

Aug. 2, 1955

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2,714,632

RINGING GENERATOR AND INTERRUPTER USING ELECTRON TUBES

Filed Dec. 20, 1949

8 Sheets-Sheet 1

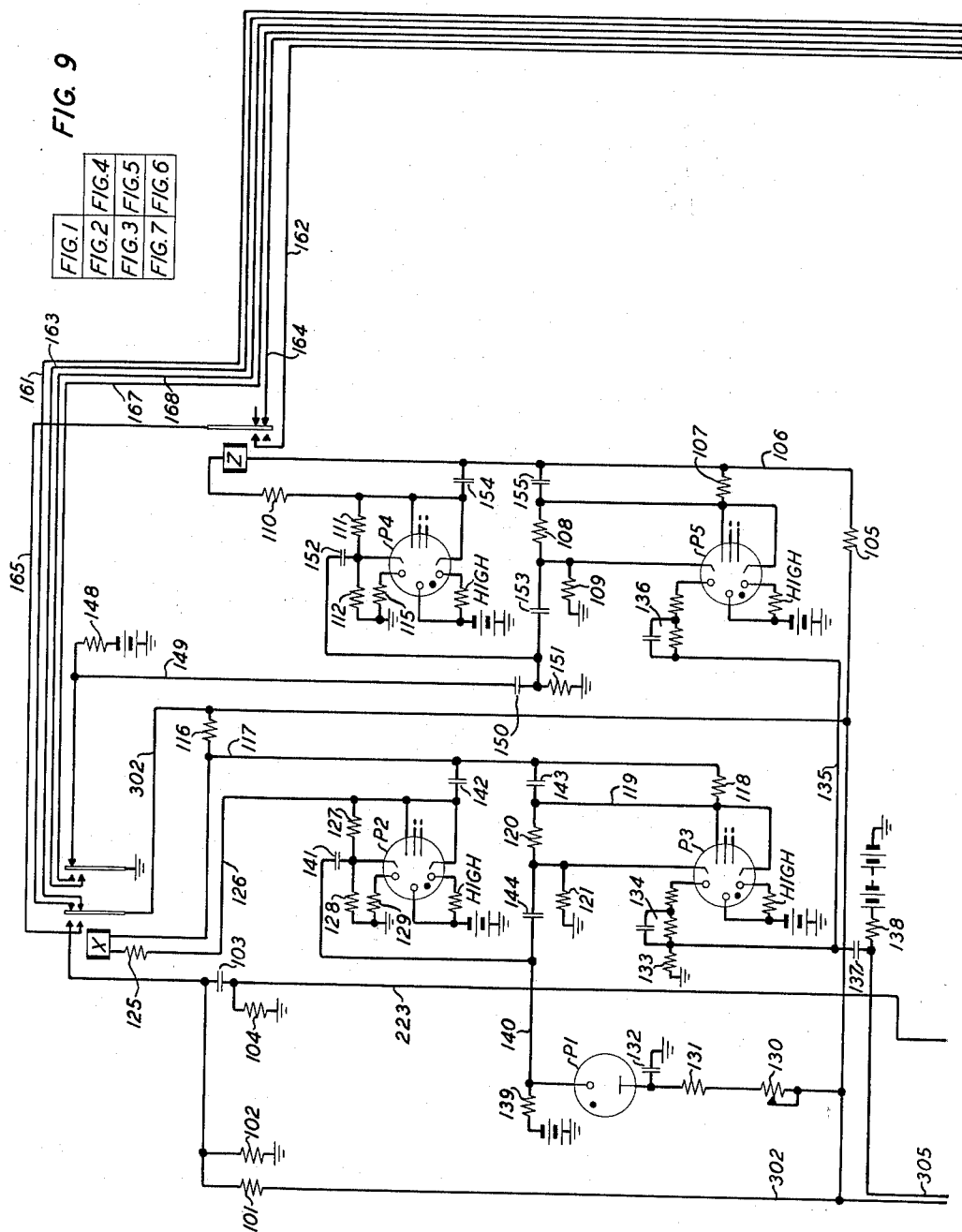


FIG. 1

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8 Sheets-Sheet 2

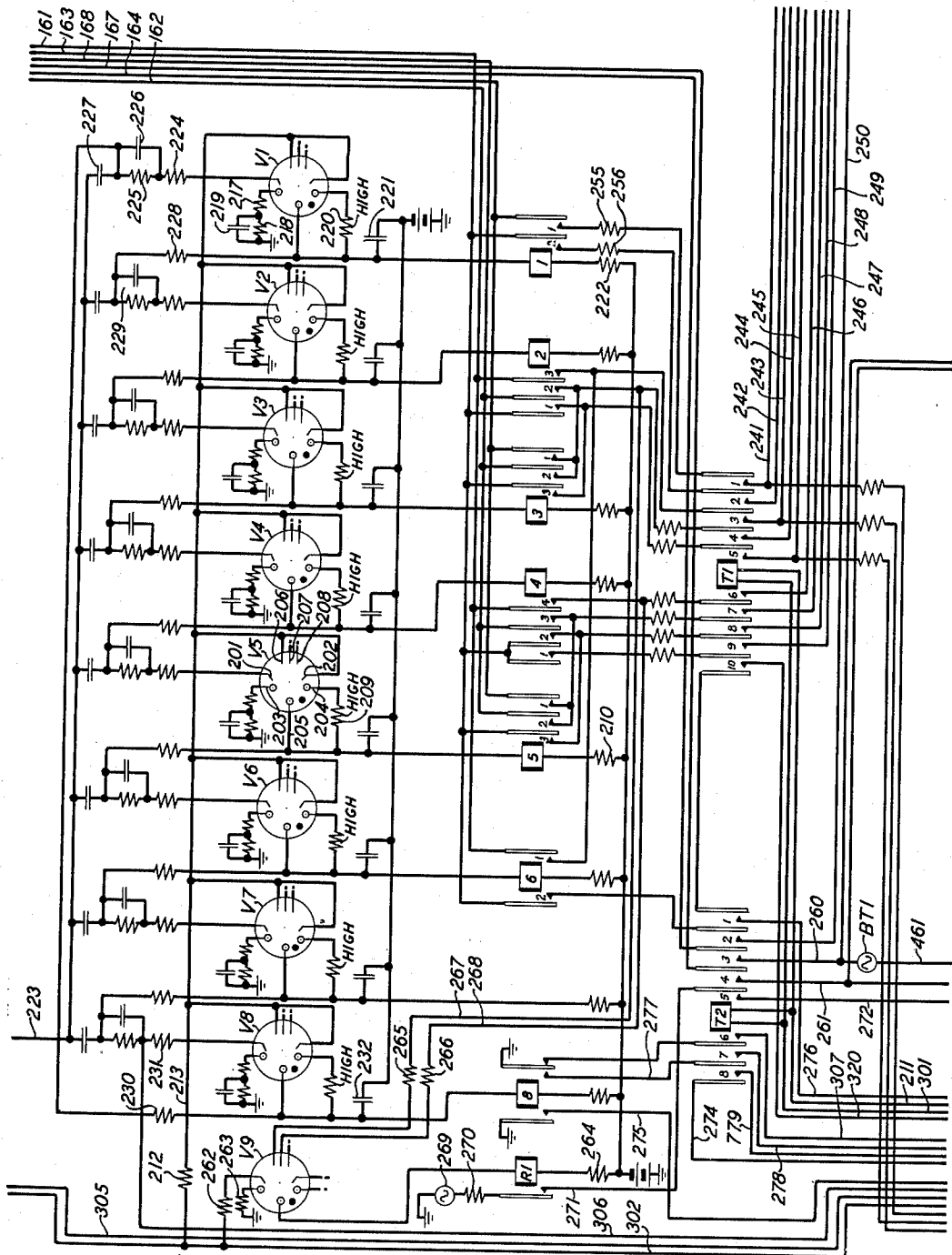


FIG. 2

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RINGING GENERATOR AND INTERRUPTER USING ELECTRON TUBES

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8 Sheets-Sheet 3

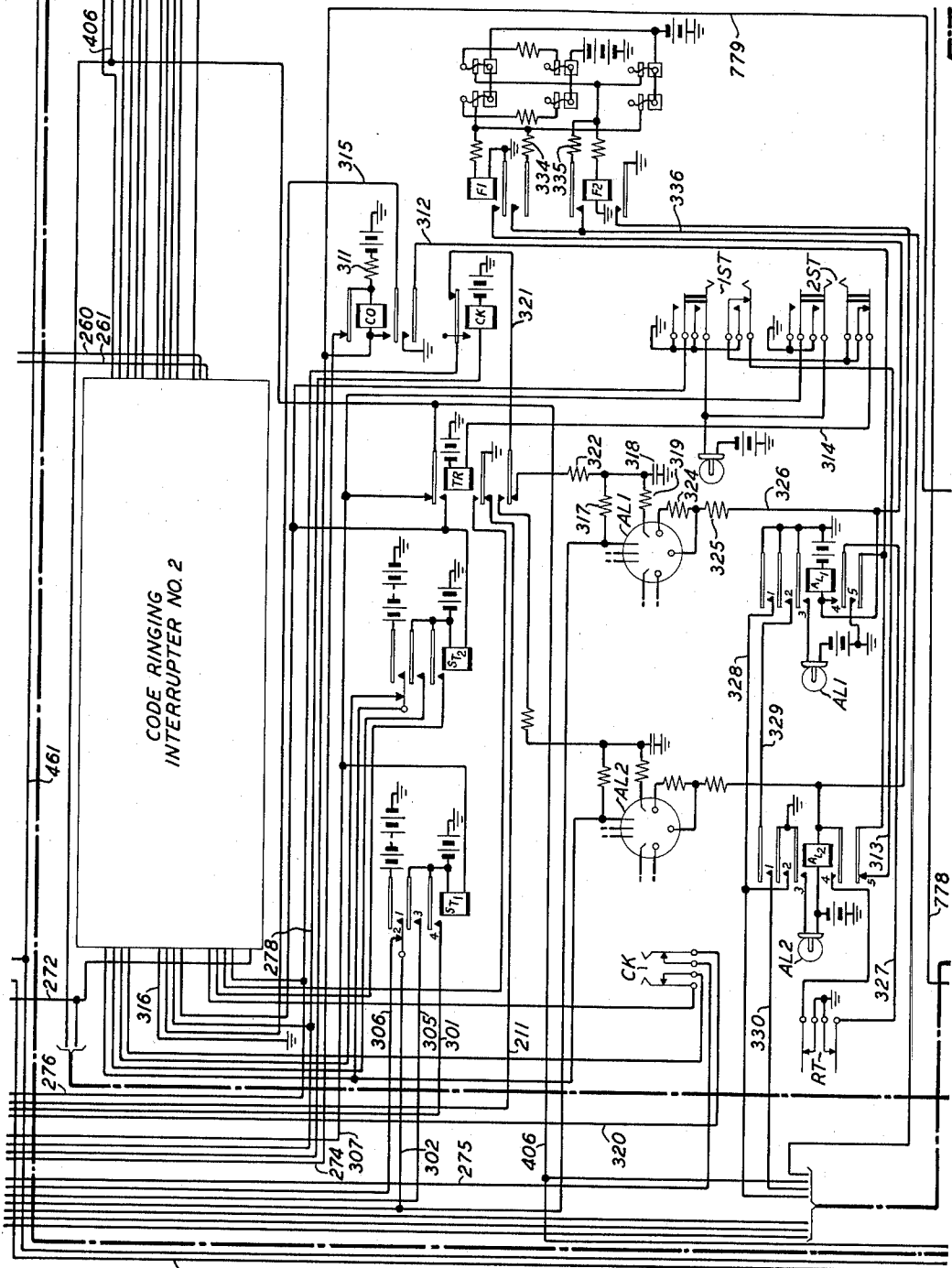


FIG. 3

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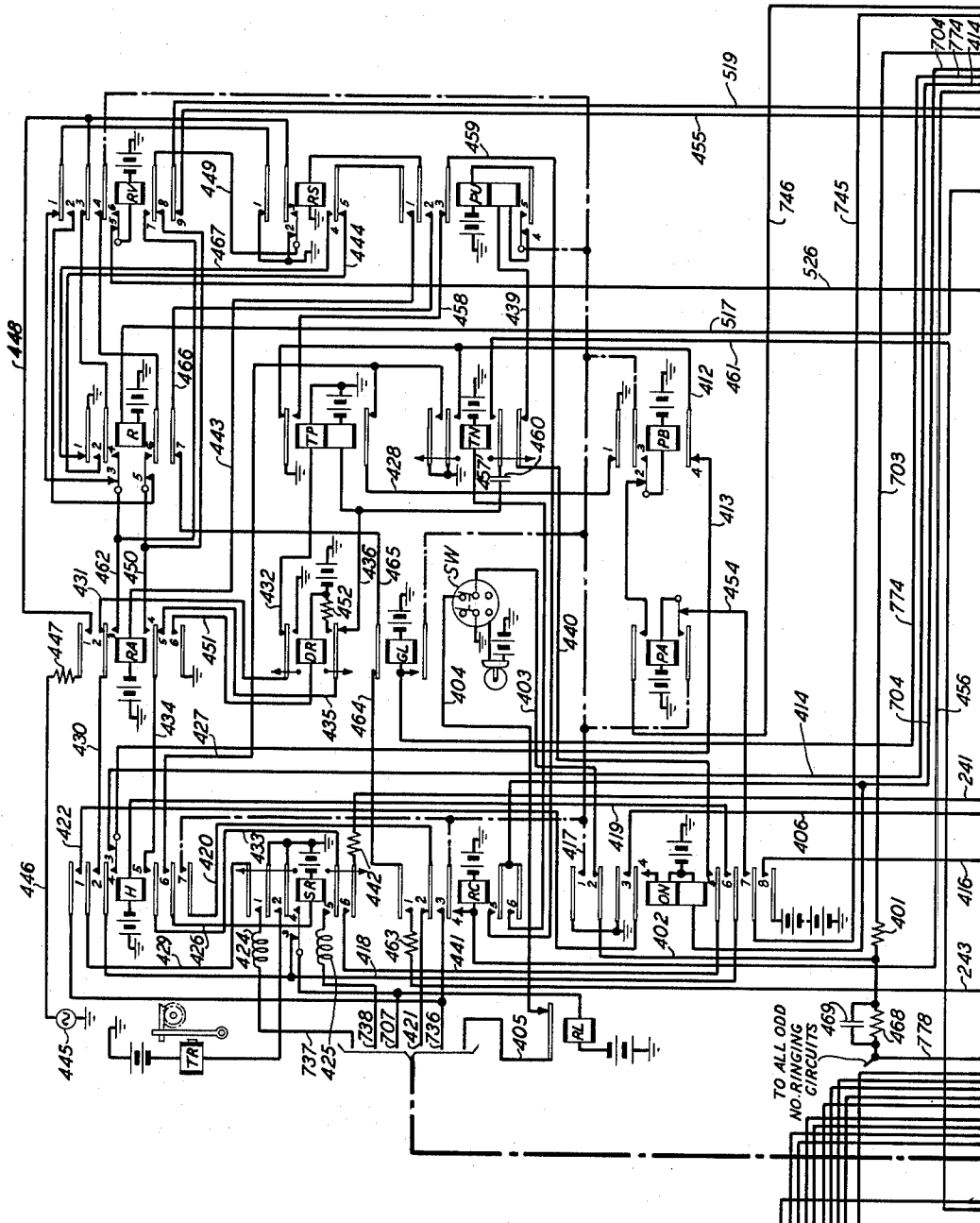


FIG. 4

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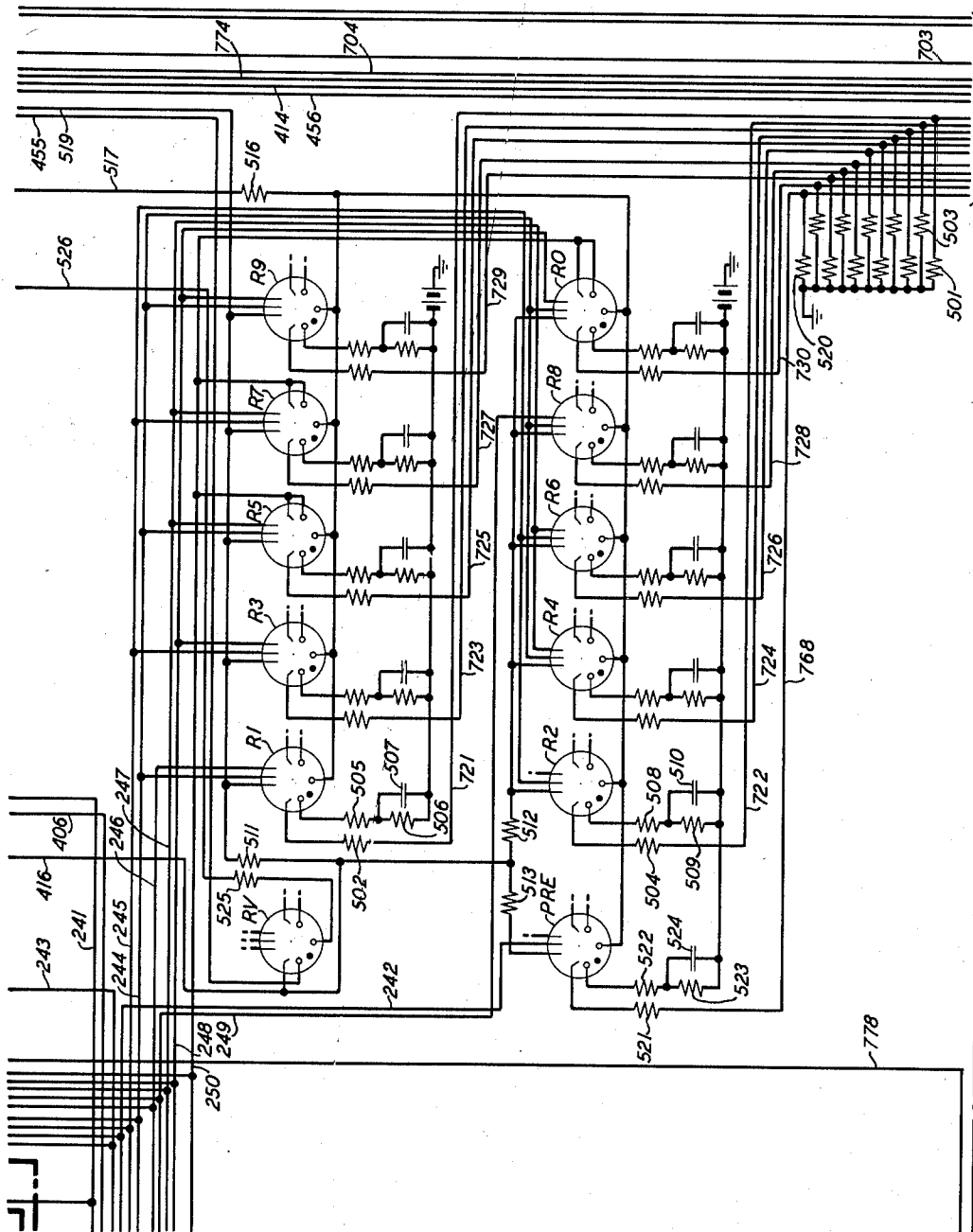
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## RINGING GENERATOR AND INTERRUPTER USING ELECTRON TUBES

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**FIG. 5**

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8 Sheets-Sheet 6

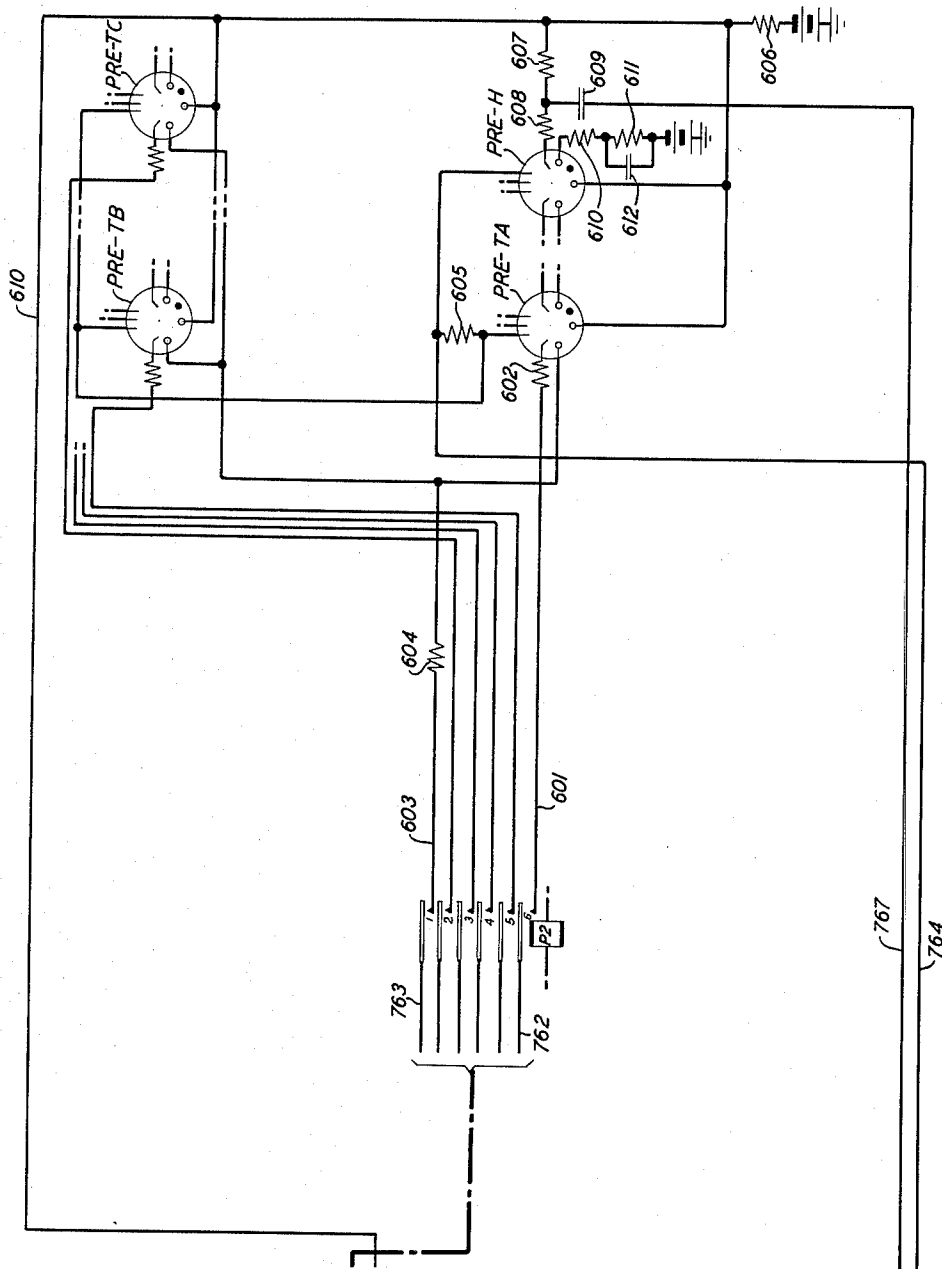


FIG. 6

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8 Sheets-Sheet 7

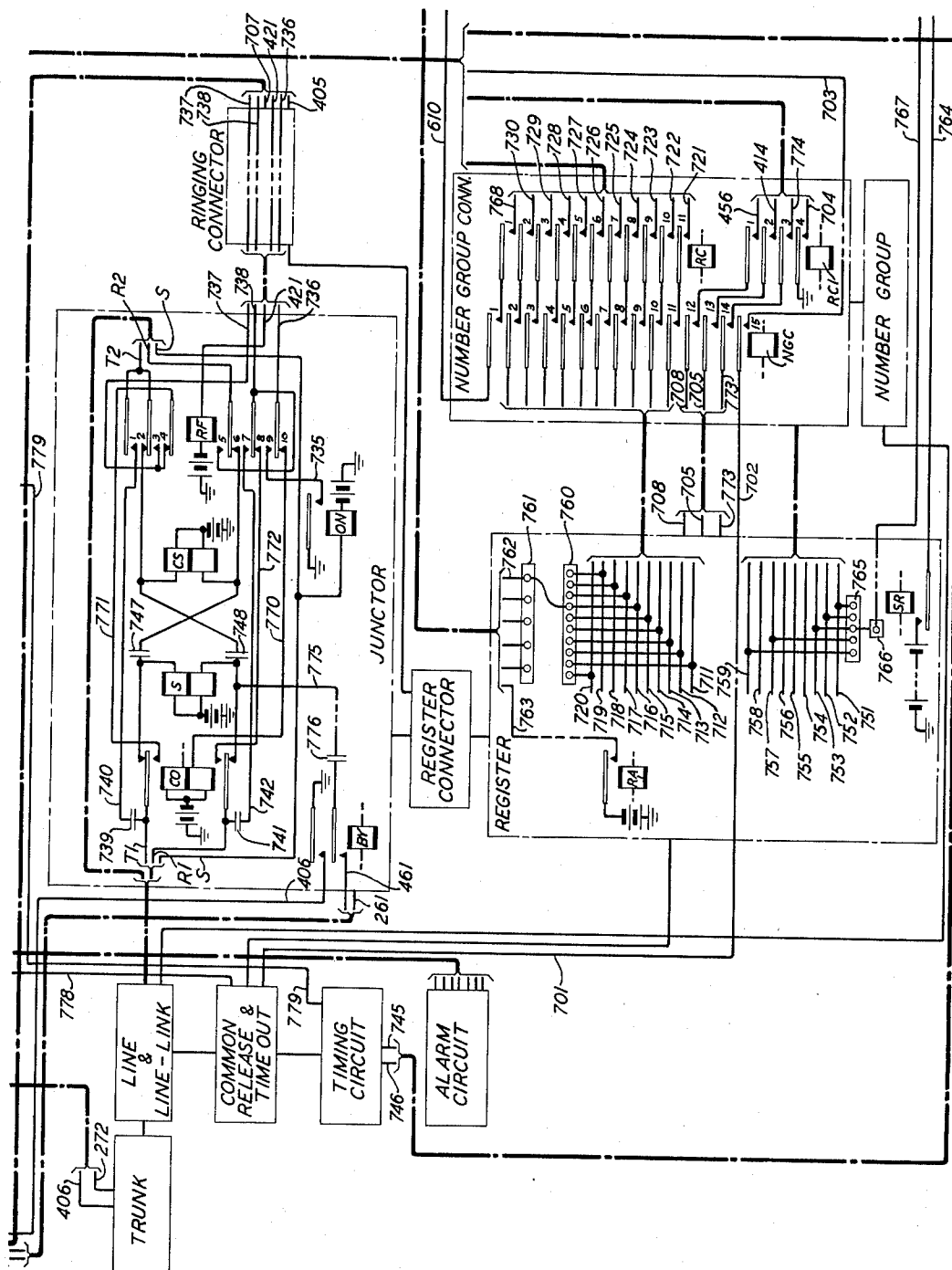


FIG. 7

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FIG. 8

| 1 CYCLE                   |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
|---------------------------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| SECONDS                   | 1    |      | 2    |      | 3    |      | 4    |      | 5    |      | 6    |      | 7    |      | 8    |      |
| NO. OF 1/2 SEC. INTERVALS | 1    | 2    | 3    | 4    | 5    | 6    | 7    | 8    | 9    | 10   | 11   | 12   | 13   | 14   | 15   | 16   |
| RELAY X(1)                | OP.  | REL. | OP.  | REL. | OP.  | REL. | OP.  | REL. | OP.  | REL. | OP.  | REL. | OP.  | REL. | OP.  | REL. |
| RELAY Z(1)                | REL. | OP.  | REL. | OP.  | REL. | OP.  | REL. | OP.  | REL. | OP.  | REL. | OP.  | REL. | OP.  | REL. | OP.  |
| COND. 161                 |      | +    |      | +    |      | +    |      | +    |      | +    |      | +    |      | +    |      | +    |
| COND. 162                 |      |      | +    |      |      |      | +    |      |      |      | +    |      |      |      | +    |      |
| COND. 163                 |      | +    |      | +    |      | +    |      | +    |      | +    |      | +    |      | +    |      | +    |
| COND. 164                 | +    |      |      |      | +    |      |      |      | +    |      |      |      | +    |      |      |      |
| COND. 241                 | +    |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| COND. 242                 |      | +    |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| COND. 243                 |      |      | +    |      |      |      |      |      |      |      | +    |      |      |      |      |      |
| COND. 244                 |      |      |      | +    | +    | +    |      |      |      |      |      |      |      |      |      |      |
| COND. 245                 |      |      |      | +    |      | +    |      |      |      |      |      |      |      |      |      |      |
| COND. 246                 |      |      |      |      |      |      | +    |      |      |      |      |      |      |      |      |      |
| COND. 247                 |      |      |      |      |      |      |      | +    | +    | +    |      |      |      |      |      |      |
| COND. 248                 |      |      |      |      |      |      |      | +    |      | +    |      |      |      |      |      |      |
| COND. 249                 |      |      |      |      |      |      |      | +    |      |      |      |      |      |      |      |      |
| COND. 250                 |      |      |      |      |      |      |      |      |      |      |      | +    |      |      |      |      |

| RINGING CODES    |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|------------------|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|
| PICKUP           |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| CODE 1           |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| CODE 2           |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| CODE 3           |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| CODE 4           |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| CODE 5           |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| CODE 6           |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| CODE 7           |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| CODE 8           |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| CODE 9           |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| CODE 10          |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| CODE 11          |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| CODE 12          |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| CODE 13          |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| CODE 14          |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| CODE 15          |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| CODE 16          |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| CODE 17          |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| CODE 18          |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| CODE 19          |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| CODE 20          |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| REVERTIVE SIGNAL |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

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## RINGING GENERATOR AND INTERRUPTER USING ELECTRON TUBES

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Application December 20, 1949, Serial No. 134,108

31 Claims. (Cl. 179—84)

This invention relates to telephone systems, and more particularly, to telephone signaling systems.

An object of this invention is to provide an electronic ringing circuit and interrupter of rapid and certain operation.

Another object of this invention is to provide a telephone signaling system capable of transmitting a variety of different signals in accordance with a number of special conditions.

A further object of this invention is to provide an electronic pulse generating and distributing system capable of selectively and cyclically transmitting pulses over a plurality of paths in accordance with a code system.

A feature of this invention is a pulse frequency divider of novel design.

Another feature of this invention is an interrupter capable of applying pulses to a plurality of conductors in accordance with a code system in cyclic repetition.

Another feature of this invention is an electronic code ringing system capable of transmitting any of a plurality of codes.

Another feature of this invention is an electronic means for causing certain of a plurality of codes to be transmitted over one of two conductors and others of a plurality of codes to be transmitted over the other of two conductors whereby any party on a multiparty line receives less than all of the codes transmitted thereover.

A further feature of this invention is an electronic means for doubling the number of codes normally available by modifying a first plurality of codes to provide a second plurality of codes.

In general, these objects have been accomplished and these features presented in the preferred embodiment of the invention by providing a ringing circuit and interrupter embodying electron discharge devices. Certain of these devices are suitably interconnected to form an interrupter circuit operable selectively, systematically and cyclically to apply pulses to a first group of conductors. This interrupter also serves to control a chain of electron discharge devices and these devices are operable on a time basis to control the interconnection of that first group of conductors with a second, and larger, group of conductors whereby this second group of conductors also has pulses applied thereto selectively, systematically and cyclically.

A plurality of code ringing electron discharge devices are provided which are selectively operable in accordance with the code to be transmitted. Means are provided to transmit the selected code operable under the control of the ringing code devices, the means being operated each time full conduction exists in any one of the code ringing electron discharge devices. Upon the selection of any one of those devices, conduction will exist therein but the current flow therethrough is limited so that the transmitting means is not operated. However, the above-mentioned second group of conductors is connected to certain of the electrodes of the ringing code devices in a systematic manner. Therefore, when those

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conductors associated with the selected ringing code device have pulses applied thereto, full conduction will exist in the selected device for the duration of each of those pulses, and the transmitting means will be operated accordingly. In consequence, signaling current will be transmitted over the line on a code basis.

In order to avoid signaling all of the subscribers on a multiparty line with each code transmitted, means are provided to transmit certain of the codes over one side of the line and the remaining codes over the other side of the line. The exemplary electromechanical means for, in effect, reversing the line is controlled by an electron discharge device. This device is associated with certain of the ringing code devices in such a manner that this device is rendered conductive when any one of those certain ringing code devices is discharged. Means are also provided effectively to double the number of codes available. Utilized with apparatus designed to transmit a certain series of codes, this means is operable to modify those codes to produce a second series differing from the first series. Thus, in the preferred embodiment of the invention, the selective discharge of any one of the ringing code tubes will result in the transmission of the selected one of ten codes. An additional electron discharge tube is provided which, if discharged by certain control means, will transmit a signal preceding the regular code.

A more complete understanding of the above-mentioned and other features of the invention may be obtained from the following detailed description of the functioning of an illustrative embodiment thereof, when read with reference to the accompanying drawings in which:

Figs. 1 and 2 disclose a first ringing-interrupter circuit constructed in accordance with the principles of the invention;

Fig. 3 is a representation of a second ringing-interrupter circuit embodying apparatus similar to that shown in Figs. 1 and 2, and also discloses a common ringing-interrupter transfer circuit;

Figs. 4 and 5 show a ringing circuit constructed in accordance with the invention;

Fig. 6 discloses means for distinguishing certain ringing codes from other ringing codes, and may herein be considered a part of the ringing circuit shown in Figs. 4 and 5;

Fig. 7 is a representation of other elements of a system with which the subject system may be associated;

Fig. 8 is a chart showing exemplary ringing codes and demonstrating the operation of the ringing-interrupter and ringing circuit; and

Fig. 9 demonstrates the method of arranging the several figures of the drawing.

Throughout the specification, the circuit elements will be identified by functional designations followed by a number in parenthesis representing the figure of the drawing upon which that element appears. For example, the off-normal relay in Fig. 4 of the drawing will hereinafter be designated "relay ON(4)."

The eight-element electron discharge devices utilized in the disclosed preferred embodiment of the invention are cold-cathode gas-filled tubes preferably of the type more fully disclosed in the copending application of W. A. Depp, Serial No. 13,283, filed March 5, 1948. As shown, for example, in Fig. 2, tube V5(2) comprises two control anodes 201 and 202, two control cathodes 203 and 204, a main cathode 205, and three main anodes 206, 207 and 208. In general, the application of a suitable potential difference between either the control anode 201 and control cathode 203 or between the control anode 202 and control cathode 204 will cause a discharge to occur across the control gap therebetween. With a suitable voltage applied to any one of the main anodes 206, 207 or 208,

the control gap discharge will be transferred so as to exist between the control cathode 203 or 204 and the main anode 206, 207 or 208. If the main cathode 205 is at a voltage sufficiently negative in respect to the control cathode 203 or 204, the discharge will then transfer to the main gap so as to exist between the main cathode 205 and the main anode 206, 207 or 208. This sequence will hereinafter be referred to as a control gap discharge followed by first and second transfers of discharge. It will be apparent that while a tube is in the condition following either the first or second transfer, the application of a suitable positive potential to any other of the main anodes 206, 207 or 208 will cause conduction to exist between that electrode and some more negative electrode. This capability of the tubes is employed in the ringing circuit of Fig. 5. It is also a characteristic of the tube that if a suitable positive potential be applied to one of the control anodes or to a control anode and control cathode tied together, this electrode, or the combination of these electrodes, may also act as the equivalent of a main anode. This capability of the tubes is utilized in the ringing circuit of Fig. 5, as, for example, in tubes R5(5), R7(5) and R0(5).

Since rapidity of operation is an object in any telephone system, it may here be noted that provision is made to decrease the ionization time of certain of the critical gaseous discharge tubes employed in the system herein disclosed. For example, the circuit of tube V5(2) is arranged so that a minute "keep-alive" current flows across the lower control gap thereof while that tube is in its non-conducting state. Prior to the time that a suitable positive potential is applied to the upper control anode 201 as will be described hereinafter, a suitable main anode potential, such as positive 135 volts, is applied to the upper main anode 206 over a path hereinafter to be traced. This potential is also applied to the lower control anode 202 of the tube. The lower control cathode 204 of tube V5(2) is connected to negative battery, which may supply a negative 48-volt potential, through resistor 209, winding of relay 5(2), and through resistor 210. Resistor 209 should have a high value of resistance as indicated in the drawings. In the disclosed embodiment, with the potentials applied, and with the characteristics of the particular tube utilized, resistor 209 has been found to best serve its function if its resistance is approximately 22 megohms. With these applied potentials and with high resistance resistor 209 in the external circuit, a current of a few microamperes flows across the lower control gap of tube V5(2), i. e., between control anode 202 and control cathode 204. This current is maintained at a value below the threshold current of the tube, but is such that upon the application of a suitable potential difference across the upper control gap of the tube, breakdown will occur considerably more rapidly than would otherwise be the case. This "keep-alive" current is interrupted when the main anode voltage is removed, as will be described hereinafter.

Referring now to Fig. 7 of the drawing, a representation is presented of an exemplary telephone switching system with which the subject system may be associated. A representative system is disclosed and described in detail in the application of W. A. Cornell, N. I. Hall, G. Hecht, C. D. Koehling, F. A. Korn and H. E. Powell, Serial No. 114,392, filed September 7, 1949. The signaling system which forms the subject of this specification is also disclosed and described in that application.

In general, in the representative telephone switching system of Fig. 7, the lines from the subscribers' stations appear in the system at the line and line-link circuit. When a calling subscriber desires to initiate a call, he will lift the receiver or remove the handset from its cradle. The line and line-link circuit is operative in response to this closure of the subscriber's loop to extend the calling party's line to one of a plurality of junctors, one of which is represented partially in detail in Fig. 7. The calling

subscriber's line will also be extended through a register connector to an idle one of a plurality of registers, one of which is represented in Fig. 7. Upon seizure, relay SR(7) in the register will be operated. The register will then transmit dial tone through the register connector, junctor, and line and line-link circuit to the calling subscriber who will then dial the numerical designation of the party he desires to call. This designation is normally a multi-digit number, the last digit of which will herein be assumed to be the ringing code digit. As the pulses representing each digit are received in the register, they are counted and stored. Each digit may be stored in an individual digit register, or, as disclosed in the above-cited application of W. A. Cornell et al., the final or ringing code digit may be stored in the counting circuit. In regular calls, relay RA1(7) in the register circuit operates and releases during each interdigital delay interval, but remains operated after the final or ringing code digit is received.

After all digits have been received and stored, the register signals the common release and time-out circuit which operates number group connector relay NGC(7) to associate the register with the number group circuit. Relay NGC(7), in operating, performs two major functions: it prepares circuits whereby certain apparatus in the register may be associated with the ringing circuit herein disclosed in detail, and it connects certain other apparatus in the register to the number group circuit. The former function will be described in detail hereinafter. By virtue of the latter function, the number group utilizes the information stored in the register as to the designation of the called party to establish a connection from the register, through the number group connector and number group, to apparatus in the line and line-link circuit associated with the called party's line. The register then functions to test the condition of the called subscriber's line in accordance with the disclosure of the above-cited application of W. A. Cornell et al. If the line tests busy or vacant, the register operates relay BY(7) in the junctor and that relay sets the ringing-interrupter circuit of Figs. 1 and 2 into operation to transmit a suitable tone to the calling subscriber as will be explained in detail hereinafter.

If the called line tests idle, a path is established, via the line and line-link circuit and junctor, between the called and calling parties' lines. The line and line-link circuit then signals the common release and time-out circuit which then transmits a signal to the ringing connector by means of which an idle one of the ringing circuits, but one of which is herein disclosed, is selected. This signal is transmitted over a path which may be traced from the common release and time-out circuit in Fig. 7, conductor 701, over a path through the selected register, conductor 702, No. 15 contact of operated number group connector relay NGC(7), through contacts of an additional relay (not shown) in the number group connector circuit, conductor 703 which is cabled to Fig. 5 and then extends to Fig. 4, resistor 401, conductor 402, No. 2 back contact of unoperated relay ON(4), conductor 403, closed contact of switch SW(4), conductor 404, back contact of "release" relay RL(4), and to conductor 405 which is cabled to the ringing connector in Fig. 7. As will be seen hereinafter, relay ON(4) is operated if the ringing circuit is busy whereby the above-described path is completed only if the ringing circuit is idle. A similar path is also extended through each of the other idle ringing circuits and to the ringing connector as is shown in the above-cited application of W. A. Cornell et al. One of the idle ringing circuits is selected by the ringing connector, and it will herein be assumed that the ringing circuit disclosed in detail is the one chosen.

The ringing connector then operates relays RC(7) and RC1(7) to associate the selected ringing circuit with the utilized register. As a result of the operation of relay RC1(7), a circuit is completed from ground, upper

back contact of relay TP(4), conductor 412, No. 4 contact of relay PB(4), conductor 413, No. 3 contact of unoperated relay H(4), conductor 414 which extends to Fig. 5 and is cabled to Fig. 7, No. 2 contact of relay RC1(7), No. 13 contact of relay NGC(7), and to the conductor 705 which extends over a path (not shown) through the register and register connector and to the ringing connector (Fig. 7). The application of this ground potential causes the ringing connector to function to associate the calling and called subscribers' lines with the ringing circuit so that by the conjoint action of the ringing-interrupter and ringing circuit, the called subscriber may be signaled and the calling subscriber informed of the fact that the signal is being transmitted, as will be described hereinafter. The operation of the ringing connector also extends the above-traced ground potential circuit over conductor 707 which is cabled to Fig. 4. The ground on conductor 707 is extended through the winding of relay RL(4) to battery, thereby operating that relay to interrupt the previously traced circuit by means of which the ringing circuit was selected. The ground on conductor 707 also serves an additional purpose hereinafter to be described.

Relay RC1(7), in operating, also applies ground through the No. 4 front contact of that relay to conductor 704, which is cabled to Fig. 5 and then extends to Fig. 4, lower winding of off-normal relay ON(4) in the ringing circuit, and to battery, whereby relay ON(4) is operated. Relay ON(4), in operating, performs a plurality of functions, only one of which will be discussed at this point.

#### *Ringing-interrupter circuit*

Relay ON(4), in operating, starts the operation of the ringing-interrupter circuit of Figs. 1 and 2 by grounding the start lead thereto over a path from ground through the No. 3 front contact of relay ON(4), conductor 406 which extends to Fig. 3, through a back or front contact of transfer relay TR(3), through the winding of start relay ST1(3) or ST2(3), respectively, and to battery. Relay TR(3) is a part of the ringing-interrupter transfer circuit and is operated or released to control whether the ringing-interrupter circuit shown in detail or ringing-interrupter circuit No. 2, shown in block diagram in Fig. 3, is to be used. The former will be assumed for the present, so relay TR(3) will be assumed to be released so that the ground on conductor 406 will cause start relay ST1(3) to be operated. Relay ST1(3), in operating, connects negative battery through its No. 4 contact, conductor 301, through the windings of relays T1(2) and T2(2), in parallel, conductor 211, inner lower back contact of relay TR(3) and to ground, thereby operating relays T1(2) and T2(2).

Relay ST1(3), in operating, also connects positive 135-volt battery through its No. 1 contact to conductor 302. This positive potential on conductor 302 is extended through resistor 212, and over conductor 213 to the upper main anode and "keep-alive" control anode of the counting chain tubes V1(2) to V8(2), inclusive.

The positive potential on conductor 302 is also extended through the voltage divider comprising resistors 101 and 102 whereby the resulting voltage will be applied to the upper electrode of capacitor 103. Since the lower electrode of capacitor 103 is connected to ground through resistor 104, that capacitor will charge, with the utilized parameters, to about positive 40 volts. The positive potential on conductor 302 is also conducted through resistor 105, conductor 106, and through resistor 107 to the main anode and to the "keep-alive" control anode of tube P5(1) and through the voltage divider comprising resistors 108 and 109 to the upper control anode of tube P5(1). The positive potential on conductor 106 is also extended through the winding of relay Z(1), resistor 110, to the "keep-alive" control and main anode of tube P4(1), and through the voltage divider comprising resistors 111

and 112 to the upper control anode of tube P4(1). The positive voltage on conductor 302 is, in a similar fashion, also conducted through resistor 116, conductor 117, resistor 118, to conductor 119 where it is applied to the "keep-alive" control anode and main anode of tube P3(1) and through the voltage divider comprising resistors 120 and 121 to the upper control anode of tube P3(1). The potential on conductor 117 is also conducted through the winding of relay X(1), resistor 125, conductor 126 to the "keep-alive" control and main anode of tube P2(1) and through the voltage divider comprising resistors 127 and 128 to the upper control anode of tube P2(1). It may be noted that although the upper control cathodes of tubes P4(1) and P2(1) are connected to ground through resistor 115 and resistor 129, respectively, the values of the voltage-divider resistances are such that tubes P2(1) and P4(1) are not conducting at this time. The main cathodes of tubes P2(1), P3(1), P4(1) and P5(1) are connected to negative battery, and the "keep-alive" control cathodes of those tubes are connected to negative battery through individual high resistances. The positive potential on conductor 302 is also extended through variable resistor 130, resistor 131 and to capacitor 132, the other electrode of which is connected to ground. As capacitor 132 charges, the rising potential is applied to the plate of gas diode P1(1).

Prior to the operation of relay ST1(3), the upper control cathode of tube P3(1) is connected to ground through resistor 133 and network 134, the upper control cathode of tube P5(1) is connected to ground through resistor 133, conductor 135, and network 136, and the upper electrode of capacitor 137 is also connected to ground through resistor 133. Since the lower electrode of capacitor 137 is connected to positive battery through resistor 138, that capacitor will be charged. Upon the operation of relay ST1(3), negative battery is connected through the No. 3 contact of relay ST1(3), conductor 305, to the lower electrode of capacitor 137 thereby lowering the potential on both sides of that capacitor and applying a negative pulse to the upper control cathode of tubes P3(1) and P5(1) in common. These tubes will therefore discharge and undergo first and second transfers of discharge so that conduction will exist between the main anode and main cathode thereof.

The cathode of gas diode P1(1) is connected to negative battery through resistor 139. Therefore, when capacitor 132 has charged to a sufficient potential, gas diode P1(1) will undergo a discharge and capacitor 132 will discharge through the diode and resistor 139 to negative battery. When the voltage across gas diode P1(1) falls below sustaining voltage, the diode is extinguished and capacitor 132 again begins to charge through resistors 130 and 131. The parameters of this oscillating circuit are preferably arranged whereby a discharge occurs across the gap of gas diode P1(1) 120 times per minute.

When gas diode P1(1) discharges, its rise in cathode potential resulting therefrom is transmitted over conductor 140 and through capacitor 141 to the upper control anode of tube P2(1) and through capacitor 144 to the upper control anode of tube P3(1). Since tube P3(1) is conducting as before described, the potential at its main anode has dropped to a value of approximately 10 volts whereby the potential at the upper control anode of that tube is at approximately 5 volts positive relative to ground due to the voltage divider comprising resistors 120 and 121.

The upper control gap of tube P3(1) will therefore not be fired by the application of the potential across capacitor 144. Since tube P2(1) is not conducting its main anode is at full 135 volts positive and the upper control anode of that tube is at approximately 60 volts positive since it is connected to the main anode through the voltage divider comprising resistors 127 and 128 as above described. Tube P2(1) therefore discharges and undergoes first and second transfers whereby conduction exists

across its main gap. As a result of this conduction, the main anode of tube P2(1) drops an appreciable amount, to approximately 10 volts. Since the main anodes of tubes P2(1) and P3(1) are interconnected through capacitors 142 and 143, the drop in voltage on the main anode of tube P2(1) causes the anode voltage of tube P3(1) to fall below the sustaining value thereof, and tube P3(1) is extinguished. Since the winding of relay X(1) is in the main anode circuit of tube P2(1) as above described, relay X(1) will be operated while tube P2(1) is conducting.

At the next discharge through tube P1(1) one-half second later, a positive pulse will again be applied through capacitors 141 and 144 to the upper control anodes of tubes P2(1) and P3(1), respectively. Since tube P2(1) is conducting, the pulse will have no effect on that tube as before described. The pulse on the control anode of tube P3(1) will cause that tube to discharge and transfer, extinguishing tube P2(1) and thereby releasing relay X(1). It may therefore be seen that gas tubes P2(1) and P3(1) and relay X(1) comprise a 60-interruptions-per-minute interrupter under control of gas diode P1(1), with relay X(1) being operated and released during alternate one-half second intervals.

During the time that relay X(1) is operated, negative battery is connected through resistor 148, conductor 149, through capacitor 150, resistor 151 and to ground. Capacitor 150 thereby becomes charged. When relay X(1) releases, ground is connected through its outer back contact to conductor 149 thereby raising the voltage on both sides of capacitor 150 and transmitting a positive pulse through capacitors 152 and 153 to the upper control anodes of tubes P4(1) and P5(1), respectively. Since tube P5(1) is conducting, the pulse is of no effect thereon in view of the considerations hereinbefore discussed in relation to tube P3(1). The application of this positive pulse to the control anode of tube P4(1) creates a discharge in that tube, and first and second transfers immediately occur. Conduction through tube P4(1) causes a drop in main anode potential of that tube, and, since the main anodes of tubes P4(1) and P5(1) are interconnected through capacitors 154 and 155, the main anode voltage of tube P5(1) is dropped below the value at which tube P5(1) will sustain, and tube P5(1) will be extinguished. Since relay Z(1) is in the main anode circuit of tube P4(1) as before described, that relay will be operated when tube P4(1) becomes conductive.

When relay X(1) again operates one-half second later, capacitor 150 will again be charged. At the next release of relay X(1), capacitor 150 will again apply a positive pulse through capacitors 152 and 153 to the upper control anodes of tubes P4(1) and P5(1), respectively. The positive pulse on the upper control anode of tube P5(1) will cause that tube to discharge and transfer extinguishing tube P4(1) and thereby releasing relay Z(1). It may therefore be seen that gas tubes P4(1) and P5(1) and relay Z(1) comprise a 30-interruptions-per-minute interrupter under control of relay X(1), with relay Z(1) being operated and released during alternate one-second intervals.

It will be noted that the pair of tubes P2(1) and P3(1) and the pair of tubes P4(1) and P5(1) each comprises a trigger circuit having two stable states. Thus, in the trigger circuit comprising tubes P2(1) and P3(1), it will be apparent from the above discussion that at any time while the circuit of Fig. 1 is in operation either tube P2(1) or tube P3(1) is conducting, i. e., the trigger circuit is in one of its two stable states. When the other one of that pair of tubes is discharged, the previously conducting tube is extinguished whereby the state of the trigger circuit is reversed.

Cold cathode gas tubes V1(2) to V8(2), inclusive, constitute a counting chain that is advanced each time relay X(1) is operated. The upper control cathodes of

tubes V1(2) to V8(2) are connected to ground through individual networks. For example, the upper control cathode of tube V1(2) is connected to ground through the network comprising resistors 217 and 218 and capacitor 219. The lower control or "keep-alive" cathodes, through individual high resistances, and the main cathodes of tubes V1(2) to V8(2) are connected to negative battery through parallel paths comprising a capacitor in one branch and a resistor and a comparably designated relay in the other branch. For example, the lower control cathode of tube V1(2) is connected through high resistance 220, and the main cathode of that tube is also connected to negative battery through capacitor 221, and in parallel therewith, to negative battery through resistor 222 and the winding of relay 1(2). The upper control anodes of tubes V1(2) to V8(2) are connected to pulse input lead 223 through individual capacitors and individual networks. For example, the upper control anode of tube V1(2) is connected to pulse input lead 223 through the network comprising resistors 224 and 225 and capacitor 226 and through the individual capacitor 227. Each tube V1(2) to V8(2) is coupled to the next succeeding tube, as for example, tube V1(2) is linked to tube V2(2) by the main cathode of tube V1(2) being connected through resistor 228 and through network 229 to the upper control anode of tube V2(2). It may be noted that the main cathode of tube V8(2) is connected through resistor 230 and through the network comprising capacitor 226 and resistors 224 and 225 to the upper control anode of tube V1(2) whereby recycling may occur.

Upon the initial seizure of the ringing interrupter and the consequent operation of relay ST1(3) as hereinbefore described, positive 135-volt battery will momentarily be applied through the Nos. 1 and 2 continuity contacts of relay ST1(3) to conductor 306, through resistor 231 and to the upper control anodes of tube V8(2), and that tube will discharge and transfer. As capacitor 232 in the main cathode circuit of that tube becomes charged, the main cathode potential of tube V8(2) will rise, and this rising potential will be applied over the above-traced path to the upper control anode of tube V1(2). The upper control anodes of the remaining tubes will remain at approximately 48 volts negative. When relay X(1) operates as above described, the positive 135-volt potential on conductor 302 is extended through the inner front contact of relay X(1) to the upper electrode of capacitor 103 which has been charged to approximately 40 volts as above described. As a result, a positive pulse will be transmitted over pulse input lead 223, and through the individual capacitors and networks to the upper control anodes of the counting chain tubes V1(2) to V8(2). Since the upper control anode of tube V1(2) is the only one with a suitable positive bias previously applied thereto as above described, tube V1(2) only will discharge and transfer. Since the main cathode of tube V8(2) has risen to a value which may be positive relative to ground, the additional drop across the common main anode resistor 212 will reduce the potential difference across the main gap of tube V8(2) to a point below sustaining, and tube V8(2) will be extinguished. As capacitor 221 becomes charged, the main cathode potential of tube V1(2) will rise, and the upper control anode of tube V2(2) will be positively biased thereby. Therefore, when relay X(1) has released for one-half second and again operates to apply a positive pulse to pulse input lead 223, tube V2(2) will be fired, extinguishing tube V1(2), and priming tube V3(2). Thus, each operation of relay X(1) will cause the next succeeding tube in the counting chain to fire and commutate. As each of the tubes V1(2) to V8(2) fires, it operates its associated relay 1(2) to 8(2), respectively, in an obvious manner.

The result of the operation of the code ringing interrupter shown in Figs. 1 and 2 may best be seen by reference to Fig. 8 of the drawing. In the preferred em-

bodiment disclosed, a whole ringing cycle has been arranged to occupy eight seconds, after which the ringing cycle repeats. This cycle, for convenience of discussion, has been divided into half-second intervals, numbered 1 to 16. As above described, relay X(1) is operated for one-half second, released for one-half second, and so on, so that it is operated during the odd-numbered intervals and released during the even-numbered intervals. Relay Z(1) operates each alternate time that relay X(1) releases, and therefore relay Z(1) is operated during the second and third intervals, released during the fourth and fifth intervals, and so on. When relay X(1) is released, the positive 135-volt potential on conductor 302 is extended through the inner back contacts of relay X(1) to conductors 161 and 163, and therefore a positive potential is applied to these conductors during the even-numbered intervals as shown in Fig. 8. During the time that relay X(1) is operated and relay Z(1) is released, the positive 135-volt potential on conductor 302 is connected through the inner front contact of relay X(1), conductor 165, back contact of relay Z(1) to conductor 164, and therefore that conductor has positive battery connected thereto during the first, fifth, ninth, and thirteenth intervals as shown in Fig. 8. During the time that both relays X(1) and Z(1) are operated, the positive potential on conductor 302 is connected through the inner front contact of relay X(1), conductor 165, front contact of relay Z(1) to conductor 162, and therefore conductor 162 has positive battery connected thereto during the third, seventh, eleventh and fifteenth half-second intervals as shown in Fig. 8.

As above described, relay 1(2) is operated during the time that relay X(1) is operated at the beginning of the cycle and continues to be operated during the release time of relay X(1), after which relay 1(2) is released. Relay 2(2) is operated during the time that relay X(1) is operated and released on its second cycle, i. e., during the third and fourth half-second intervals. Relay 3(2) is operated during the fifth and sixth intervals, and so on. The armatures of relay 1(2) are connected to conductors 164 and 161. While relay 1(2) is operated during the first and second intervals, positive battery is connected to conductor 164 during the first interval, and this potential is conducted through the No. 1 contact of relay 1(2), through resistor 255, No. 1 contact of operated relay T1(2) and to conductor 241, as is represented in Fig. 8. During the second interval, while relay 1(2) remains operated, positive potential is connected to conductor 161, and this potential is extended through the No. 2 contact of relay 1(2), resistor 256, No. 2 contact of relay T1(2), and to conductor 242 as shown in Fig. 8. By referring to the chart of Fig. 8, it may be seen that conductors 241 to 250 receive one or more one-half second pulses of positive voltage as a result of the conjoint functioning of relays X(1), Z(1) and relays 1(2) to 6(2), inclusive. It may be noted that certain of the front contacts of the relays 1(2) to 6(2) are cross-connected whereby certain of the conductors 241 to 250 receive more than one pulse per cycle. For example, conductor 247 receives a positive pulse of one-half second duration during the eighth interval through the No. 3 contact of relay 4(2), which is operated during the seventh and eighth intervals, and over conductor 163 which is supplied with positive potential during the eighth interval. Conductor 247 also receives a pulse during the ninth interval through the No. 1 contact of relay 5(2), which is operated during the ninth and tenth intervals, and over conductor 164 which is supplied with positive potential during the ninth interval. Conductor 247 also receives a pulse throughout the tenth interval through the No. 2 contact of operated relay 5(2) and over conductor 163 which is supplied with positive potential during the tenth interval. These voltages are applied to the ringing circuit as will be described hereinafter.

### Call to single party line

As previously mentioned, the selected ringing circuit of Figs. 4 and 5 is connected to the utilized register through the connector relays RC(7), RC1(7) and NGC(7). The ringing code digit is stored in the register, and that digit is herein assumed to be represented by a positive potential on the corresponding one of the leads 711 to 720 in the register shown in Fig. 7, with a lower potential being applied to the remaining ones of the conductors 711 to 720. It will herein be assumed that a positive 50-volt potential is applied to the appropriate one of the leads 711 to 720 while a negative 48-volt potential is applied to the others. It is to be understood, however, that other suitable potentials may be employed. For example, in the above-cited disclosure of W. A. Cornell et al., the selected ringing code digit is represented by a positive voltage on the selected lead, negative battery is connected to certain others of the leads, and others are left at open circuit whereby they are placed at ground potential through individual voltage-divider resistors as will be noted hereinafter. Suitable register means for applying these potentials is disclosed in the above-cited application of W. A. Cornell et al. The register lead 711 to 720 are extended through the Nos. 11 to 2 contacts, respectively, of relays NGC(7) and RC(7), after which they appear as conductors 721 to 730, respectively, which are cabled to Fig. 5. Conductors 721 to 730 are then connected through individual resistors to the left-hand control anodes of the ringing tubes R1(5) to R0(5), respectively. Each conductor 721 to 730 is also connected to ground through an individual voltage-divider resistor. Thus, conductor 721 is connected to ground through voltage-divider resistor 501 and is connected through resistor 502 to the left-hand control anode of ringing tube R1(5). Similarly, conductor 722 is grounded through resistor 503 and is connected through resistor 504 to the left hand control anode of ringing tube R2(5), and so on. Therefore, upon the operation of the connector relays NGC(7) and RC(7) a suitable positive potential will be applied to the left-hand control anode of one of the ringing tubes R1(5) to R0(5) and a negative potential (or ground potential) will be applied to the left-hand control anodes of the remaining ringing tubes R1(5) to R0(5).

The left-hand control cathodes of the ringing tubes R1(5) to R0(5) are connected to negative battery through individual resistance-capacitance networks. Thus the left-hand control cathode of the tube R1(5) is connected to negative battery through the network comprising resistors 505 and 506 and capacitor 507, the left-hand control cathode of tube R2(5) is connected to negative battery through the network comprising resistors 508 and 509, and capacitor 510, and so on. Therefore, upon the application of a suitable positive potential to the left-hand control anode of any one of the ringing tubes R1(5) to R0(5), a discharge will occur across the left-hand control gap thereof. Let it be assumed for the present that the ringing code digit is "2," and that, as a result, ringing tube R2(5) undergoes a control gap discharge upon the operation of the connector relays RC(7) and NGC(7).

It will be recalled that relay ON(4) was previously operated. Relay ON(4), in operating, connects 135-volt positive battery through its No. 8 contact to conductor 416, through resistor 511 and to the left-hand main anodes of the odd-numbered ringing tubes R1(5), R3(5), R7(5) and R9(5), through resistor 512 to the left-hand main anodes of the even-numbered ringing tubes R2(5), R4(5), R6(5), R8(5) and R0(5), and also, it may be noted, through resistor 513 to the left-hand main anode of tube PRE(5). Since tube R2(5) has been assumed to have undergone a control gap discharge, upon the application of this positive potential, a first transfer will occur whereby conduction will exist between the left-hand control cathode and the left-hand main anode of tube R2(5).

It will be noted that current flow through this path is limited by the main anode impedance 512, which is common to all of the even-numbered ringing tubes. The main cathode of each of the ringing tubes R1(5) to R0(5) (and of tube PRE(5)) is connected to negative battery through resistor 516, conductor 517, and through the winding of ringing relay R(4). That ringing tube which has undergone a first transfer of discharge, now assumed to be tube R2(5), may or may not undergo a second transfer discharge at this time. If a second transfer occurs, current will flow through the winding of relay R(4), but due to the presence of resistor 512, of relatively high value, in the circuit of the left-hand main anode of tube R2(5), this circuit flow will be insufficient to operate relay R(4).

It may be noted at this time that after the selected ringing tube has undergone a first transfer of discharge, the tube will sustain even though the potential applied to the left-hand control anode thereof is removed. Therefore, the register may now be disconnected from the ringing circuit. As fully described in the above-cited application to W. A. Cornell et al., the register, register connector, and number group circuit may now be released for utilization in the completion of other calls.

When the selected ringing tube R1(5) to R0(5) has been rendered conductive as above described, appropriate potentials are applied to the anodes of the several ringing tubes by the ringing-interrupter circuit in accordance with a predetermined code and via the conductors 244 to 250. When the positive potential on one of the conductors 244 to 250 is connected to one of the main anodes (other than the left-hand main anode) of that one of the code ringing tubes which is previously conducting, conduction will also occur between that other main anode and the main cathode of that tube, and sufficient current will flow to operate relay R(4). For example, the center main anode of tube R1(5) is connected to conductor 244 and, therefore, as per Fig. 8, a suitable positive potential is applied to that main anode during the fourth, fifth and sixth intervals, and, as a result of the increased conduction through the tube, relay R(4) will be operated during that period. The right-hand main anode of tube R1(5) is connected to conductor 246 and therefore has a suitable positive potential applied to it during the seventh interval, the increased conduction continues through the seventh interval, and relay R(4) therefore remains operated for a two-second period during the fourth to seventh intervals, inclusive. It may be noted that if tube R6(5) or R7(5) had been previously conducting, since the center main anode of each of those tubes is connected to conductor 245, and since the right-hand main anode of each of those tubes is connected to conductor 247, relay R(4) would have been operated during the fourth, sixth, eighth, ninth, and tenth intervals as shown in Fig. 8. In addition, the combination of the right-hand control anode and control cathode of tube R7(5) is also employed in the function of a main anode, being connected to conductor 250. Therefore, if tube R7(5) had been conducting, relay R(4) would also have been operated during the twelfth interval as shown in the chart of Fig. 8.

It was previously assumed that the code ringing digit was "2" and that therefore code ringing tube R2(5) was conducting. The center main anode of that tube is connected to conductor 245. Therefore, increased current will flow to operate relay R(4) during the fourth and sixth intervals, representing code "2," and causing the bell of the subscriber's station to emit two "short" rings, as will be seen hereinafter. Other details of the ringing circuit including the effects of an odd-numbered code, 20-party code, and a reverive signal will be discussed hereinafter.

It may be noted that an alternative method of operation of the ringing tubes R1(5) to R0(5) may be employed. For example, in the case of ringing tube R2(5), the parameters of the circuits may be arranged so that no

second transfer of discharge will occur in the selected ringing tube until positive battery is connected to the middle main anode thereof by the ringing-interrupter circuit. Prior to the application of that positive potential a discharge will occur between the left-hand main anode and the left-hand control cathode of that tube whereby the selected tube is marked so that the register may be released. Upon application of the positive potential to the middle main anode of the selected ringing tube R2(5), the discharge will transfer so that conduction will occur both between the left-hand main anode and the main cathode of the selected tube and between the middle main anode and the main cathode of the selected tube. Conduction across the latter path causes the operation of relay R(4) as above described. At the removal of positive battery from the middle main anode of tube R2(5), conduction continues between the left-hand main anode and the main cathode of that tube but the current flow is insufficient to maintain relay R(4), operated.

Referring again to Fig. 4, relay ON(4), in operating, also performs a number of functions additional to those above-mentioned. Thus, relay ON(4) connects ground through its No. 1 contact to ringing circuit off-normal ground conductor 417, indicated by a dash-dot line in Fig. 4. Relay ON(4), in operating, also extends the above-mentioned ground on conductor 707 through the No. 3 contact of unoperated relay SR(4), conductor 418, No. 6 contact of relay ON(4), conductor 419, winding of relay H(4), and to negative battery, thereby operating relay H(4). When relay H(4) operates, ground is connected through the upper back contact of relay TP(4), conductor 412, No. 4 contact of relay PB(4), conductor 413, No. 4 contact of operated relay H(4), and to conductor 418. The ground on conductor 418 is extended through the No. 6 contact of relay ON(4), conductor 419, winding of relay H(4) and to battery, thereby locking relay H(4) operated. The ground on conductor 418 is also extended through the No. 3 contact of unoperated relay SR(4), conductor 707 and back over the previously traced path to the ringing connector momentarily to hold that circuit operated as is fully disclosed in the above-cited application of W. A. Cornell et al.

When relay H(4) operates, ground on off-normal ground conductor 417 is connected through the No. 7 contact of relay H(4), conductor 420, No. 2 contact of relay RC(4), conductor 421, which is cabled to Fig. 7, through the ringing connector to the utilized junctor, through the winding of relay RF(7), and to negative battery. The "ring front" ringing control relay RF(7) in the junctor is thereby operated. Relay ON(7) in the junctor was previously operated from ground on the calling subscriber's sleeve lead S. The operation of relay RF(7) completes a locking circuit for relay ON(4) which may be traced from ground through the front contact of relay ON(7), conductor 735, No. 9 contact of relay RF(7), conductor 736 which is extended through the ringing connector and cabled to Fig. 4, No. 1 contact of relay H(4), conductor 422, No. 4 contact of relay ON(4), upper winding of relay ON(4), and to battery.

Relay RF(7) in operating, also extends the calling and called subscribers' tip and ring conductors through the ringing connector to the ringing circuit. The calling and called subscribers' tip, ring and sleeve conductors are extended from the line and line-link circuit and appear at the left of the box representing the junctor in Fig. 7. Upon the operation of relay RF(7), the called subscriber's tip conductor T2 is connected through the No. 3 contact of relay RF(7) to conductor 737, and the called subscriber's ring conductor R2 is connected through the No. 5 contact of relay RF(7) to conductor 738. The calling subscriber's tip and ring conductors are also connected to conductors 737 and 738 through individual capacitors; the calling subscriber's tip conductor T1 is connected through capacitor 739, conductor 740, Nos. 1 and 3 contacts of relay RF(7), and to conductor 737,



the calling subscriber's ring conductor R1 is connected through capacitor 741, conductor 742, No. 7 contact of relay RF(7) to conductor 738. The tip and ring conductors 737 and 738 are extended through the ringing connector and cabled to the ringing circuit of Fig. 4 where they are connected to inductors 424 and 425, respectively.

When relay H(4) operates, relay SR(4) is operated over a path from battery, winding of relay SR(4), conductor 426, No. 6 contact of relay H(4), conductor 427, lower back contact of relay TP(4), conductor 428, No. 1 contact of relay PB(4) and to ground. When relay SR(4) operates, the tip conductor 737 is extended through inductor 424, No. 1 contact of relay SR(4), conductor 429, No. 2 contact of relay H(4), conductor 430, No. 2 contact of relay RA(4), conductor 431, upper back contact of relay DR(4), conductor 432, upper winding of relay TP(4), and to ground. Upon the operation of relay SR(4), the ring conductor 738 is extended through inductor 425, No. 5 contact of relay SR(4), conductor 433, No. 5 contact of relay H(4), conductor 434, No. 5 contact of relay RA(4), conductor 435, lower back contact of relay DR(4), conductor 436, lower winding of relay TP(4), and to negative battery. It may be noted that relay TP(4) does not operate at this time since the calling subscriber's line is connected through the windings thereof through capacitors 739 and 741 as above described, and the called subscriber's switchhook contacts have not as yet been closed.

Relay SR(4), in operating also connects ground through its No. 4 contact to conductor 707 to lock the ringing connector operated. When relay SR(4) is operated, a circuit is completed from ground on off-normal conductor 417, No. 4 contact of pick-up relay PU(4), lower winding of relay PU(4), conductor 439, outer lower back contact of relay TN(4), conductor 440, No. 5 contact of relay ON(4), conductor 441, No. 6 contact of relay SR(4), resistor 442, and to conductor 241. It may be noted, by reference to Fig. 8, that positive 135-volt battery is connected to conductor 241 for one-half second during the first interval of each ringing cycle. Therefore, at the beginning of the first ringing cycle to commence after relay SR(4) operates, relay PU(4) will be operated. Relay PU(4), in operating interrupts its own energizing circuit at its No. 4 contact, but locks operated through its upper winding and through its No. 5 contact to ground on off-normal ground conductor 417.

Relay PU(4), in operating, prepares a circuit from battery, winding of relay RA(4), conductor 443, No. 1 contact of relay PU(4), No. 5 contact of relay RS(4), conductor 444, No. 2 contact of relay R(4), and to ground. Therefore, relay RA(4) will follow the operations of relay R(4) in response to the ringing code as above described, i. e., with the assumed code, both relays R(4) and RA(4) will be operated for one-half second during the fourth interval of each ringing cycle and for one-half second during the sixth interval of each ringing cycle. When relays R(4) and RA(4) operate, ringing current is connected from alternator 445 through conductor 446, resistor 447, No. 1 contact of relay RA(4), conductor 448, No. 3 contact of relay RV(4), No. 4 contact of relay R(4), No. 3 contact of relay RA(4), conductor 430, No. 2 contact of relay H(4), conductor 429, No. 1 contact of relay SR(4), inductor 427, and to tip conductor 737. Ringing ground is connected through the No. 2 contact of unoperated relay RS(4), conductor 449, No. 8 contact of relay RV(4), conductor 450, No. 4 contact of relay RA(4), conductor 434, No. 5 contact of relay H(4), conductor 433, No. 5 contact of relay SR(4), inductor 425, and to ring conductor 738. Therefore, the called subscriber's bell will be energized during the one-half second interval and the calling subscriber will receive audible ringing induction. Relay RA(4), in operating, also operates slow-to-release relay DR(4) over a path from ground, No. 6 contact of relay RA(4), con-

ductor 451, winding of relay DR(4) and to negative battery. After relay RA(4) releases and before slow-to-release relay DR(4) has released, the tip conductor is momentarily connected to ground through the upper front contact of relay DR(4) and the ring conductor is momentarily connected to negative battery through resistor 452 and the lower front contact of relay DR(4). This momentary application of these potentials discharges the line so that when relay DR(4) releases and reconnects the tip and ring conductors to the windings of relay TP(4), relay TP(4) will not be falsely operated to trip ringing.

The ringing cycles repeat and the called subscriber continues to be signaled until one of three events occurs: until the calling party hangs up, until the circuits time out, or until the called party answers.

If the calling party hangs up on failure of the called party to answer, relay ON(7) in the junction is released thereby releasing relay ON(4). Relay ON(4), in releasing, releases relay H(4), removes ground from the off-normal ground lead 417 to release all relays locked to that ground, removes positive 135-volt battery from the ringing code tubes of Fig. 5 whereby any of those tubes which are conducting will be extinguished, and interrupts the energizing circuit for the ringing-interrupter start relay ST1(3). Relay H(4), in releasing, opens the tip and ring conductors, releases relay RF(7) in the junction, and releases relay SR(4). Relay SR(4), in releasing, interrupts the circuit over which the ringing connector was held operated, thereby releasing the ringing connector and the ringing circuit. Relay ST1(3) does not immediately release upon the interruption of its energizing path since it is locked over a path including conductor 307, No. 6 contact of relay T2(2), right-hand back contact of relay 8(2), and to ground. Therefore, the ringing interrupter continues to operate until tube V8(2) fires to operate relay 8(2) which releases relay ST1(3). Relay ST1(3), in releasing, removes positive and negative battery from the circuit thereby extinguishing all tubes and releasing all relays in the ringing interrupter and restoring that circuit to its normal idle condition.

Ringling will also cease if the called subscriber fails to answer, and if the calling subscriber fails to disconnect within a predetermined time, after which time out occurs. Referring to Fig. 7, the timing circuit represented in block form is provided with means for momentarily applying ground potential to conductors 745 and 746 on a cyclic basis. In accordance with the operation of the preferred embodiment of the invention, the timing circuit momentarily grounds conductor 745, immediately thereafter momentarily grounds conductor 746, and then, two to four minutes later, again successively momentarily grounds conductors 745 and 746, and so on. Suitable timing means for performing this function are disclosed in the above-cited application of W. A. Cornell et al.

When relay ON(4) is operated upon the seizure of the ringing circuit, conductor 745 is extended through the No. 7 contact of that relay, conductor 454, lower back contact of relay PA(4), winding of relay PA(4), and to battery. When the timing circuit of Fig. 7 connects ground to lead 745, which occurs at two- to four-minute intervals as above described, relay PA(4) is operated. Relay PA(4) locks to off-normal ground conductor 417 through its lower front contact, and connects conductor 746 through its upper front contact, through the No. 2 back contact of relay PB(4), winding of relay PB(4), and to battery. At the end of the timing cycle of the timing circuit of Fig. 7, ground is connected to conductor 746 as above described and relay PB(4) is operated. Relay PB(4) locks through its No. 3 contact to off-normal ground and releases relays H(4) and SR(4) by opening its No. 4 contact. Relay H(4), in releasing, releases relay ON(4), and the ringing circuit, ringing interrupter, and ringing connector are restored to normal as above described. It may be noted that if ground has just been

removed from lead 745 by the timing circuit of Fig. 7 when relay ON(4) operates, approximately four to eight minutes will elapse before relay PB(4) is operated. If relay ON(4) operates during the time that conductor 745 is grounded, approximately two to four minutes will elapse before relay PB(4) is operated to release the circuit.

5 Ringing will also be interrupted when the called subscriber answers. If the called subscriber closes his switch-hook contacts during a silent interval, the windings of relay TP(4) will be connected to the tip and ring conductors and relay TP(4) will be operated. If the called subscriber answers during a ringing interval, at the end of the interval relays RA(4) and DR(4) will release to reconnect the tip and ring conductors through the windings of relay TP(4), and relay TP(4) will then be operated to trip ringing. Relay TP(4), in operating, releases relays H(4) and SR(4). Relay SR(4), in releasing, releases the ringing connector. Relay SR(4) also releases relay RL(4) to prepare the reestablishment of the circuit by which the ringing circuit was initially selected as above described.

Relay H(4), in releasing, opens the line so that relay TP(4) is released, and releases relay ON(4) and relay RF(7) in the junctor. Relay ON(4), in releasing, removes ground from off-normal ground conductor 417 to release all remaining operated relays in the ringing circuit, thereby restoring the ringing circuit to normal. Relay ON(4), in releasing, also releases ringing-interrupter start relay ST1(3) to restore the ringing interrupter to normal, as above described.

Referring now to Fig. 7, and assuming ringing has been tripped by the called subscriber answering, relay RF(7) in releasing, establishes a talking circuit between the calling and called subscribers' lines. Thus, the calling subscriber's tip conductor T1 is extended through the upper back contact of relay CO(7) (which is unoperated at this time), capacitor 747, No. 6 contact of released relay RF(7) and to the called subscriber's ring conductor R2. The calling subscriber's ring conductor R1 is extended through the lower back contact of unoperated relay CO(7), capacitor 748, No. 2 contact of released relay RF(7) and to the called subscriber's tip conductor T2. Supervision is obtained and talking battery is supplied by relay S(7) associated with the calling subscriber's line and by relay CS(7) associated with the called subscriber's line, in the normal fashion.

Upon disconnection, the circuits are restored to normal in the manner disclosed in the above-cited application of W. A. Cornell et al.

#### *Revertive call on multiparty line*

The functioning of the ringing circuit under the conditions wherein an odd-numbered code is to be transmitted over a multiparty line and under the further condition that the call be revertive, i. e., that the calling and called parties be on the same line, will be discussed in relation to a single call.

In general, as above indicated, the ringing circuit is adapted to transmit a plurality of different codes over multiparty lines. Twenty codes have been shown as an example. The codes comprising the last ten of these codes are identical respectively to the first ten codes except that means are provided to transmit an initial "short" ring, herein referred to as a preliminary or a "pre" ring, on the last ten codes. To avoid ringing the bells in all the subscribers' sets on the called line at each code, means are also provided for transmitting the even-numbered code ringing current over one side of the line and the odd-numbered code ringing current over the other side of the line. In the event that a call is revertive and the calling and called subscribers' ringers are connected to opposite sides of the line, means are provided for transmitting a revertive signal over the side of the line opposite to that over which the code ringing current is transmitted.

Since twenty codes are provided in the preferred embodiment, up to twenty parties may be associated with a single line. As discussed in detail in the above-cited application of W. A. Cornell et al. and employing a four-digit designation for each subscriber with the first digits identifying the line and the last digit representing the ringing code, ten of these stations will be given designations having common, hundreds, tens and units digits and individual ringing code digits, viz., 347-1 to 347-0, inclusive. The remaining of these stations will be similarly designated with a common hundreds digit which is the same as for the other ten stations, a common tens digit which must be different from that for the other ten stations, a common units digit, and individual ringing code digits, viz., 364-1 to 364-0. One of the groups of ten subscribers is signaled by the regular ringing codes 1 to 10 as shown in Fig. 8. The other group of ten subscribers is signaled by ringing codes 11 to 20 which are as the regular codes except that they are preceded by a "short" preliminary ring during the second ringing interval. It will be assumed that those subscribers' stations designated 347-x will receive codes 1 to 10, and those designated 364-x will receive codes 11 to 20.

Let it be assumed that the subscriber designated 347-4 desires to call the subscriber designated 364-1. Subscriber 347-4 will lift the receiver or remove the handset from its cradle, and, assuming the line to be idle, will be connected through the line and line-link circuit to a junctor, assumed to be the junctor shown in Fig. 7, and through the register connector to a register, assumed to be the register shown in Fig. 7, in a manner similar to that described on the previous call. The calling subscriber will then receive dial tone and will dial the number 364-1. As previously indicated, the hundreds, tens and units digits will be counted and then stored in their respective digit registers and the ringing code digits will be counted and stored either in a separate digit register or in the counting circuit, the latter of which is herein assumed. The first or hundreds digit will be counted in the counting circuit, conductors 711 to 720 being considered to extend therefrom, and then transferred to and stored in the hundreds digit register, conductors 751 to 759 being considered to extend therefrom. Since the hundreds digit is, under the assumed called subscriber's designation, "3," conductor 753 extending from the hundreds digit register may be considered to have a positive potential applied thereto. The tens digit will then be counted in the counting circuit of the register. At this instant one of the conductors 711 to 720 extending from the counting circuit will be at a potential considerably more positive than the others as hereinbefore described. Since the tens digit has been assumed to be "6," conductor 716 will be at this higher potential. The conductors 711 to 720 are tapped to the cross-connection terminal strip 760. A suitable cross-connection is made between terminal strips 760 and 761 in accordance with which, if any, digits are to be used as the tens digit of the second group of ten subscribers' designations in a twenty-party line. For example, since it is desired that there be a preliminary ring preceding the code of those subscribers designated 364-x, the conductor at terminal strip 760 associated with the digit "6" is cross connected to one of the conductors at terminal strip 761, viz., to conductor 762 which is cabled to Fig. 6. At this time relay P2(6) is operated by the register in a manner disclosed in the above-cited application of W. A. Cornell et al. Therefore, the positive potential on conductor 716 will be extended to conductor 762, through the No. 6 contact of operated relay P2(6), conductor 601, and through resistor 602 to the left-hand control anode of "pre-tens" tube PRE-TA(6). It may be noted that this potential could have been applied to any of the "pre-tens" tubes shown, or to any additional such tubes, as many as ten "pre-tens" tubes being associable with any one "pre-hundreds" tubes such as PRE-H(6). It may be further



noted that although ten "pre-tens" tubes may be associated with each "pre-hundreds" tube, other "pre-hundreds" tubes may be added, each having an additional ten "pre-tens" tubes associable therewith.

As previously indicated, relay RA1(7) in the register is operated during each interdigital interval. A circuit is therefore completed from negative battery, front contact of relay RA1(7), through certain other closed relay contacts (not shown), conductor 763, which is cabled to Fig. 6, No. 1 contact of operated relay P2(6), conductor 603, resistor 604, and to the left-hand control cathode of tube PRE-TA(6) and to the control cathodes of all additional "pre-tens" tubes which may be provided, such as tubes PRE-TB(6) and PRE-TC(6).

Positive 135-volt battery is supplied to the "pre" tubes of Fig. 6 through the front contact of operated relay SR(7) in the register, conductor 764, and to the main anode of "pre-hundreds" tube PRE-H(6), and through resistor 605 to the main anode of tube PRE-TA(6) as well as to the main anodes of the other "pre-tens" tubes. The main cathodes of the "pre-tens" tubes and of the "pre-hundreds" tube are connected to negative battery through resistor 606. Therefore, tube PRE-TA(6) will undergo a control gap discharge and first and second transfers of discharge. It may be noted that this will occur during each originating call in which the digit "6" is the tens digit. It should be further noted that the "pre-tens" tube would not have been fired had the calling party dialed 347-x. On a call to a subscriber's station so designated, no preliminary ring is required. After firing, the main cathode of tube PRE-TA(6) rises to ground potential or above, and this bias voltage is applied through resistors 607 and 608 to the right-hand control anode of tube PRE-H(6).

The tens digit "6" is then transferred to and stored in the tens digit register (not shown), the units digit is counted and stored in the units digit register (not shown), and the ringing code digit is counted and stored in the counting circuit of the register. It may be noted that relay P2(6) is operated at the receipt of the first dial pulse of the tens digit of the called subscriber's designation and is released at the receipt of the first dial pulse of the next or units digit. Therefore, only the tens digit is effective to condition the "pre-tens" tubes of Fig. 6.

As represented in Fig. 7, conductors 751 to 759 extend from the hundreds digit register, and with a hundreds digit stored in that register, the appropriate one of the conductors 751 to 759 is at a potential more positive than the other. One or more of these conductors may be tapped to the cross-connection terminal strip 765 depending on which hundreds digit may be assigned to multiparty lines. A cross connection is then made between terminal strips 765 and 766 for the hundreds digit so assigned. It is herein assumed that multiparty lines shall have the number "3" as the hundreds digit of their designation, and therefore a cross connection is made between conductor 753 and terminal strip 766. Since the number "3" is recorded in the hundreds digit register, a positive potential will be applied via conductor 753, cross-connection terminal strips 765 and 766, conductor 767, through certain operated relay contacts (not shown) in the register, capacitor 609, resistor 608, and to the right-hand control anode of "pre-hundreds" tube PRE-H(6). Although the right-hand control cathode of tube PRE-H(6) is connected to negative battery through the network comprising resistors 610 and 611 and capacitor 612, in the preferred embodiment of the invention the positive pulse applied at this time through capacitor 609 to the right-hand control anode of this tube from the hundreds digit register is insufficient to cause tube PRE-H(6) to undergo a control gap discharge. As fully disclosed in the above-cited application of W. A. Cornell et al., however, the register is subsequently operable to transmit a heavy positive pulse over the above-traced path to the right-hand control anode of tube

PRE-H(6) whereby that tube will undergo a control gap discharge and first and second transfers of discharge.

As a result of conduction across the main gap of "pre-hundreds" PRE-H(6), the main cathode potential thereof will rise due to the potential drop across resistor 606. Conduction through that one of the "pre-tens" tubes which is conducting, here assumed to be tube PRE-TA(6), will also cause an additional potential drop across resistor 606 whereby the potential on conductor 610 will rise to a value of approximately 50 volts positive. This potential subsequently is applied to the ringing circuit to control means to cause a preliminary "short" ring to precede the regular code as will be seen hereinafter.

The preliminary ring tubes and circuits of Fig. 1 are also disclosed in the application of N. I. Hall, G. Hecht, and C. D. Koehling (Case 14-18-14) filed concurrently herewith.

The register then signals the common release and time-out circuit of Fig. 7 which operates number-group connector relay NGC(7). The register then tests the called line and finds it busy. As disclosed in the above-cited application of W. A. Cornell et al., a reverte test is then made whereby it is determined, as is here assumed, that the calling and called subscribers are on the same line. It may be noted that relay BY(7) in the junctor is operated when the line tests busy whereby conductor 406 is grounded to start the ringing interrupter as above mentioned, but when the line is further tested and the call proves to be reverte, relay BY(7) is released and the ringing interrupter restores to normal.

When the register receives an indication that the call is reverte, it applies a positive potential to conductor 762 which is extended through the number-group connector relay NGC(7), through the ringing circuit and to the ringing connector circuit as fully described above whereby one of the ringing circuits is selected, here assumed to be the ringing circuit shown. The ringing connector then causes the operation of relays RC(7) and RC1(7), the latter of which operates ringing circuit off-normal relay ON(4) as above described. Relay ON(4) in operating, performs the previously mentioned functions, including the supplying of positive 135-volt battery, via conductor 416 to the left-hand main anodes of the ringing code tubes R1(5) to R0(5) and of tube PRE(5). It may be noted that this positive potential on conductor 416 is also applied to the left-hand control anode of "reverse" tube RV(5) and that this potential is then extended through resistor 511, conductor 519, through the No. 9 back contact of unoperated "reverse" relay RV(4), conductor 455, and to the left-hand control cathode of tube RV(5) for a purpose hereinafter to be described.

With the connector relays NGC(7) and RC(7) operated, conductor 610 extending from the main cathodes of the "pre" tubes of Fig. 6 is connected through the No. 1 contact of relays NGC(7) and RC(7), and to conductor 768 which is cabled to Fig. 5. A positive potential is applied over this path to conductor 768 by the circuit of Fig. 6 as previously indicated. This positive potential on conductor 768 is divided to ground through resistor 520 and a potential is then applied through resistor 521 to the left-hand control anode of tube PRE(5). The left-hand control cathode of tube PRE(5) is connected to negative battery through the network comprising resistors 522 and 523 and capacitor 524. The main cathode of tube PRE(5) is connected, in parallel with the main cathodes of the other ringing code tubes, to negative battery through resistor 516 and the winding of relay R(4). Therefore tube PRE(5) will undergo a control gap discharge and first and second transfers, but, as before, relay R(4) will not be operated due to the presence of the current limiting resistor 513.

Since the ringing code digit "1" is stored in the counting circuit of the register, upon the operation of relay RC(7), ringing code tube R1(5) will discharge and

undergo first and second transfers in a manner similar to that previously described, but relay R(4) will still not be operated due to the presence of current limiting resistor 511 in the circuit of the left-hand main anode of tube R1(5). However, the potential drop across resistor 511 is sufficient to cause the left-hand control gap of tube RV(5) to break down. Since the left-hand control anode of that tube is supplied with positive 135-volt battery and since the main cathode of that tube is connected to negative battery over a path including resistor 525, conductor 526, and the No. 5 contact and winding of "reverse" relay RV(4), a transfer will occur in tube RV(5) whereby conduction will exist between the left-hand control anode and the main cathode thereof. It may be noted that tube RV(5) will discharge and transfer in this fashion when any of the odd-numbered ringing code tubes R1(5), R3(5), R5(5), RC7(5) or R9(5) are rendered conductive, but will not be discharged if an even-numbered ringing code tube is conducting. Conduction in tube RV(5) will cause the operation of relay RV(4) which locks to ground on off-normal ground conductor 417 through its No. 6 contacts, and interrupts the previously traced circuit of the main and left-hand control cathodes of tube RV(5), thereby extinguishing that tube. Relay RV(4), in operating, also reverses certain ringing connections as will be described hereinafter.

Since the operation of the ringing interrupter has been started by the operation of relay ON(4), positive 135-volt battery is systematically applied to the several conductors 241 to 250 as hereinbefore described and as represented in the chart of Fig. 8. Since the middle main anode of conducting ringing code tube R1(5) is connected to conductor 244 and since the right-hand main anode of tube R1(5) is connected to conductor 246, increased conduction will occur through that tube, and relay R(4) will be operated in response thereto, during the fourth, fifth, sixth and seventh half-second intervals, i. e., a single "long" ring. Since the middle main anode of conducting tube PRE(5) is connected to conductor 242, increased conduction will exist through that tube during the second half-second interval and relay R(4) will therefore also be operated during that interval. This additional "pre" pulse is the short ring preceding the code which distinguishes the "pre" codes 11 to 20 from the normal codes 1 to 10, as shown in Fig. 8, and, in this case, generates code "11" as shown in that chart.

After a delay interval and if the call be reverive, as is here assumed, a circuit is completed for the operation of "reverive call" relay RC(4). This path may be traced from negative battery, winding of relay RC(4), conductor 456 which is cabled to Fig. 7, No. 1 contact of operated relay RC1(7), No. 12 contact of operated relay NGC(7), and to conductor 708. Conductor 708 is extended over a path through the register and is connected to positive battery through a tube in the junctor which is rendered conductive if the call is reverive. This circuit is more fully disclosed in the above-cited application of W. A. Cornell et al. Relay RC(4), in operating, locks to ground on off-normal ground conductor 417 through its No. 4 contact, and completes a circuit from negative battery, winding of relay TN(4), conductor 457, No. 6 contact of relay RC(4), conductor 704 which is cabled to Fig. 7, No. 4 contact of relay RC1(7) and to ground, whereby relay TN(4) is operated for a purpose hereinafter to be described.

In the manner hereinbefore described, the ringing connector is operated by the register over the previously traced path from ground through the upper back contact of relay TP(4), and, in this case, also from ground through the inner upper front contact of relay TN(4), conductor 412, No. 4 contact of relay PB(4), conductor 413, No. 3 contact of relay H(4), conductor 414 which is cabled to Fig. 7, No. 2 contact of relay RC1(7), No. 13 contact of relay NGC(7), conductor 705, and through the register and register connector to the ringing

connector. As previously described, the ringing connector, in operating, extends the ground on conductor 705 to conductor 707 which is cabled to Fig. 4 and through the winding of relay RL(4) to battery, and, in parallel therewith, through the No. 3 contact of unoperated relay SR(4), conductor 418, No. 6 contact of operated relay ON(4), conductor 419, winding of relay H(4), and to battery. Relay H(4), in operating, connects ground through the upper back contact of relay TP(4) and through the inner upper front contact of relay TN(4), conductor 412, No. 4 contact of relay PB(4), conductor 413, No. 4 contact of relay H(4), and to conductor 418 whereby relay H(4) is locked operated and whereby, temporarily, this ground is extended through the No. 3 contact of relay SR(4) to conductor 707 to lock both the ringing connector and relay RL(4) operated as above mentioned. Relay H(4), in operating, also completes a circuit from ground on off-normal ground conductor 417 through its No. 7 contact, conductor 420, No. 3 contact of operated relay RC(4), to conductor 736. This ground is extended, over one path, through the No. 1 contact of relay H(4), conductor 422, No. 4 contact and upper winding of relay ON(4), and to battery whereby relay ON(4) is locked operated. The ground on conductor 736 is also extended through the operated ringing connector of Fig. 7, through the No. 10 back contact of relay RF(7) in the junctor (which is not operated since this is a reverive call), conductor 770, lower winding of relay CO(7), in the junctor and to battery whereby relay CO(7) is locked operated.

Relay H(4), in operating, operates relay SR(4) over the previously traced path through back contacts of relays TP(4) and PB(4) to ground, and also, in this case, through the outer upper front contact of relay TN(4) to ground. Relay SR(4), in operating, connects ground through its No. 4 contact to lock relay RL(4) and the ringing connector operated as in the previous call. With relay CO(7) in the junctor locked operated as above described, upon the operation of relay SR(4), the calling and called subscribers' common line is extended to the ringing circuit. The common tip and ring conductors T1 and R1 (Fig. 7) are extended through the upper front contact and through the lower front contact, respectively, of relay CO(7), to conductors 771 and 772, respectively, through the Nos. 4 and 8 contacts, respectively, of unoperated relay FR(7), to conductors 737 and 738, respectively, which are extended through the ringing connector of Fig. 7 and cabled to Fig. 4 through inductors 424 and 425, respectively, through the Nos. 1 and 5 contacts of relay SR(4), to conductors 429 and 433, respectively, through the Nos. 2 and 5 contacts, respectively, of relay H(4), to conductors 430 and 434, through the Nos. 2 and 5 contacts, respectively, of relay RA(4), to conductors 431 and 435, through the back contacts of relay DR(4) to conductors 432 and 436, and through the windings of relay TP(4) to ground and negative battery, respectively. Since the calling subscriber is on this line as well as the called subscriber, the line is closed and relay TP(4) will immediately operate. Relay TP(4), in operating, closes ground through its upper front contact to conductor 458, No. 3 contact of relay PU(4), conductor 459, Nos. 5 and 6 contacts of relay RC(4), conductor 457, winding of relay TN(4) and to battery, thereby locking relay TN(4) operated under the control of relays TP(4) and PU(4).

It may be noted that these operations occur prior to the time that relay RC1(7) is released as a result of the release of the register, register connector and number group connector. Thus, relay TN(4) is locked operated before relay RC1(7) releases to interrupt the energizing circuit therefor. With relay TN(4) operated, the extension 436 of the subscribers' ring conductor is extended through capacitor 460, through the inner lower front contact of relay TN(4), and to conductor 461

which extends to Fig. 2, and also to Fig. 7 as will be noted hereinafter.

It will be recalled that relay X(1) is operated and released during alternate half-second intervals. Therefore, ground is connected through the outer right-hand front contact of relay X(1) to conductors 167 and 163 during alternate half-second intervals. The ground on these conductors is extended through the Nos. 3 and 4 contacts of relay T2(2) to conductors 260 and 261. Conductor 260 is connected through alternator BT1(2) to conductor 461. Alternator BT1(2) is arranged to generate an alternating current of a suitable audible frequency. Thus, an audible tone is transmitted to various points in the system via conductor 461 at half-second intervals when any of the ringing interrupters are operating. This tone, recognized by the subscribers as the "busy" tone, is therefore transmitted over the subscribers' line on a reverive call as an indication to the calling subscriber to hang up so that ringing may proceed. The intermittent ground applied to conductor 261 is used as a "busy tone" on a trunk call as will be mentioned hereinafter.

At the receipt of this indication, the calling subscriber hangs up to open his switchhook contacts and relay TP(4) is released which releases slow-to-release relay TN(4). When relay TN(4) releases, busy tone is removed from the subscribers' line and the lower winding of the pick-up relay PU(4) is connected to conductor 241 over a patch including the outer lower back contact of relay TN(4) as on the previous call. As shown in Fig. 8, during the first half-second interval of the next succeeding ringing cycle, positive battery is connected to conductor 241 which operates relay PU(4). Relay PU(4) locks to off-normal ground and connects the winding of relay RA(4) through the No. 5 contact of unoperated relay RS(4) and to ground through the No. 2 contact of relay R(4) whereby relay RA(4) will be operated each time relay R(4) operates, as hereinbefore described. It may be noted that relay DR(4) follows relay RA(4) as in the previously described call. Since ringing code No. 11 is to be transmitted, relay R(4) is operated during the second half-second interval to transmit a "pre" pulse and during the fourth, fifth, sixth and seventh intervals to transmit a single "long" ring as above described. Relay RA(4) will therefore be operated during the same interval.

It will be recalled that "reverse" relay RV(4) is operated when an odd-numbered code is to be transmitted, and is released when an even-numbered code is to be transmitted. With relay RV(4) unoperated, as in the previous call, ringing voltage is connected to the subscriber's tip conductor and ringing ground is connected to the subscriber's ring conductor, as hereinbefore described. Since the assumed code is an odd-numbered code whereby tube RV(5) was rendered conductive to operate relay RV(4), these connections are reversed. During the periods when relays R(4) and RA(4) are operated, the extension 430 of the subscriber's tip conductor is connected through the No. 3 contact of relay RA(4), conductor 462, No. 7 contact of operated relay RV(4), conductor 449, No. 2 contact of unoperated relay RS(4), and to ground; and the extension 434 of the subscriber's ring conductor is connected through the No. 4 contact of operated relay RA(4), conductor 450, No. 6 contact of operated relay R(4), No. 4 contact of operated relay RV(4), conductor 443, No. 1 contact of relay RA(4), resistor 447, conductor 446, and to the ringing alternator 445. Therefore, in odd-numbered codes, ringing voltage is connected to the ring conductor and ringing ground is connected to the tip conductor.

Assuming that grounded ringers are provided, if the ringers of both the calling and called subscribers are connected to the same side of the line, both subscribers will receive the code signal. However, if the ringers of the calling and called parties are connected to opposite sides of the line, i. e., in this case, if the calling subscriber's

ringer is connected to the tip conductor while the called subscriber's ringer is connected to the ring conductor, the calling subscriber would receive no signal and would not be notified that the line was being rung nor would there be an indication that the called subscriber had answered. Therefore, a reverive signal comprising a short ring during the third and eleventh half-second intervals of each cycle is transmitted over the opposite conductor, in this case, over the tip conductor. The ringing interrupter applies positive battery to conductor 243 for one-half second during the third interval, and again during the eleventh interval as is shown in the chart of Fig. 8. This potential on conductor 243 is connected through resistor 463, No. 1 contact of relay RC(4), conductor 464, upper back contact of relay GL(4), conductor 465, No. 7 contact of relay R(4), conductor 466, No. 2 contact of operated relay PU(4), winding of relay RS(4), and to ground. Therefore, on a reverive call, relay RS(4) is operated during the third and eleventh intervals. As may be noted in Fig. 8, no regular codes are transmitted during these intervals, and therefore relay R(4) is released while relay RS(4) is operated. A circuit is therefore completed from negative battery, winding of relay RA(4), conductor 443, No. 1 contact of relay PU(4), contact of relay RS(4), conductor 467, and to ground through the No. 1 contact of relay R(4) whereby relay RA(4) follows relay RS(4). In order that the reverive signal may be transmitted over the opposite side of the line from that over which the ringing voltage is applied, the subscriber's tip conductor, which normally, in an odd-numbered code, is connected to ground through the No. 2 contact of relay RS(4) as above described, is, upon the operation of relay RS(4), extended through the No. 3 contact of relay RS(4) to the source of ringing voltage 445. In an even-numbered code where the ringing voltage is normally applied to the tip conductor, relay RS(4), in operating, causes ringing voltage to be applied to the ring conductor during the third and eleventh half-second intervals.

It may be noted that during the time during which the reverive signal is being transmitted over one side of the line, the opposite side of the line is interrupted, and is not connected to ground. In the case of grounded ringers, there is no necessity of having the opposite side of the line grounded during these intervals, and in the case of a line in which the ringers are bridged, there is no necessity of a reverive signal being sent since all parties thereon receive all rings, and, in fact, the transmission of a reverive signal on lines having bridged ringers would be undesirable since it would cause a variation of the regular code.

It may further be noted that the reverive signal is also omitted on a reverive call to a grounded line, i. e., a line comprising a single conductor and a return path through ground. As above indicated, the energizing path for relay RS(4) includes the upper back contact of relay GL(4). When a call originates on a grounded line and when an affirmative answer is obtained from the reverive test, the register (Fig. 7) connects ground to conductor 773 which is cabled to the number group connector, through the No. 14 contact of relay NGC(7), No. 3 contact of relay RC1(7), conductor 774 which extends to Fig. 4, winding of relay GL(4) and the battery. Relay GL(4) operates, locks to ground on off-normal ground conductor 417, and interrupts, at its upper back contact, the previously traced energizing path for relay RS(4) whereby a reverive signal will not be transmitted.

Since under the assumed condition the calling and called subscribers are provided with grounded ringers, and since the called subscriber's code is odd while the calling subscriber's code is an even-numbered code, the called subscriber will be signaled by a short ring followed by a long ring, and the calling subscriber will receive a reverive signal. This ringing continues until

one of three events occurs: until the ringing circuit times out as above described; until the calling subscriber releases the circuit because of a failure of the called subscriber to answer; or until the call is completed.

If the calling subscriber decides to cease attempting to signal the called subscriber, he lifts his receiver for a brief interval and then returns it to the switchhook. If the receiver is removed from the cradle to close the switchhook contacts while relays RA(4) and DR(4) are released, or otherwise when those relays do release, relay TP(4) will be operated to trip ringing. Similarly, if the called subscriber answers, the line will also be closed to operate relay TP(4) to trip ringing, in which case the calling subscriber will remove his receiver from its cradle and proceed with the conversation. In either case and as hereinbefore described, relay TP(4), in operating, releases relay H(4) which, in turn, releases relay TP(4). Relay H(4), in releasing, releases relays SR(4), ON(4), and relay CO(7) in the junctor. Relay SR(4), in releasing, releases relay RL(4) and also releases the ringing connector. Relay ON(4), in releasing, extinguishes the tubes of Fig. 5, releases the remaining operated relays in the ringing circuit, and removes ground from the ringing-interrupter start lead 406 whereby the ringing interrupter will become idle as hereinbefore described. Then the ringing connector, the ringing circuit and the ringing interrupter restore to their normal condition and may be utilized in a subsequent call.

With relay CO(7) in the junctor released, talking battery is connected to the common calling and called line through the windings of supervisory relay S(7). This condition continues until the line is opened. If the called subscriber has answered and a conversation has ensued, the line is not opened until both parties have hung up. If the called subscriber has not answered, and the calling party has lifted his receiver to release the circuit, the line is opened when that subscriber returns his receiver to its cradle. Upon the opening of the line, relay S(7) releases to release the junctor and all circuits used on this call are restored to normal in preparation for subsequent calls in a manner fully disclosed in the above-cited application of W. A. Cornell et al.

#### *Called line busy*

If when the register tests the called line, that line proves to be busy, relay BY(7) in the junctor is operated by the register as previously mentioned. Relay BY(7), in operating, grounds conductor 406 to start the operation of the ringing interrupter. If the subsequent reverte test proves that the call is not reverte, i. e., that the calling and called subscribers are not on a common line, relay CO(7) in the junctor is released by the register. Relay CO(7), in releasing, locks relay BY(7) operated over a path (not shown) and connects the calling subscriber's line through the windings of supervisory relay S(7). Relay CO(7), in releasing, also completes a circuit from the calling subscriber's ring conductor R1, lower back contact of relay CO(7), conductor 775 which extends through certain closed contacts (not shown) in the junctor, capacitor 776, inner front contact of relay BY(7) and to conductor 461 which extends to Fig. 2 and which is supplied with an intermittently applied audio alternating current representing "busy tone" as hereinbefore described. Therefore "busy tone" is transmitted to the calling subscriber until he disconnects, at which time the circuits restore to normal.

#### *Miscellaneous conditions*

In a call in which a trunk circuit is employed, the ringing circuit herein disclosed functions only to transmit an equivalent of "busy tone" and audible ringing induction. In an incoming call, the calling subscriber or operator is connected to the office represented in Fig. 7 through one of a number of trunk circuits such as the

one represented at the upper left of Fig. 7. If the called subscriber's line tests busy, relay BY(7) in the junctor is operated. Relay BY(7), in operating, starts the operation of the ringing-interrupter circuit as before mentioned. The ringing interrupter intermittently applies ground to conductor 261 as hereinbefore described. Conductor 261 extends to the junctor of Fig. 7, and is then extended over a path (not shown) through the junctor, line and line-link circuit and to the trunk circuit of Fig. 7 whereby an equivalent of "busy tone" is transmitted to the calling subscriber or operator.

In a call originating within the office represented in Fig. 7 and directed to an operator outside of the office who may be reached through one of the trunk circuits, such as the one shown in Fig. 7, audible ringing induction is transmitted to the calling subscriber from the ringing interrupter. When the trunk circuit of Fig. 7 is seized, it grounds conductor 406 to start the operation of the ringing interrupter as before described. The circuits thereafter function in a manner fully disclosed in the above-cited application of W. A. Cornell et al., and a signal is transmitted to the distant operator. At this time, assuming that start relay ST1(3), rather than relay ST2(3) is operated, positive battery is connected through the No. 1 contact of relay ST1(3), conductor 302, resistor 262, and to the upper control anode of tube V9(2). Since the upper control cathode of that tube is connected to ground through resistor 263, tube V9(2) undergoes a control gap discharge which continues as long as the ringing interrupter continues to operate. The main cathode of that tube is connected to negative battery through resistor 264 and the winding of relay R1(2). The two main anodes of tube V9(2) are connected through resistors 265 and 266 to conductors 267 and 268, respectively, which are connected to receive positive voltage from the interrupter circuit at the same time that voltage is applied to conductors 244 and 246. Thus, as shown in Fig. 8, positive battery is connected to the main anodes of tube V9(2) during the fourth, fifth, sixth and seventh half-second intervals of each ringing cycle, and during those intervals the conductive path in tube V9(2) will transfer to operate relay R1(2) during that time. Therefore, for a two-second period during each ringing cycle, ringing voltage from alternator 269 is connected through resistor 270, front contact of relay R1(2), conductor 271, No. 5 contact of operated relay T2(2), conductor 272, which is cabled to the trunk circuit, as, in the assumed case, to the trunk circuit shown in Fig. 7. This signal is then transmitted through the trunk circuit to the calling subscriber's line to provide audible ringing induction.

As fully disclosed in the above-cited application of W. A. Cornell et al., means are provided in the common release and time-out circuit, represented in Fig. 7, for establishing a changing preference on behalf of certain of the ringing circuits, one of which is herein disclosed. At settable intervals, the common release and time-out circuit grounds conductor 778 which extends to Fig. 4. This ground is then applied through the network comprising resistor 468 and capacitor 469 to conductor 402 which is extended over the previously traced path through the ringing circuit (assuming it to be idle) and to the ringing connector. This ground potential establishes a low preference for the disclosed ringing circuit in the selecting means of the ringing connector. Assuming the disclosed ringing circuit to be an odd-numbered one of the several provided ringing circuits, conductor 778 may be multipled to all other odd-numbered ringing circuits as indicated in Fig. 4, whereby when conductor 778 is grounded, the even-numbered ringing circuit will be given preference over the odd-numbered ringing circuits. Conversely, means may also be provided to supply ground to a similar point in the even-numbered ringing circuits instead of to conductor 778 to establish a preference in favor of the odd-numbered ringing circuits.

*Ringling-interrupter transfer circuit*

Two ringing interrupter circuits have been represented on the drawings, one being shown in detail and one being represented by the block in Fig. 3. These circuits are identical and the conductors leading therefrom are multiplied so that the same result is produced regardless of which of these circuits function. Means are provided to alternate the use of these circuits.

The timing circuit, represented in Fig. 7, is arranged alternatively to open and ground conductor 779 at two to four-minute intervals. Conductor 779 extends to Fig. 3. When conductor 779 is not connected to ground, relays CO(3) and TR(3) are unoperated, as was assumed in the above description, whereby the starting ground on conductor 406 from the ringing circuit (or elsewhere as above described) operated relay ST1(3) and ringing interrupter No. 1 (shown in detail) is employed as above described. It may be noted that when relay T2(2) is operated immediately after the seizure of ringing interrupter No. 1, a circuit is completed from the winding of relay CO(3), conductor 779, No. 8 contact of relay T2(2), conductor 274, upper back contact of relay CO(3), and to the other side of the winding of relay CO(3), thus shunting relay CO(3) so that a ground on conductor 779 will not operate relay CO(3) to cause a transfer to ringing interrupter No. 2 (Fig. 3) while ringing interrupter No. 1 is in operation. With the ringing interrupters idle, when conductor 779 is grounded, this ground is conducted through the winding of relay CO(3), resistor 311, and to negative battery whereby relay CO(3) is operated. Relay CO(3), in operating, connects ground through its outer lower front contact, conductor 312, No. 5 contact of relay AL2(3), conductor 313, lower back contacts of switches 1ST(3) and 2ST(3), conductor 314, winding of relay TR(3), and to battery, thereby operating relay TR(3). If, when the ringing transfer circuit is in this condition, ground is connected from one of the ringing circuits through the ringing-interrupter start lead 406, this ground is now conducted through the upper front contact of operated relay TR(3), winding of relay ST2(3), and to battery, whereby ringing interrupter No. 2 (Fig. 3) is employed instead of ringing interrupter No. 1. To prevent transfers during the use of interrupter No. 2, relay CO(3) locks operated over a path including its inner lower front contact, conductor 315, through operated contacts of relay T2 (not shown) in ringing interrupter No. 2, conductor 316, and to ground. It may therefore be seen that the ringing transfer circuit serves to distribute the working load between the ringing interrupter circuits.

Assuming again that relays CO(3) and TR(3) are released when ground is connected to conductor 406 so that ringing interrupter No. 1 is employed, when relay ST1(3) is operated, positive battery is connected through the No. 1 contact of that relay, conductor 302, to the main anode of tube AL1(3) and through resistor 317, capacitor 318, and to ground. Capacitor 318 commences to charge and the rising potential thereon is applied through resistor 319 to the right-hand control anode of tube AL1(3). Relay ST1(3), in operating, also fires tube V8(2) which operates relay 8(2) as above described. Relay 8(2), in operating, connects ground through its left-hand front contact, conductor 275, right-hand back contact of switch CK(3), conductor 320, No. 10 contact of relay T1(2), No. 1 contact of relay T2(2), conductor 276, back contact of relay CK(3), conductor 321, outer lower back contact of relay TR(3), resistor 322 and to the upper electrode of capacitor 318 whereby that capacitor is discharged. Relay 8(2), in operating, also connects ground through its right-hand front contact, conductor 277, No. 7 contact of relay T2(2), conductor 278, winding of relay CK(3), and to negative battery. Relay CK(3) operates to interrupt the previously

traced discharging path for capacitor 318, but is sufficiently slow to operate so that capacitor 318 may become fully discharged. If relay ST1(3) operates, but, by some malfunctioning, tube V8(2) or relay 8(2) fails to operate, capacitor 318 will continue to charge and tube AL1(3) will be fired as will hereinafter be described.

At the first operation of relay X(1), tube V1(2) is fired, tube V8(2) is extinguished and relay 8(2) is released as above described. Relay 8(2), in releasing, release relay CK(3) and interrupts the previously traced discharging path for capacitor 318. As the counting chain tubes V1(2) to V8(2) are progressively rendered conductive by the successive operations of relay X(1), tube V8(2) will again be rendered conductive to operate relay 8(2) which discharges capacitor 318. The cycles thus repeat with capacitor 318 never becoming sufficiently charged in normal operation to fire tube AL1(3). If for any reason tube V8(2) does not re-fire within a suitable interval, such as, for example, ten to fifteen seconds, the charge on capacitor 318 will rise to a sufficient value to cause tube AL1(3) to undergo a discharge from its right-hand control anode, right-hand control cathode, resistors 324 and 325, conductor 326, winding of relay AL1(3) and to negative battery. The main cathode of tube AL1(3) is also connected to negative battery through resistor 325, conductor 326, and through the winding of relay AL1(3), and the main anode is connected to positive battery as above described. Tube AL1(3) will therefore undergo first and second transfers of discharge and relay AL1(3) will be operated. Relay AL1(3) locks through its No. 4 contacts, conductor 327, and through the lower back contact of switch RT(3), to ground, and lights, through its No. 3 contact, alarm lamp AL1(3). Relay AL1(3), in operating, also connects ground through its No. 1 contact to conductor 328, and connects ground through its No. 2 contact to conductor 329 whereby, if relay AL2(3) becomes operated, ground will be connected to conductor 330. Conductors 328 and 330 are cabled to the alarm circuit of Fig. 7 to provide a trouble indication. A suitable alarm circuit is disclosed in the above cited application of W. A. Cornell et al. Relay AL1(3), in operating, also connects ground through its No. 5 contact to conductor 312 whereby relay TR(3) is operated as above described. Relay TR(3), in operating, transfers the ringing interrupter start lead 406 from the winding of relay ST1(3) to the winding of relay ST2(3) thereby operating the latter relay. Relay TR(3), in operating, also interrupts the energizing paths for relays T1(2) and T2(2), allowing them to release, and connects ground through its inner lower front contacts to the corresponding relays T1 and T2 (not shown) in ringing interrupter No. 2 (Fig. 3). Relay TR(3), in operating, also transfers lead 321 from the time delay network associated with tube AL1(3) and connects it to the corresponding network associated with tube AL2(3). Relay T2(2), in releasing, allows relay ST1(3) to release thereby permitting ringing interrupter No. 1 to become idle. The release of relay T2(3) also removes the shunt from the winding of relay CO(3) as above described to allow that relay to operate the next time ground is connected to conductor 776. Relay ST2(3), in operating, starts the functioning of ringing interrupter No. 2 (Fig. 3) with that interrupter being associated with alarm tube AL2(3). Since relay TR(3) is locked to relay AL1(3), ringing interrupter No. 2 will continue to be used until switch RT(3) is operated. Similarly, malfunctioning of code ringing interrupter No. 2 will cause relay AL2(3) to be operated which will cause a transfer to ringing interrupter No. 1 and will also ground conductor 328. If both relays AL1(3) and AL2(3) become operated, conductor 330, which extends to the alarm circuit of Fig. 7, will be grounded.

It is to be understood that although individual batteries have been shown in the ringing interrupter and transfer circuit for purposes of clarity, the batteries asso-



ciated with the fuses at the right of Fig. 3 represent the batteries supplied for all ringing interrupters. If any of the fuses at the right of Fig. 3 are operated, relay F1(3), or relay F2(3) is operated, depending on whether the operated fuse is associated with ringing interrupter No. 1 or ringing interrupter No. 2. If relay F1(3) is operated, ground is connected through its inner lower front contact to operate relay AL1(3). If relay F2(3) is operated, ground is connected through its lower front contact to operate relay AL2(3). Relay AL1(3) or relay AL2(3), in operating, functions as above described to transfer the interrupter circuit and to ground conductor 328, and, if both relays operate concurrently, to ground conductor 330. It may be noted that if relay F1(3) operates, negative battery is connected through resistor 334 and through its lower outer front contact to conductor 336. If relay F2(3) operates, negative battery is connected through resistor 335 and through its upper front contact to conductor 336. Conductor 336 is cabled to the alarm circuit of Fig. 7 for alarm purposes.

It is to be understood that the above-described arrangements are but illustrative of the application of the principles of the invention. Numerous modifications may be devised by those skilled in the art, without departing from the spirit and scope of the invention.

What is claimed is:

1. An interrupter circuit comprising a first electronic trigger circuit having two stable states, means periodically reversing the state of said first trigger circuit, a second electronic trigger circuit having two stable states, and circuit means operative each time that, and only when, said first trigger circuit is in a certain one of its stable states for reversing the state of said second trigger circuit, said circuit means comprising a relay connected to said first trigger circuit and means controlled by said relay for applying a state-changing pulse to said second trigger circuit.

2. In a pulse generating system, a first group of conductors and means for selectively and cyclically applying pulses thereto comprising a second group of conductors, an interrupter operable selectively and cyclically to apply pulses to said second group of conductors on a time basis, and means operable under the control of said interrupter for selectively and cyclically interconnecting said first group and said second group of conductors on a time basis.

3. A pulse generating system comprising a first group of conductors, means for selectively and cyclically applying pulses to said first group of conductors on a time basis, a second group of conductors, a plurality of electron discharge devices sequentially and cyclically rendered conductive under the control of said means, and a relay individual to each of said devices and operable in response to conduction in the associated one of said devices, said relays being operable selectively to interconnect said first and said second groups of conductors.

4. In a pulse generating system, a first electronic trigger circuit having two stable states, apparatus periodically reversing the state of said first trigger circuit, a second electronic trigger circuit having two stable states, first means operable each time that, and only when, said first trigger circuit is in a certain one of its stable states for reversing the state of said second trigger circuit, second means operable each time said second trigger circuit is in a certain one of its stable states, a first group of conductors, said first and said second means cooperating selectively and cyclically to apply pulses to said first group of conductors on a time basis, a second group of conductors, and means operable in response to said first means for selectively and cyclically interconnecting said first and said second group of conductors on a time basis.

5. In a pulse generating system, a first electronic trigger circuit having two stable states, apparatus periodically reversing the state of said first trigger circuit, a second electronic trigger circuit having two stable states, first

means operative each time that, and only when, said first trigger circuit is in a certain one of its stable states for reversing the state of said second trigger circuit, second means operable each time said second trigger circuit is in a certain one of its stable states, a first group of conductors, said first and said second means cooperating selectively and cyclically to apply pulses to said first group of conductors on a time basis, a second group of conductors, a plurality of electron discharge devices sequentially and cyclically rendered conductive under the control of said first means, and a relay individual to each of said devices and operable in response to conduction in the associated one of said devices, said relays being operable selectively to interconnect said first and said second group of conductors.

6. A pulse distributing system comprising a first group of conductors, first means for selectively and cyclically applying pulses to said first group of conductors on a time basis, a second group of conductors, means operable in response to said first means for selectively and cyclically interconnecting said first and said second groups of conductors on a time basis, control means, and selectively operable means for operating said control means in accordance with the pulses on said second group of conductors.

7. A pulse distributing system comprising a first group of conductors, first means for selectively and cyclically applying pulses to said first group of conductors on a time basis, a second group of conductors, means operable in response to said first means for selectively and cyclically interconnecting said first and said second groups of conductors on a time basis, control means, and means for selectively interconnecting said control means and selected ones of said second group of conductors.

8. A pulse generating system comprising a first group of conductors, means for selectively and cyclically applying pulses to said first group of conductors on a time basis, a second group of conductors, a plurality of relays operated sequentially and cyclically under the control of said means, said relays being operable selectively to interconnect said first and said second groups of conductors, control means, and means for selectively interconnecting said control means and selected ones of said second group of conductors.

9. A pulse generating system comprising a first group of conductors, means for selectively and cyclically applying pulses to said first group of conductors on a time basis, a second group of conductors, a plurality of electron discharge devices sequentially and cyclically rendered conductive under the control of said means, a relay individual to each of said devices and operable in response to conduction in the associated one of said devices, said relays being operable selectively to interconnect said first and said second groups of conductors, control means, and means for selectively interconnecting said control means and selected ones of said second group of conductors.

10. In a pulse generating system, a first electronic trigger circuit having two stable states, apparatus periodically reversing the state of said first trigger circuit, a second electronic trigger circuit having two stable states, first means operable each time that, and only when, said first trigger circuit is in a certain one of its stable states for reversing the state of said second trigger circuit, second means operable each time said second trigger circuit is in a certain one of its stable states, a first group of conductors, said first and said second means cooperating selectively and cyclically to apply pulses to said first group of conductors on a time basis, a second group of conductors, means operable in response to said first means for selectively and cyclically interconnecting said first and said second groups of conductors on a time basis, control means, and means for selectively interconnecting said control means and selected ones of said second group of conductors.

11. In a pulse transmitting system, a gaseous discharge

device having a pair of control electrodes, a cathode, and three anodes, means for applying discharge initiating potentials to said control electrodes, means for applying discharge-sustaining potentials to one of said anodes and to said cathode, control means connected in series with said cathode, current limiting means in series with said one of said anodes for preventing the operation of said control means, and means for applying timed pulses to each of the other of said anodes for causing a corresponding operation of said control means.

12. In a pulse transmitting system, a plurality of electron discharge devices, a group of conductors selectively connected therewith, means selectively and cyclically applying pulses to said group of conductors on a code basis, control means, means for selectively rendering at least one of said devices conductive, and means including said at least one of said devices for applying to said control means all of the pulses applied to the ones of said conductors which are connected to said at least one of said devices.

13. In a pulse transmitting system, a plurality of multi-electrode electron discharge devices, a plurality of conductors, said conductors being selectively connected to certain of the electrodes of said devices, means selectively and cyclically applying pulses to said conductors, means for rendering at least one of said devices conductive, and control means operable in response to the pulses applied to said certain of the electrodes of the said at least one of said devices which has been rendered conductive.

14. In a code ringing system, a plurality of multi-element electron discharge devices, means for applying code pulses to at least one of the electrodes of each of said devices, means for rendering at least one of said devices conductive, and control means operable in response to the conduction through the conducting one of said devices resulting from the application of said code pulses to said at least one of the electrodes of the conductive one of said devices.

15. In a code ringing system, a plurality of multi-element electron discharge devices, means for applying potentials to certain of the electrodes of a selected one of said devices for rendering said selected device conductive, control means associated with each of said devices, means normally limiting current flow through the selected one of said devices for preventing the operation of said control means, and means for applying code pulses to at least one of the electrodes of said selected one of said devices for causing sufficient current flow through the selected one of said devices to operate said control means.

16. In a code ringing system, a plurality of gaseous discharge devices each having a pair of control electrodes, a cathode, and two anodes, means for applying potentials to the control electrodes of a selected one of said devices to cause a discharge thereacross, means applying a potential to a first one of said anodes of said selected device to cause said discharge to transfer thereto, apparatus connected to the cathode of the selected one of said devices, current limiting means in the circuit of said first anode of said selected device for preventing the operation of said control means, and means for applying code pulses to the second of said anodes in the selected one of said devices to cause sufficient current flow through said selected device to operate said apparatus.

17. In a code ringing system, a gaseous discharge device having a pair of control electrodes, a cathode, and two anodes, means for applying potentials to said control electrodes to cause a discharge therebetween, means applying a potential to a first one of said anodes to cause said discharge to transfer thereto, apparatus connected to the cathode of said device, current limiting means in the circuit of said first anode for preventing the operation of said apparatus, and means for applying pulses in accordance with a code to the second of said anodes to cause sufficient current flow through said device to operate said apparatus in accordance with said pulses.

18. In a code ringing system, a gaseous discharge device having a pair of control electrodes, a cathode, and three anodes, means for applying potentials to said control electrodes to cause a discharge therebetween, means applying a potential to a first one of said anodes to cause said discharge to transfer thereto, apparatus connected to the cathode of said device, current limiting means in the circuit of said first anode for preventing the operation of said apparatus, and means for applying pulses in accordance with a code to said second and said third anodes to cause sufficient current to flow through said device to operate said apparatus in accordance with said pulses.

19. In a code ringing system, means for transmitting a selected one of a plurality of codes normally over only one side of a telephone line, an electron discharge device, means responsive to the operation of said device for causing the codes to be transmitted over only the other side of the telephone line, and means operative in response to the transmission of certain ones of said codes for operating said device.

20. In a code ringing system, two conductors, a plurality of electron discharge devices each operable to transmit a distinctive code, means operable in response to the operation of any of said devices for applying the selected code only to one of said conductors, and means operable in response to the operation of certain of said devices for causing the selected code only to be applied to the other of said conductors.

21. In a code ringing system, two conductors, a plurality of electron discharge devices each operable to transmit a distinctive code, means operable in response to conduction through any one of said devices for applying the selected code to one of said conductors, an impedance in a circuit common to certain of said devices, a gaseous discharge tube having two electrodes interconnected through said impedance, and means operable in response to conduction through said tube resulting from a potential drop across said impedance for causing the selected code to be applied to the other of said conductors.

22. In a code ringing system, means for transmitting a plurality of codes, an electron discharge device operable to transmit a code preceding the transmission of any one of said plurality of codes, and means for operating said device in combination with said means to produce codes additional to said plurality of codes.

23. In a code ringing telephone system, apparatus for registering the digits of telephonic designations, apparatus for transmitting any one of a plurality of codes, means for modifying said codes, and a plurality of electron discharge devices operable in response to the registration of signals representing certain designations for operating said means.

24. In a code ringing telephone system, apparatus for registering the digits of telephonic designations, apparatus for transmitting any one of a plurality of codes, a first electron discharge device, means rendering said first device operable in response to the registration of certain digits in a certain digital position, a second electron discharge device, means rendering said second device operable in response to the registration of certain digits in a different digital position, and means operable upon the conjoint operation of said devices for modifying said codes.

25. In a code ringing telephone system, apparatus for registering the digits of telephonic designations, apparatus for transmitting any one of a plurality of codes, a first electron discharge device, means for rendering said first device conductive upon the registration of a certain tens digit, a second electron discharge device, means for rendering said second device conductive upon the registration of a certain hundreds digit, and means operable as the result of the conjoint conduction in said devices for modifying said codes.

26. In a code ringing telephone system, apparatus for

registering the digits of telephonic designations, apparatus for transmitting any one of a plurality of codes, a first electron discharge device, means rendering said first device conductive upon the registration of a certain tens digit, a second electron discharge device, means rendering said second device conductive in response to conduction through said first electron discharge device and upon the registration of any of certain hundreds digits, and means operable as the result of the conjoint conduction in said devices for modifying said codes.

27. In a code ringing telephone system, first apparatus for registering the digits of telephonic designations, apparatus operable in response to said first apparatus for transmitting any one of a plurality of codes, a plurality of electron discharge devices, means for selectively operating said devices in response to the registration of certain tens digits in said first apparatus, an electron discharge tube, means rendering said tube operable in response to the registration of any of certain hundreds digits in said first apparatus, and means operable in response to the conjoint operation of one of said plurality of electron discharge devices and of said tube for modifying said codes.

28. In a code ringing telephone system, first apparatus for registering the digits of telephonic designations, a first gaseous discharge device, means operable in response to the registration of certain tens digits in said first apparatus for applying discharge sustaining potentials to said first gaseous discharge device, a second gaseous discharge device, means operable in response to the registration of any of certain hundreds digits in said first apparatus for applying discharge sustaining potentials to said second gaseous discharge device, and means operable in response to the discharge of both of said devices for modifying said codes.

29. In a code ringing telephone system, first apparatus for registering the digits of telephonic designations, apparatus operable in response to said first apparatus for transmitting a plurality of codes, a first gaseous discharge device, means operable in response to the registration of a certain tens digit in said first apparatus for applying discharge sustaining potentials to said first gaseous discharge device, a second gaseous discharge device, means operable in response to a discharge in said first device and in response to the registration of any of certain hundreds digits in said first apparatus for applying discharge sustaining potentials to said second gaseous discharge device, and means operable in response to the discharge of both of said devices for modifying said codes.

30. In a code ringing telephone system, first apparatus

for registering the digits of telephonic designations, apparatus operable in response to said first apparatus for transmitting a plurality of codes, a plurality of gaseous discharge devices, means operable in response to the registration of any of certain tens digits in said first apparatus for selectively applying discharge sustaining potential to the selected one of said devices, a gaseous discharge tube, means operable in response to the registration of any of certain hundreds digits in said first apparatus for applying discharge sustaining potentials to said tube, and means operable in response to the concurrence of a discharge in one of said devices and in said tube for modifying said codes.

31. An arrangement for generating alternating current signals for telephone exchanges comprising, a plurality of electronic oscillators less than the number of signals required, output circuits for said electronic oscillators, signal leads, means connecting the output circuits of certain of said oscillators to certain of said signal leads, a relay set and means connecting the output circuits of other of said oscillators to other of said signal leads under the control of said relay set.

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