes shown in Fig. 3 connected to them. Upon the simultaneous operation of tube B—5 current flows in resistor 64 and the IR drop across it raises the potential of point *p*—4 across the potentiometer formed by resistors 64, 72, 73 and 74 to 20 volts. Line 4 thus acquires a potential of 20 volts and is capable of rendering operative the register tubes connected to it.

Upon the operation of tube B—6 as a result of operating potential on line 35 due to a fifth impulse, the potential of point *p*—5 and so of line 5 is raised to 20 volts, rendering it capable of operating tubes connected to it. The value of resistor 65 is greater than that of 64 so that when tube B—6 operates the IR drop across resistor 65 is sufficient to give point *p*—5 a potential of 20 volts, but the drop across resistor 13 is now so large that the potential of point *p*—4 drops below 20 volts, rendering line 4 incapable of operating tubes connected to it.

The potential of *p*—5 remains 20 volts during the next four signals from the counting circuit. Upon a signal from line 40, however, the operation of tube B—7 so increases the IR drop across series resistor 13 as to greatly reduce the IR drop across resistor 65. As a consequence the potential of *p*—5 and line 5 is reduced to a value less than 20 volts, rendering it incapable of operating tubes connected to it.

Upon the operation of tube B—8 as a result of potential on line 36 due to a sixth impulse, current flows in resistor 68. The IR drop across this is 100 volts (the potential on line 76 is 1000 volts) with the result that the potential of *p*—1 and line 1 on the potentiometer is raised to 20 volts again. The value of the current through resistors 62 and 66 should be ten times that through 67 and 66; the value of resistor 67 should be four times that of 66. Thus, with potential on line 36 indicating the reception of the sixth impulse from the dial, the differentiating circuit has placed an operating potential of 20 volts on lines 5 and 1.

Upon the operation of tube B—9 as a result of potentials on line 37 due to a seventh impulse, current flows in resistor 71, the value of which is greater than 68. The result is to raise the potential of *p*—2 and line 2 to 20 volts again, and, because the drop across resistor 58 is increased by the operation of B—9, the drop across 68 is decreased and so the potential of point *p*—1 and line 1 is reduced to below 20 volts, rendering it incapable of operating its register tubes (Fig. 3). As before, the values of resistors 63, 69, 70, and 71 are proportional to 62, 66, 67, and 68, respectively.

Upon the operation of tube B—10 as a result of potential on line 38 due to an eighth impulse, the potential of *p*—1 and line 1 is again raised to 20 volts, due to the increase of the current flow through 67 and 68 and 66 and 62 due to the opening up of another electrical channel through tube B—10 and resistor 57, to a source of potential of 160 volts in the power

supply K—2. Thus, register tubes connected to lines 5, 2, and 1 can operate. When B—11 operates as a result of potential on line 39 due to a ninth impulse, the drop across resistor 58 is increased so that the potential of points *p*—1 and *p*—2, and, of course, lines 1 and 2, drops to below 20 volts again. The simultaneous operation of B—12 causes current to flow through resistor 74 and, in the same way as before, the potential of *p*—4 and line 4 is raised to 20 volts again, making it possible for register tubes connected to lines 5 and 4 to operate.

Finally, upon the operation of tube B—13 as a result of potential on line 40 due to a tenth (or zero) impulse, current flows through resistor 75 which is greater than 74 raising the potential of *p*—*z* and line *z* to 20 volts. The increased IR drop across resistor 56 reduces the current through 74 and thus the potential on *p*—4 and line 4 to below 20 volts. Simultaneously, as previously described, the operation of B—7 has reduced the potential of *p*—5 and line 5 to below 20 volts. Thus, as a result of potential on line 40 only line *z* remains with 20 volts on it and only tubes connected to line *z* can operate.

A capitulation of the results attained by the differentiating circuit is contained in the following table:

B means tube is operative
X means tube is not operative

Dial impulse No.	Potential on differentiator output lines				
	Line 1	Line 2	Line 4	Line 5	Line Z
1	B 20	X 0	X 0	X 0	X 0
2	X 10	B 20	X 0	X 0	X 0
3	B 20	B 20	X 0	X 0	X 0
4	X 6	X 10	B 20	X 0	X 0
5	X 6	X 10	X 10	B 20	X 0
6	B 20	X 10	X 10	B 20	X 0
7	X 10	B 20	X 10	B 20	X 0
8	B 20	B 20	X 10	B 20	X 0
9	X 6	X 10	B 20	B 20	X 0
10	X 6	X 10	X 10	X 10	B 20

Dialing 3—6—2—7769 will produce potentials on the following output lines of the differentiating circuit:

Dialing "3" will place operating potentials on output lines 31, 32, and 33 of the counting circuit (Fig. 1) and will put operating potentials of plus 20 volts on lines 1 and 2 shown in Fig. 2. Upon the return of the dial to rest, the dial stop signal will operate. This dial stop signal like the regular dial signal is a transient impulse of 20 volts or more and is represented in Figure 3 as input line 22, 18. This dial stop signal controls the grids of tubes C—6 and C—7, D—6 and D—7 . . . J—6 and J—7 a series of seven pairs of tubes, primary and secondary, exactly equivalent to the pairs of tubes in the counting circuit of Figure 1. The function of these latter tubes, however, is not only to count the impulses sent out by the dial stop signal but by their operation to place suitable plate potential at the proper instant upon register tubes C—1, C—2, C—3, C—4, and C—5; D—1, D—2, D—3, D—4, and D—5; . . . J—1, J—2, J—3, J—4, and J—5 after receipt of each successive dial stop signal. The drawing of current by any of the C—6, D—6 . . . J—6 tubes from source of supply L—1 Figure 2, through resistor 89, line 25, the current regulating resistor in each plate circuit, a —6 tube and thence through its cathode potentiometer to ground, will create a small IR drop across the resistor 80. This potential change will induce a transient through transformer 28 onto the grid circuit of vacuum tube K—1 Figure 2. This temporary change in grid bias of tube K—1 will cause the fast electromagnet relay 20 in its plate circuit to be momentarily energized, drawing current from plus 120 volts at power supply L—1 through line 88, relay 20, tube K—1 and thence to ground. As the relay becomes energized, its contacts 23 and 24, momentarily open, interrupting the source of potential to power supply K—2 from supply lines 43 and 44. This will momentarily reduce the plate voltage of all the gaseous-discharge tubes in Figures 1 and 2 to zero. As a consequence all the grids will regain control and the counting and differentiating circuits will be immediately ready for another series of incoming signals from the dial input line, 21, 19. This cycle of operations wil be repeated each time the dial comes to rest against the bracket after a given number is dialed.

Upon the next set of impulses from the dial the counting circuit will put potential on lines 31, 32, 33, 34, 35, and 36, and the differentiating circuit will operate to put 20 volts on lines 5 and 1. Dialing 2 will will put 20 volts on line 2; dialing 7 twice will put 20 volts on lines 5 and 2 twice in succession; dialing 6 will put 20 volts on lines 5 and 1; and dialing 9 will put 20 volts on lines 5 and 4. Upon the final return of the dial to rest the operation of tube K—1 will reset the differentiating circuit and it will then be ready for a new set of signals.

The function of the register circuit, Figure 3, is to receive the results of the counting and codification of the dialed impulses and to actuate apparatus in the unit following the panel sender corresponding to the numbers dialed. This apparatus is represented by circles in the plate circuits of the tubes of the register groups.

The resistor circuit is divided into seven groups of tubes, C—tubes, D—tubes, E—tubes, F—tubes, G—tubes, H—tubes, and J—tubes, each group of which registers in the code the impulses of a single number dialed. Each group is subdivided into two sets of tubes. Tubes numbered —1, —2, —4, —5, and —*z*, called the main register circuit tubes, record the signals on the output lines of the differentiating circuit, tubes numbered —6 and —7 count the dial stop signals at the end of each dialing operation and function to transfer the output signals of the differentiating circuit to successive groups of —1 to —*z* tubes. Thus, the first dial stop signal from lines 22, 18 serves to put group C in action, the second dial stop signal puts group D in action, and so forth to the seventh and last dial stop signal which puts group J in action. When the subscriber moves the dial away from the rest position as he begins to dial the desired number, nothing happens in the register circuit Figure 3. Nothing happens in the circuit as he winds the dial to the desired digit or letter of the number and nothing happens in the register circuit as the dial is released and clicks out its signals. But when the dial returns to rest after this operation, the dial stop signal sends its impulse through input lines 22, 18 to the grids of all —7 tubes in Figure 3, temporarily raising their potential to 20 volts or more. In the meanwhile the counting and differentiating circuits have picked up the signals of the dial input line 21, 19 and have placed operating potentials on lines 1, 2, 4, 5, and *z* in accordance with the number dialed and the code it repre-

sents. But even the operation of a —7 tube in Figure 3 does not permit —1, —2, —4, —5, or —z tubes in the main register circuit to operate, even though operating potential is available on their grids. These main register circuit tubes must wait until after the dial stop signal has died out before a —6 tube, which is controlled by time delay circuit in its grid, exactly as in the counting circuit of Figure 1, puts current through the potentiometer in its cathode. These —6 tubes receive plus 1000 volts plate potential from source L—1, Figure 2, through resistor 80, line 26, an individual current limiting resistor in each of their plate circuits, thence through the tubes and the potentiometer in each cathode to ground. The potential across the potentiometer is 120 volts and the current through it should be at least ten times the maximum load (three operative tubes) that the main register circuit tubes —1, —2, —4, —5, —z will draw. The —7 tubes in Figure 3 operate as follows: Tube C—7, in a similar way to tube A—1 of Figure 1, is connected from a 120 volt source of supply at L—1 in Figure 2 through line 27 and, current limiting resistor 45, to a grid bias resistor 46, which controls tube C—6, and thence to ground. The remaining —7 tubes are connected in the same manner except that they obtain their plate voltage supply from across the potentiometer in the grid of the preceding —6 tube, for example, tube D—7 obtains its plate supply from potentiometer 81 in the cathode of tube C—6.

How the register circuit of Figure 3 functions as an entity will now be described in some detail. Upon the first dial stop signal or input lines 18, 22, C—7 operates (since it is connected directly to a plus 120 volt line), and through a time delay circuit exactly as in the counting circuit shown in Figure 1, Tube C—6 operates. Current then flows in resistor 81 across which are connected in parallel tube D—7 including its cathode resistor 49 and plate resistor 41 and tubes C—1 through C—z inclusive with their associated common cathode series resistor 91. The grids of these tubes C—1 through C—z will then respond to whatever signals have been set up in lines 1 to z. If more than one line has an operating potential, this corresponds to a tie or simultaneous operation of two different portions of the differentiating circuit. The main register circuit group of tubes are designed to record such ties, providing that the grid signals arrive simultaneously or, as in the case at hand, the signals have all arrived—though not simultaneously—before plate potential is supplied to the registering group. Resistor 91 will draw a current corresponding to the number of tubes operative, current from one tube being sufficient to create a cathode bias across resistor 91 which will prevent the future operation, until a plate potential interruption, of any more tubes in the C group.

Thus upon the dialing of the number "3" of a first series of signals on impulse 21, 19, and the assumption of a potential of 20 volts by lines p—1 and p—2 and the actuation of the first dial stop signal on signal line 22, 18 and the subsequent operation of tubes C—7 and C—6 thereby placing 120 volts on potentiometer 81, the grids of tubes C—1 and C—2 will simultaneously lose control causing current to flow from the cathode of tube C—6, the high side of potentiometer 81, through the control apparatus in the plates of each of tubes C—1 and C—2, through the tubes in parallel thence via resistor 91 to ground. The drop across series resistor 91 will raise the bias on the grids of the remaining non-operative tubes in this C— group to a point where they can no longer lose control until a plate circuit interruption reduces the bias through resistor 91.

Because of the time delay in the operation of tube C—6 after the dial stop signal to the grid of tube C—7, tube D—7 has been prevented from operating on the first dial stop impulse. As a consequence potentiometer 82 in the cathode of tube D—6 cannot supply plate voltage to the D group of register tubes. Thus, these do not respond to the operating potentials on input lines 1 to z corresponding to the first set of impulses sent out by the dial. Similarly groups E, F, G, H, and J do not respond.

The operation of tube C—6 also causes current to flow through resistor 80 which in turn transmits an impulse to the transformer in the grid of vacuum tube K—1. This responds to the impulse in such a way as stated before as to actuate relay 20 just long enough to momentarily open contacts 23 and 24. This clears the counting circuit and differentiating circuits for the next set of impulses from the dial but not before the old set has been recorded by the first register group of tubes. Upon each successive signal from the dial stop line 22, 18 and the subsequent operation of a —6 tube, resistance 80 will receive an additional increment of current through it. Each increment serves to actuate K—1 and relay contacts 22 and 24 and so to reset the counting and differentiating circuit. The value of 80 must be large enough to create the desired effect in the vacuum tube but must not be so large as to materially effect the potential on the plates of the —6 tubes with which it is in series. In addition, upon each successive signal from the dial stop line 22, 18 and the subsequent operation of a —6 tube, successive register groups will receive plate potential from the potentiometers 82, 83 . . . 87 in the cathodes of these —6 tubes in such sequence that groups D, E, F, G, H, and J will be rendered operative in that order.

As each set of impulses from the dial is transformed by the counting and differentiating circuits to potentials of 20 volt magnitude on the register circuit input lines 1, 2, 4, 5 and z, a new group of 1 to z tubes is made ready to receive these signals. The number 3—6—2—7769 will accordingly set up as follows in the register circuit:

1	2	4	5	Z
B	B	X	X	X
B	X	X	B	X
X	B	X	X	X
X	B	X	B	X
X	B	X	B	X
B	X	X	B	X
X	X	B	B	X

Upon the completion of the final dialing operation by the subscriber, tube J—6 will operate, sending current through resistor 87 and causing tubes J—1 to J—Z to respond to the signals on lines 1, 2, 4, 5, and z. No series resistance is required in the cathode circuit of the final register group as no more signals will be applied to the grids in this group.

As soon as the apparatus in the plate circuits of the main register groups have performed their appropriate functions in the next piece of ap-

paratus after the panel sender, a final signal will be given which will momentarily open contacts 93 and 99 shown in Fig. 2, thereby temporarily reducing the potential of lines 26 and 27 to zero and so permitting the grids of all the tubes in Figure 3 to regain control. But before this signal is given, the operation of tube J—6 will have momentarily operated vacuum tube K—1, and through it, relay contacts 23 and 24, thereby resetting all tubes in Figures 1 and 2. Hence, immediately after receipt of the final signal, the panel sender described herewith will be again ready to receive signals from the dial.

It should be understood that in the above description of my invention, the voltages recited are for illustrative purposes only. My invention is operable with other voltages suitably chosen in consideration of the particular gaseous discharge devices used, as long as the relative magnitude of these voltages are properly maintained. It should be further understood that apparatus constructed in accordance with my invention may be operated satisfactorily with many types of gaseous discharge tubes, and that therefore I have not specified illustrative values for the various circuit components shown, such as resistors and condensers, because the value of such circuit components would be primarily dependent upon the particular type of gaseous discharge devices used. The particular values of these components, therefore, do not, per se, form an important element of my invention so long as the ratio between the voltage values, above described, are properly maintained, and the time constants of the various circuits suitably chosen for the purposes for which they are intended.

It is to be understood that this description is merely illustrative of my invention and that it is not limited to the specific form herein described.

I claim:

1. In an automatic telephone system, in combination, a signal line for receiving a plurality of series of signal impulses from a calling station, a first set formed of a plurality of pairs of gaseous discharge tubes connected to said line, means operating each of said pairs in response to signal impulses only, the number of pairs of said set operated in sequence corresponding to the number of impulses in each signal series received, a second set of gaseous discharge tubes connected to the first set of tubes, potentiometers in the cathode circuits of said second set of tubes, means interconnecting said cathode potentiometers, the tubes in said second set being responsive to the sequential operation of the pairs of tubes in the first set to produce a component of potential on their output circuits corresponding to the number of pairs of tubes in the first set which have operated in sequence, means for receiving an auxiliary stop signal at the conclusion of each series of signal impulses, a third series of tubes, apparatus connected thereto to reset all tubes of the first and second sets responsive to said stop signals from said last named means, a fourth set formed of a plurality of groups of tubes, the number of groups corresponding to the maximum possible number of series of impulses, the number of tubes in each group corresponding to the number of units in each signal series, means for resetting tubes of the fourth set, means connected with said third set of tubes for successively rendering operative each group of tubes of said fourth set of tubes, whereby the number of tubes operative in each group and the number of groups operative correspond respectively to the number of impulses in each series and the number of each series of signals received over the signal line.

2. In an automatic telephone system, in combination, a signal line for receiving a plurality of series of signal impulses from a calling station, counting means including a first set of gaseous discharge tubes connected to said line, means sequentially operating a number of pairs of tubes in said set corresponding to the number of impulses in each signal series received, means permitting operation of said pairs only in response to signal impulses, means to reset the tubes of said first set after each signal series, a second set of gaseous discharge tubes connected to the first set of tubes, the number of groups in said set corresponding to the maximum number of signal series to be used, the number of tubes in each group corresponding to the maximum number of impulses in each series, means to reset said tubes of said second set, means including a third set of tubes successively sequentially rendering operative groups of tubes in said second set corresponding to the number of series of received signals and a number of tubes in each group corresponding to the number of signal impulses in each successive signal series.

3. A differentiating circuit for transforming a series of successive non-synchronous signals into a predetermined coded system of signals, comprising, in combination, a group of circuits each one of which is composed of a plurality of grid-controlled gas-filled tubes connected across a source of electrical potential, means effectively connecting in parallel all of the series of each of said groups, an impedance in series with each group of parallel connected tubes, means for selectively rendering the tubes operative, impedances in the cathode circuit of each tube, means interconnecting said cathode impedances to form output circuits corresponding to the number of signals in the coded systems, whereby the component of potential existing in said output circuit upon the receipt of a series of successive impulses will be in accordance with the predetermined code.

4. In an automatic telephone system using a mechanism for producing sequential non-synchronous signals at the calling station, a circuit for sequentially counting the series of successive impulses forming any given signal, comprising, in combination, a series of pairs of gaseous discharge tubes, the number of pairs corresponding to the maximum number of impulses which may occur in any signal, each pair of tubes comprising a primary and a secondary tube, each of said pairs being operable only in response to the receipt of signal impulses, means energizing a number of pairs of said tubes in sequence in response to any signal corresponding to the number of the impulses forming said signal, comprising, means effectively connecting the grids of all of the primary tubes together and to the line from the calling station, means effectively connecting all the secondary tubes in parallel, a source of potential connected directly to the first primary tube, a second source of potential connected through each of said secondary tubes to each succeeding primary tube, a potentiometer in the cathode circuit of each tube. means effectively connecting the plate of

each primary tube, except the first, to the potentiometer in the cathode of the secondary tube of the preceding pair, means including a time constant circuit interposed between the primary and secondary tubes to provide a time interval between operation of a primary tube and operation of the secondary tube of the pair which is greater than the duration of the impulse but less than the interval between impulses, whereby the number of primary tubes operated in response to each successive signal will equal the number of impulses in said signal.

5. In an automatic call responsive system responsive to sequential non-synchronous signals from a calling station, such signals consisting of a series of impulses, a circuit for sequentially counting the series of successive impulses forming any given signal, comprising, in combination, a series of gaseous discharge tubes the number of tubes corresponding to the maximum number of impulses which may occur in any given signal, means for effectively connecting the grids of all of these tubes together and to the signal source, and a source of potential directly connected to the plate circuit of the first tube, and means for supplying operating potential to the plate circuit of each successive tube a predetermined time interval after each successive impulse has subsided but before the next impulse occurs to operate a number of tubes in sequence which will equal the number of impulses corresponding to the given signal.

6. In an automatic telephone circuit, in combination, a register circuit responsive to a plurality of series of sequential non-synchronous signals periodically punctuated by an auxiliary stop signal following each series of signals, comprising, a plurality of sets of grid-controlled gaseous discharge tubes, means connecting in parallel all said tubes in each of said sets, an impedance in series with the parallel connected tubes in each of said sets, means responsive to the number of signals in each series selectively applying operating potentials to corresponding grids of each of said sets, and means responsive to each auxiliary stop signal for sequentially controlling the application of cathode-anode potentials to each of the plurality of sets of tubes through said impedances, said cathode-anode potentials being applied to an additional set of said tubes only after each auxiliary stop signal is received, whereby all tubes having cathode-anode operating potentials at the moment their grids have operating potentials respond to said signals.

7. Apparatus for recording a sequence of a plurality of impulses, comprising, in combination, a signal line, a series of electronic indicating devices sequentially responsive to a plurality of impulses, means connected therewith to sequentially supply operating potentials to a second series of electronic indicating devices, means connecting together said second electronic indicating devices to supply operating potential to a third series of sets of electronic indicating devices in accordance with a predetermined code, means connected with said third series of sets of electronic indicating devices for rendering them operative sequentially in response to the operated devices in said second series of devices, and means associated with the third series of devices for resetting the first and second series after the operation of each set of devices in the third series of sets, whereby the individual devices of the third series of devices will operate in response to impulses transmitted over the signal line in accordance with the predetermined code.

8. In a register circuit, in combination, a plurality of sets of tubes serving as recording devices, a second group of tubes sequentially operative in accordance with the successive series of incoming impulses, a third group of tubes selectively operative in accordance with a pre-arranged code and responsive to the sequential operations of said second group of tubes, means associated with said third group of tubes for selectively rendering each set of tubes conducting in accordance with the pre-arranged code, a fourth group of tubes, means associated therewith and with said third group of tubes and controlled by a dial stop signal for rendering each of said sets of tubes operative in sequence whereby the registration of the sets will control recording in accordance with the incoming series of impulses.

9. In a panel sender device for a dial telephone system using a sequential code signal producer at the calling station and a non-synchronous register circuit for registering said signals to operate selective mechanism to connect the calling station with the proper called station, in combination, a plurality of sets of register tubes, means for rendering said sets of register tubes sequentially operative in response to a dial stop signal at the completion of each series of incoming impulses, means for counting each series of incoming impulses, means associated with said counting means for selectively rendering each of the plurality of sets of register tubes conductive in accordance with each series of non-synchronous incoming impulses whereby the registration of said sets of tubes will control registry in accordance with the successive series of incoming impulses.

10. In a panel sender for a dial telephone system, in combination, a first group of grid-controlled tubes, means associated therewith for sequentially rendering said tubes conductive in response to the successive series of incoming impulses, a second group of tubes, means associated therewith for rendering said tubes responsive to the sequential operation of said first group of tubes in accordance with a predetermined code, a third plurality of sets of tubes, a fourth group of tubes, means associated therewith for rendering each set of the third plurality of tubes sequentially operative in response to a dial stop signal at the completion of each series of impulses, and means associated with said third plurality of sets of tubes for rendering each set selectively operative in response to the second group of tubes whereby the registration of the plurality of sets of tubes will control registration in accordance with the incoming series of impulses.

11. In an automatic telephone circuit, in combination, a register circuit responsive to a series of signals periodically punctuated by an auxiliary stop signal, comprising a plurality of sets of grid-controlled gaseous discharge tubes, the number of sets of tubes corresponding to the number of series of signals, the number of tubes in each set corresponding to the number of signals in each of said series, means effectively connecting in parallel all the tubes in each of said sets, an impedance in series with the parallel-connected tubes in each of said sets, means responsive to their corresponding signals for selectively applying operating potential to the grids in each set and means responsive to said auxiliary stop sig-

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nal for sequentially controlling the application of cathode-anode potential to each of the plurality of sets of tubes whereby only those tubes which have cathode-anode operating potential at the moment when their grids have operating potential can respond to said signals, and a counting circuit, comprising a series of electronic devices, the number of said devices corresponding to the number of register sets, means including a time delay circuit for rendering each of the electronic devices responsive to said auxiliary stop signal impulses, means for connecting said devices across a source of electrical potential, a potentiometer in the output circuit of each device, means for connecting the corresponding set of register tubes thereacross, and bias means for preventing the operation of the next electronic means in series until the stop signal impulse corresponding to said next electronic means is transmitted whereby successive devices will operate responsive to auxiliary stop signal impulses to sequentially control the application of operating plate potential to the tubes of the plurality of register sets.

12. In an automatic telephone circuit, in combination, a register circuit responsive to a series of signals periodically punctuated by an auxiliary stop signal, comprising a plurality of sets of grid-controlled gaseous discharge tubes, the number of sets of tubes corresponding to the number of series of signals, the number of tubes in each set corresponding to the number of signals in each of said series, means effectively connecting in parallel all the tubes in each of said sets, an impedance in series with the parallel-connected tubes in each of said sets, means responsive to their corresponding signals for selectively applying operating potential to the grids in each set, and means responsive to said auxiliary stop signal for sequentially controlling the application of cathode-anode potential to each of the plurality of sets of tubes whereby only those tubes which have cathode-anode operating potential at the moment when their grids have operating potential can respond to said signals, a counting circuit, comprising a series of electronic devices, the number of said devices corresponding to the number of register sets, means including a time delay circuit for rendering each of the electronic devices responsive to the auxiliary stop signal impulses, means for connecting said devices across a source of electrical potential, a potentiometer in the output circuit of each device, means for connecting the corresponding set of register tubes thereacross, and bias means for preventing the operation of the next electronic means in series until the stop signal impulse corresponding to said next electronic means is transmitted whereby successive devices will operate responsive to auxiliary stop signal impulses to sequentially control the application of operating plate potential to the tubes of the plurality of register sets, and a control circuit comprising an impedance in series with said electronic devices in the counting circuit, means connected across said impedance for operating a circuit interrupter device, means responsive to the sequential operation of each of the devices in said counting circuit for operating said circuit interrupter device whereby each set of impulses and each set of coded signals in the cycle of signals will be reset as soon as they are recorded on a register set.

13. In an automatic telephone circuit, in combination, a register circuit responsive to a series of signals periodically punctuated by an auxiliary stop signal, comprising a plurality of sets of grid-controlled gaseous discharge tubes, the number of sets of tubes corresponding to the number of series of signals, the number of tubes in each set corresponding to the number of signals in each of said series, means effectively connecting in parallel all the tubes in each of said sets, an impedance in series with the parallel-connected tubes in each of said sets, means responsive to their corresponding signals for selectively applying operating potential to the grids in each set, and means responsive to said auxiliary stop signal for sequentially controlling the application of cathode-anode potential to each of the plurality of sets of tubes whereby only those tubes which have cathode-anode operating potential at the moment when their grids have operating potential can respond to said signals, and a counting circuit, comprising a series of pairs of tubes connected across a source of electrical potential responsive to a predetermined series of successive signals, the number of pairs corresponding to the number of sets of tubes in the register circuit, each pair of tubes being responsive sequentially to the series of successive signals, a potentiometer in the output circuit of each pair of tubes which controls the plate voltage supply of the corresponding set of register tubes whereby each set of register tubes is sequentially rendered operative in response to the predetermined signals.

14. In an automatic telephone circuit, in combination, a register circuit responsive to a series of signals periodically punctuated by an auxiliary stop signal, comprising a plurality of sets of grid-controlled gaseous discharge tubes, the number of sets of tubes corresponding to the number of series of signals, the number of tubes in each set corresponding to the number of signals in each of said series, means effectively connecting in parallel all the tubes in each of said sets, an impedance in series with the parallel-connected tubes in each of said sets, means responsive to their corresponding signals for selectively applying operating potential to the grids in each set, and means responsive to said auxiliary stop signal for sequentially controlling the application of cathode-anode potential to each of the plurality of sets of tubes whereby only those tubes which have cathode-anode operating potential at the moment when their grids have operating potential can respond to said signals, and a differentiating circuit for transforming said series of successive signals into a predetermined coded system of signals, comprising a group of circuits each one of which is composed of a plurality of grid-controlled gas-filled tubes connected across a source of electrical potential, means effectively connecting in parallel all of the tubes of each of said groups, an impedance in series with each group of parallel-connected tubes, means for selectively rendering the tubes operative in sequence, impedances in each cathode circuit of each tube, means interconnecting said cathode-impedances to form output circuits corresponding to the number of signals in the coded system whereby the component of potential existing in said output circuits upon receipt of a series of successive impulses will be in accordance with the predetermined code.

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