Aug. 19, 1941. W. H. T. HOLDEN 2,252,766

SIGNALING SYSTEM

Filed Oct. 17, 1940 4 Sheets-Sheet 1

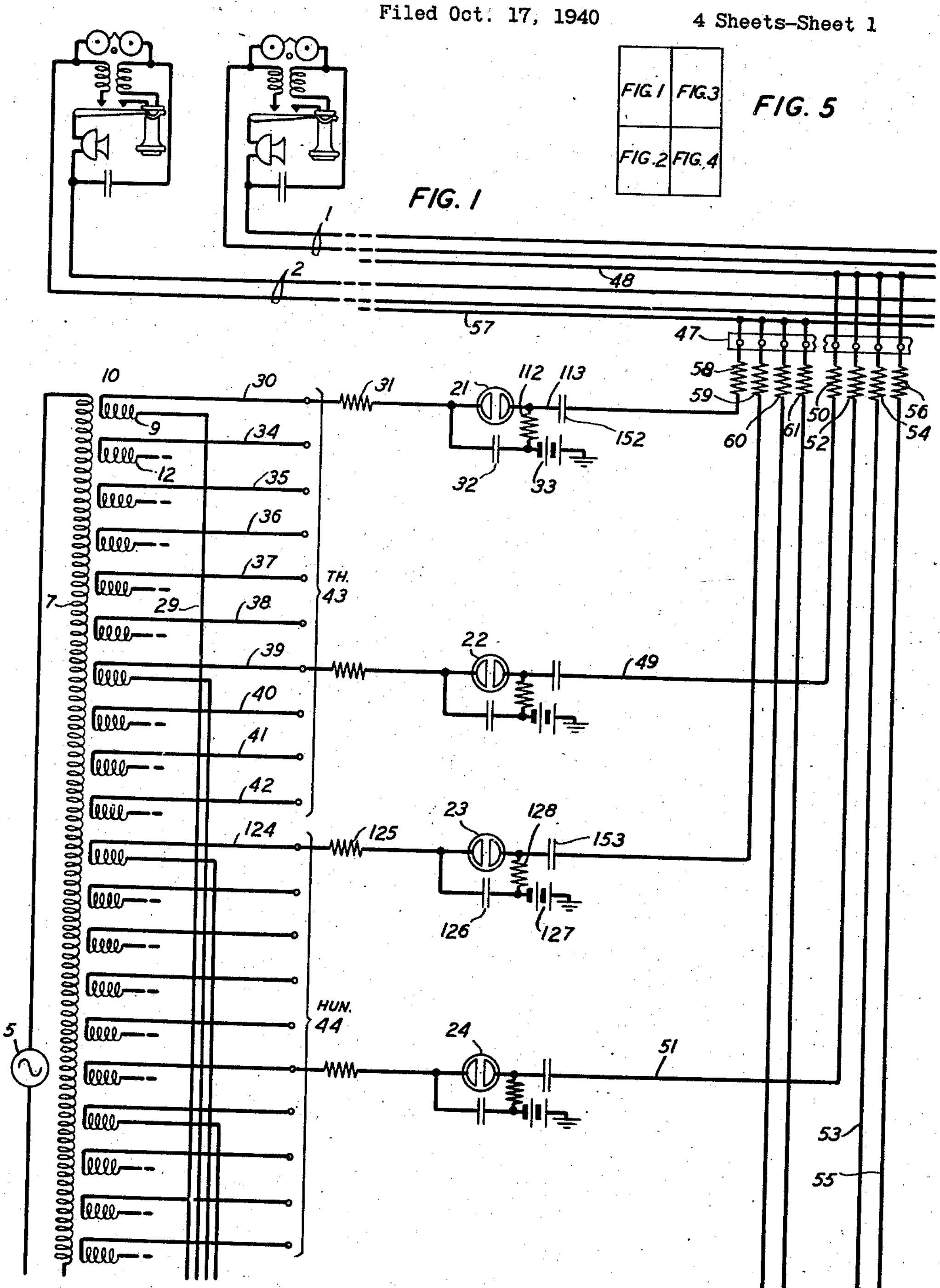


FIG. 1

FIG. 5

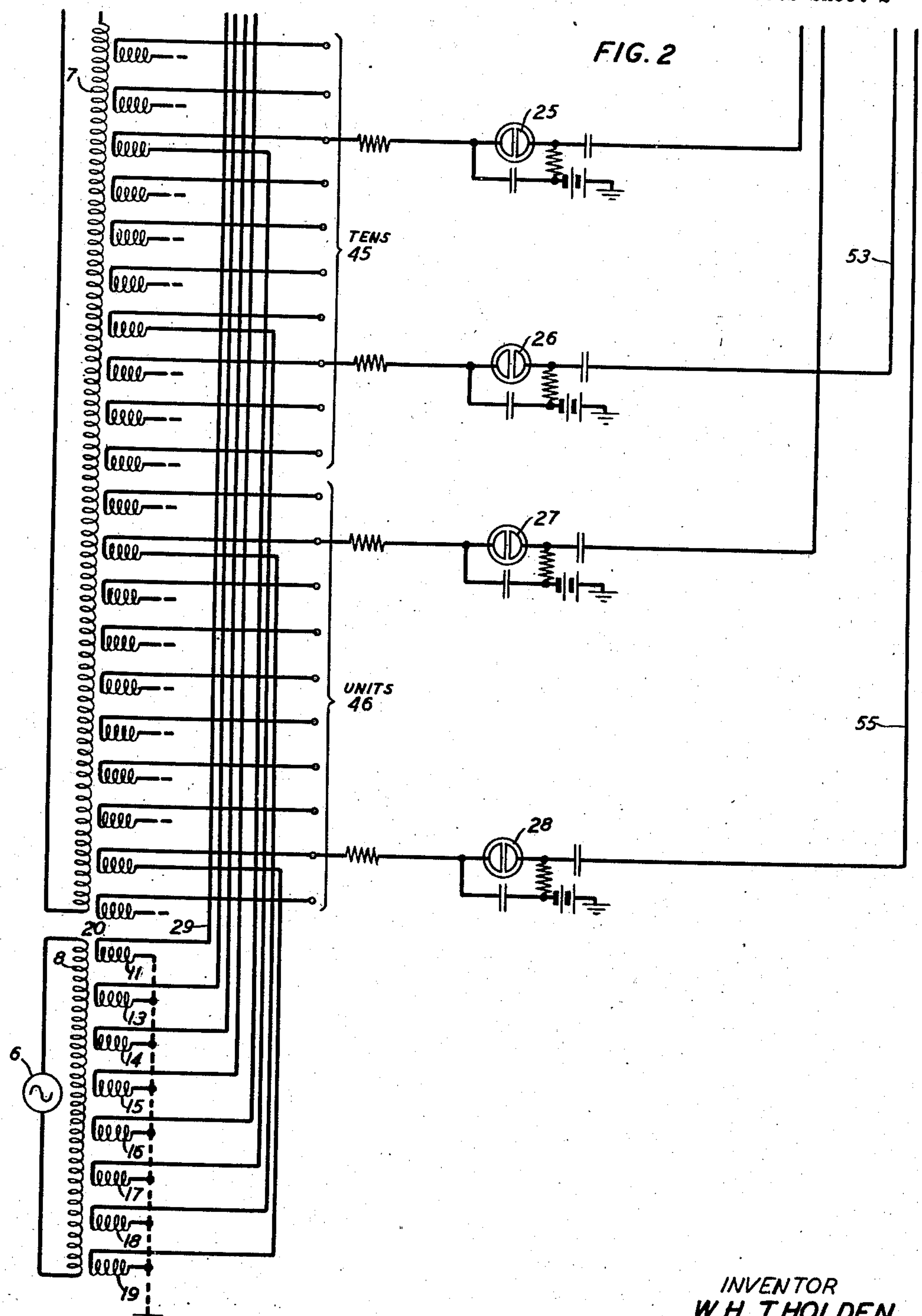
INVENTOR
W. H. T. HOLDEN
BY
[signature]
ATTORNEY

Aug. 19, 1941. W. H. T. HOLDEN 2,252,766

SIGNALING SYSTEM

Filed Oct. 17, 1940 4 Sheets-Sheet 2

FIG. 2



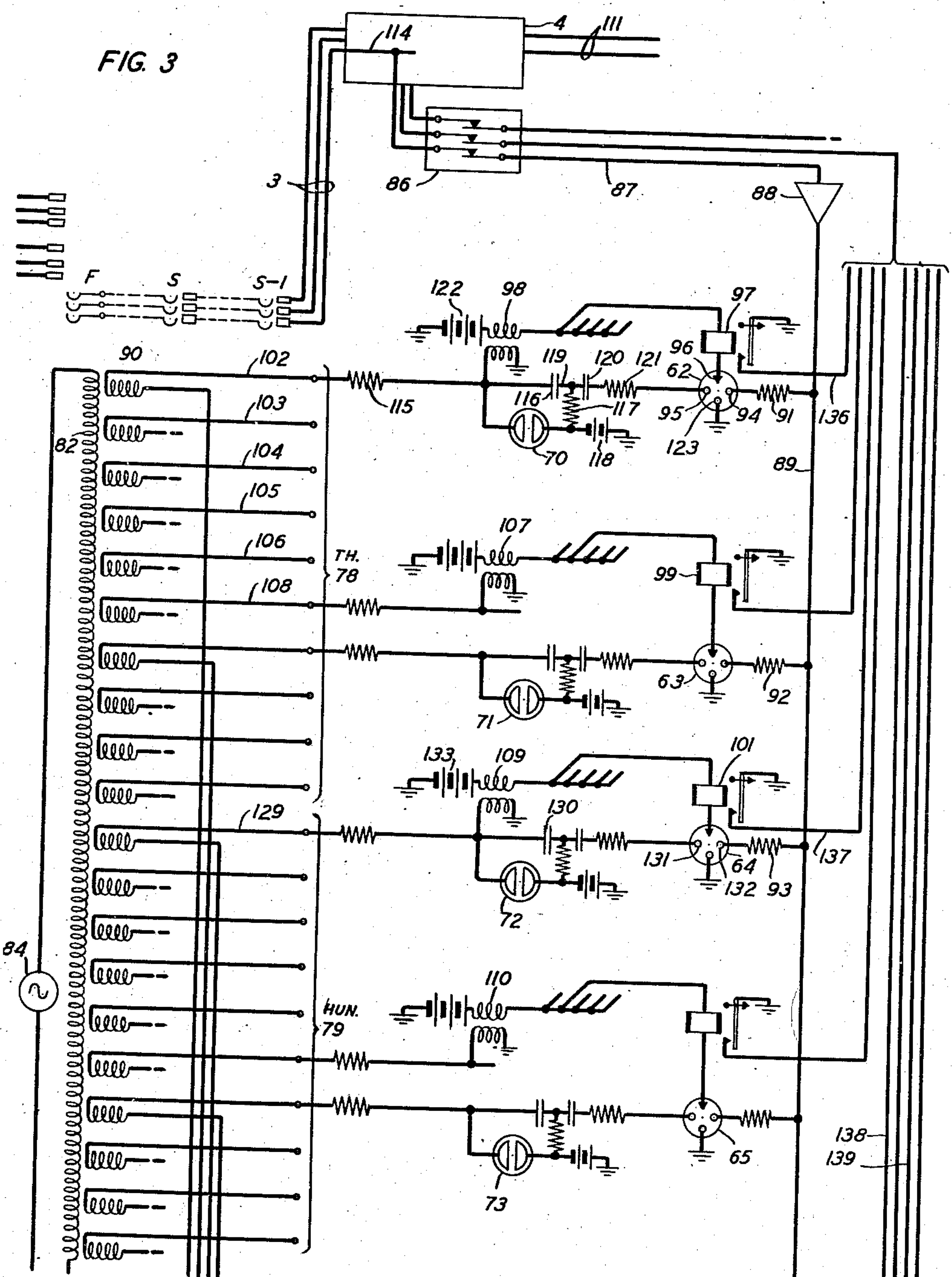
INVENTOR
W. H. T. HOLDEN

BY
W. R. McKenney
ATTORNEY

SIGNALING SYSTEM

Filed Oct. 17, 1940 4 Sheets-Sheet 3

FIG. 3



INVENTOR
W. H. T. HOLDEN
BY W. C. McKenney
ATTORNEY

Aug. 19, 1941.

W. H. T. HOLDEN

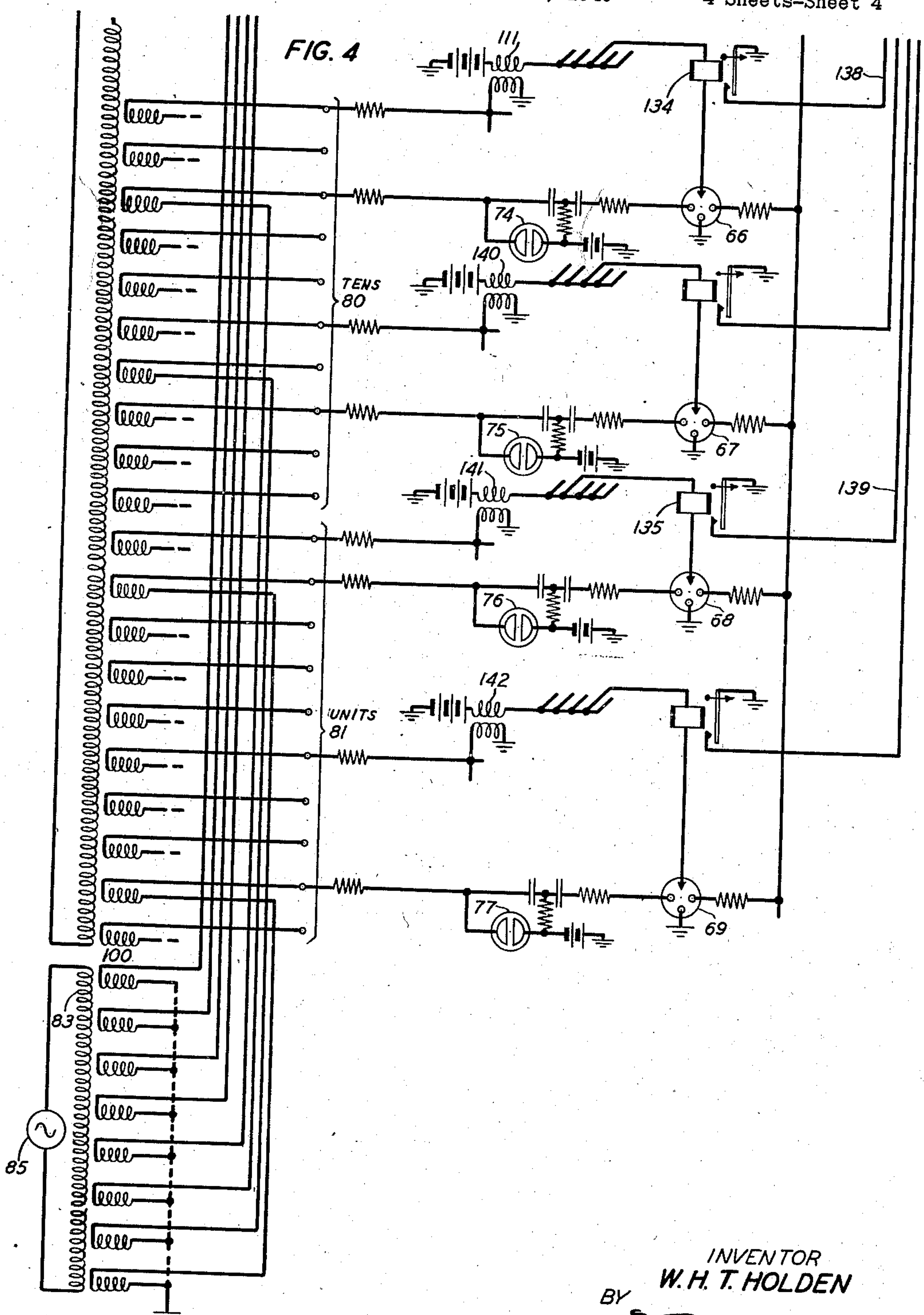
2,252,766

SIGNALING SYSTEM

Filed Oct. 17, 1940

4 Sheets-Sheet 4

FIG. 4



INVENTOR
W. H. T. HOLDEN
BY M. C. McKenney
ATTORNEY

Patented Aug. 19, 1941

2,252,766

UNITED STATES PATENT OFFICE

2,252,766

SIGNALING SYSTEM

William H. T. Holden, Woodside, N. Y., assignor to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

Application October 17, 1940, Serial No. 361,538

8 Claims. (Cl. 179—27)

This invention relates to signaling systems and particularly to systems in which a multiplicity of signals are transmitted over a single transmission line.

An object of the invention is to facilitate the identification of lines or other circuits.

Another object is to identify the designation of a telephone line by means of a multiplex signaling system in which the characters of the designation are determined by the phase of the signals transmitted.

Another object of the invention is to simplify and otherwise improve both the signal transmitting and receiving equipments utilized in the identification of telephone lines.

The foregoing objects are realized by means of a system in which a signal impulse transmitter, common to a plurality of subscribers' lines in a telephone office, is arranged to generate a multiplicity of impulses of a given polarity and of different phases. These impulses are applied to the sleeve conductor of the line to be identified over leads permanently connected thereto, the phases of the impulses being selected to represent the numbers or other characters identifying the line. The impulses thus applied to the sleeve conductor are transmitted through the switches involved in the connection to a receiving mechanism which includes a plurality of discharge tubes having control electrodes to which the incoming impulses are applied. At the same time impulses of opposite polarity and of various phases are applied to other control electrodes of these discharge tubes. The particular tubes having impulses of like phase applied to their electrodes operate to register the designation of the subscriber's line involved in the connection. The registered designation may then be used to control the printing of a ticket to charge for the call being made or for any other purpose.

Other features of the invention will be described more fully in the following specification.

In the drawings accompanying the specification:

Figs. 1 to 4, when arranged in the order shown in Fig. 5, illustrate a portion of an automatic telephone system incorporating the features of the present invention.

Fig. 1 shows the subscribers' lines entering the telephone office together with a portion of the impulse sending mechanism for sending impulses identifying these lines;

Fig. 2 shows the remaining portion of the impulse sending mechanism;

Fig. 3 illustrates the automatic switches for extending the subscribers' lines together with a portion of the impulse receiving mechanism which receives and records the identity of the subscribers' lines; and

Fig. 4 shows the remaining part of the impulse receiving mechanism.

The present invention is particularly useful in systems in which tickets are prepared for the purpose of assessing the calling subscriber for each conversation held with other subscribers. Since these tickets are prepared automatically, it is necessary to determine the number of the calling line in order that the charge be assessed against the proper party. However, the invention may be used in any type of system where it is desirable to determine automatically the identity of a line, trunk, or other circuit. For example, it is often desirable to display the number of a calling party before the operator to whom the line has been extended, eliminating the necessity of the operator making an oral request or performing the usual number-checking operation.

Referring particularly to the drawings, two subscribers' lines 1 and 2 are shown appearing in the terminal bank of line-finder switch F. The finder F operates to seize a subscriber's line when calling, and the selector switches S and S—1 respond to impulses transmitted from the subscriber's line to extend the line over trunks to succeeding switches. Certain of the trunks accessible to switch S—1, such as the trunk 3, lead to the tandem office or to distant zones requiring the preparation of a ticket for charging the call. To this end the trunk 3 is provided with the necessary equipment 4 for preparing a ticket containing the calling subscriber's number, the called subscriber's number and the proper charges for the call.

The identity of a particular calling subscriber's line is determined by the impulse generating and transmitting mechanism shown in Figs. 1 and 2. This mechanism includes a system of transformer windings for producing alternating currents having a multiplicity of separate phases and a plurality of discharge tubes responsive to these alternating currents for generating momentary impulses of the corresponding phases. The alternating currents are supplied by sources 5 and 6, the voltages of which are maintained in quadrature relation. The source 5 is connected to the primary winding 7 of transformer 10, and the source 6 is connected to the primary winding 8 of transformer 20. Each of these transformers is provided with forty secondary windings, each secondary winding of one transformer being connected in series with the corresponding winding of the other transformer. These forty pairs of windings serve to produce voltages of forty different phases. The forty different phases are divided into four groups of ten, these four groups corresponding to the ten different values of the thousands, hundreds, tens and units digits of the subscribers' telephone numbers. For example, the No. 1 secondary winding 9 of transformer 10 is connected in series with the No. 1 secondary winding 11 of transformer 20, the No. 2 winding 12 of transformer 10 is connected in series with the No. 2 winding (not shown) of transformer 20, etc. To simplify the drawings, the majority of the windings of transformer 20 have been omitted, the windings 11, 13, 14, 15, 16, 17, 18 and 19 shown being the No. 1, No. 7, No. 11, No. 17, No. 23, No. 27, No. 32 and No. 39 windings. The circuits including the forty pairs of secondary windings are connected to the forty impulse generating tubes, of which eight are shown, namely tubes 21, 22, 23, 24, 25, 26, 27 and 28. For example, the circuit including the first pair of windings 9 and 11 may be traced from ground through winding 11, conductor 29, winding 9, conductor 30, resistance 31 to one of the electrodes of tube 21 and also to one terminal of condenser 32, the other terminal of which is connected through battery 33 to ground. The second pair of windings are included in a circuit which extends over conductor 34 to the second generating tube (not shown). Similarly the next eight pairs of windings are included in circuits 35, 36, 37, 38, 39, 40, 41 and 42, extending to the corresponding eight impulse generating tubes of which one tube, tube 22, is shown in the drawings. These first ten supply circuits 43 and the corresponding ten tubes constitute the thousands group and serve to transmit the impulses representing the ten different values that the thousands digit may have.

The next ten pairs of secondary transformer windings are included in the ten supply circuits 44 which are connected to ten different impulse tubes, including tubes 23 and 24. These ten supply circuits and tubes constitute the hundreds group and serve to transmit the impulses identifying the different values of the hundreds digit.

In like manner the tens group is comprised of ten supply circuits 45 and ten impulse tubes, including tubes 25 and 26; and the units group comprises ten supply circuits 46 and ten generating tubes, including the tubes 27 and 28.

Since the voltages of the sources 5 and 6 are in quadrature, it is possible to graduate the phases of the voltages produced in the forty consecutive supply circuits 43, 44, 45 and 46, by graduating the number of turns and the poling of the windings in the successive secondary windings of the transformers 10 and 20. The voltage in the supply circuit 30, for instance, is the result of the voltages in windings 9 and 11, the phases of which are at right angles to each other. Therefore, the phase of the resultant voltage may be fixed at any desired time in the cycle by properly selecting the relative number of turns on windings 9 and 11. Similarly the relatively number of turns and polarity on the remaining pairs of windings are selected in such a manner that the phases of the voltages in the supply circuits are spaced at substantially uniform intervals. In other words, the voltage in each of the forty consecutive supply circuits 30, 34, 35, 36, 37, etc., rises to its maximum value once per cycle of the sources 5 and 6, each of the forty different voltages occurring at forty different periods in the cycle.

The forty impulse generating tubes to which the supply circuits are connected are arranged to discharge and produce impulses once during each positive half-cycle of the supply voltage. Accordingly, the forty tubes produce forty successive impulses per cycle, and each one of the subscribers' lines is identified by connecting its sleeve conductor to a combination of four of the impulse generating tubes, one tube in each of the thousands, hundreds, tens and units groups. The subscriber's line 1, for example, has its sleeve conductor 48 permanently connected by way of the connecting rack 47 to the generating tubes 22, 24, 26 and 28. The connection from the tube 22 extends over the impulse circuit 49 through resistance 50 to the sleeve conductor 48, the circuit from tube 24 extends over impulse circuit 51 through resistance 52, the circuit from tube 26 extends over impulse circuit 53 through resistance 54, and the circuit from tube 28 extends over impulse conductor 55 and resistance 56 to said sleeve conductor. Since the tubes 22, 24, 26 and 28 are the No. 7, No. 6, No. 8 and No. 9 tubes in the thousands, hundreds, tens and units groups, respectively, the number of subscriber's line 1 is 7689. In like manner, the sleeve conductor 57 of subscriber's line 2 is connected permanently through resistances 58, 59, 60 and 61 to the impulse generating tubes 21, 23, 25 and 27, the number of line 2 being 1132. Likewise, each of the remaining subscriber's lines in the office is connected to a different combination of impulse generating tubes for identifying its number. The purpose of the resistances between the impulse generators and the sleeve conductor is to prevent the impulses of one generator from appearing on the impulse leads of other generators.

The line identifying equipment, which is associated with the seized outgoing trunk 3, includes a series of forty discharge tubes 62, 63, 64, 65, 66, 67, 68, 69, etc. These identifying tubes respond to the impulses transmitted from the sending equipment associated with the calling subscriber's line and also respond to impulses of varying phases produced locally in the receiving equipment. These local impulses are produced by a series of forty impulse generating tubes 70, 71, 72, 73, 74, 75, 76, 77, etc. The alternating currents of different phases for energizing the tubes 70, 71, 72, etc., are supplied by the four groups of supply circuits 78, 79, 80 and 81. The forty supply circuits in the four groups are connected, respectively, to the forty pairs of secondary windings on the transformers 90 and 100. The primary windings 82 and 83 of these transformers are connected to voltage sources 84 and 85 which are in quadrature relation and which are in phase, respectively, with sources 5 and 6 supplying the transformers 10 and 20. If desirable, the primary windings 7 and 82 may be supplied from the same source and primary windings 8 and 83 from a second source which is in quadrature to the first source. The secondary windings of the transformer 100 are connected respectively in series with the corresponding secondary winding of the transformer 90, the same as the windings of transformers 10 and 20.

Thus the ten supply circuits 78, the ten impulse generating tubes to which these are connected, including tubes 70 and 71, and the ten indicating tubes associated with the respective generating tubes, including the tubes 62 and 63, constitute the thousands group and serve to indicate the value of the thousands digit of the particular line being identified. Similarly, the ten supply circuits 79, the ten associated impulse generating tubes, including tubes 72 and 73, and the ten indicating tubes, including tubes 64 and 65, constitute the hundreds group for identifying the value of the hundreds digit of the number. In like manner the tens and units groups include the supply groups 80 and 81, respectively, the associated groups of impulse generating tubes and the associated groups of indicating tubes, the latter including the tubes 66 and 67 and the tubes 68 and 69.

Since the receiving and indicating equipment is common to a plurality of trunks, a connecting device 86 is provided for connecting the indicating mechanism with any particular trunk, such as the trunk 3, requiring its services. In addition to other leads, the connector 86 extends the sleeve conductor of the connection through to the impulse receiving conductor 87 which delivers the incoming impulses to the forty indicating tubes 62, 63, 64, etc. If desirable, the incoming impulses may be amplified to increase their energy by a suitable amplifier 88. After amplification, these incoming impulses are applied over the common conductor 89 and through resistance elements 91, 92, 93, etc., to one of the control electrodes of each of the indicating tubes, such as the electrode 94 of tube 62. The other control electrode of each indicating tube, such as the electrode 95 of tube 62 is connected to the impulse conductor associated with the generating tube 70. The third electrode or anode of each tube, such as the anode 96 of tube 62, is connected to an indicating relay 97, the operating energy for the indicating relay being supplied from a transformer 98.

Since the voltages produced in the forty supply circuits 78, 79, 80 and 81 are in phase with the corresponding voltages produced in the forty supply circuits 43, 44, 45 and 46 at the sending end, the forty successive impulses applied to the electrodes of the indicating tubes 62, 63, 64, etc., are in phase respectively with the forty impulses produced in the impulse circuits of generating tubes 21, 22, 23, etc., for each positive half-cycle of the alternating voltage. It follows, therefore, that if any particular combination of four generating tubes 21, 22, 23, etc., are connected to the sleeve conductor of the line and this sleeve conductor is extended through to the impulse receiving conductor 89 associated with the forty indicating tubes 62, 63, 64, etc., the corresponding four indicating tubes will have impulses applied simultaneously to their control electrodes. Since, as will be described hereinafter, the impulses produced by the tubes 21, 22, 23, etc., are positive in polarity and the impulses produced by generating tubes 70, 71, 72, etc., are negative in polarity, the simultaneous application of a positive and a negative impulse to the control electrodes of an indicating tube produces sufficient voltage across these electrodes to ionize the tube. Hence the four indicating tubes which correspond to the four generating tubes connected to the sleeve conductor of the line are ionized and cause the operation of their associated indicating relays 97, 99, 101, etc., to identify the digital characters of the subscriber's line.

It will be noted that the anode circuit of the tube 62 is connected to the secondary winding of the transformer 98 and that the primary winding of this transformer is energized by the alternating current flowing in the supply circuit 102 of phase No. 1. Hence the anode supply voltage will be at substantially its maximum value at the instant ionization occurs across the control gap 94—95, and the relay 97 obtains a maximum current flow at each ionization of the tube, that is, at each positive half-cycle of the supply voltage. The relay 97 is designed to operate after a succession of impulses have been received and to maintain its operation between successive ionizations of the tube. Each of the indicating relays may be operated by a separate transformer, the transformers being connected to the respective supply circuits 102, 103, 104, 105, 106, etc. However, it is sufficient to connect a group of five successive relays to the secondary winding of a single transformer 98 as illustrated in the drawing. In other words, the phases of a series of five consecutive supply circuits are sufficiently close to insure the operation of all five of the indicating relays. With this arrangement it is only necessary to provide a transformer for each five relays. Transformer 98 serves the first five relays, including relay 97. Transformer 107 serves the next five relays, including relay 99, and derives its energizing current from the supply circuit 108. Similarly, other transformers 109, 110, 111, 140, 141 and 142 supply the succeeding groups of indicating relays.

To further describe the detailed operation of the indicating system disclosed herein, it will be assumed that the subscriber of line 2 wishes to make a call requiring the preparation of a ticket indicating the charges assessed the subscriber for the conversation. The call is initiated in the usual manner, and the line finder F operates to seize the terminals in which the line 2 appears. Thereupon the subscriber manipulates his dial to operate selector switches S and S—1 to extend the connection to the control circuit 4 of trunk 3 and thence over the tip and ring conductors 111 to a distant office. As soon as the trunk 3 is seized, the controlling equipment 4 causes the operation of the connecting device 86 for associating the control equipment 4 with the line identifying mechanism shown in Figs. 3 and 4. As soon as the sleeve conductor 57 of the line has been extended through to the conductor 89 in the indicating mechanism, positive impulses are transmitted over this conductor from the impulse sending mechanism associated with the sleeve conductor 57. On the next positive half-cycle of the sources 5 and 6 following the completion of the impulse transmitting circuit the voltage of phase No. 1 in supply circuit 30 causes the charging of condenser 32. Upon reaching the breakdown voltage of tube 21 the charge on condenser 32 causes the tube to ionize, and current from the condenser flows across the control gap of the tube and through the resistance 112. It will be noted that the flow of current in the resistance 112 is in such a direction that the impulse conductor 113 is made positive with respect to ground. This positive potential impulse is transmitted through the condenser 152, resistance 58, sleeve conductor 57 thence through the switches S and S—1 to the sleeve conductor 114 of trunk 3 through the connector 86, conductor 87, amplifier 88, conductor 89 thence in parallel through resistances 91, 92, 93, etc., to the control electrodes of the respective tubes 62, 63, 64, etc.

At the same time the alternating current of phase No. 1 flows over supply circuit 102 through resistance 115, condenser 116, resistance 117, battery 118 to ground. The condenser 116 is charged in this circuit until it reaches the ionizing voltage of tube 70, which occurs at the same instant that condenser 32 reaches the ionizing voltage of tube 21 at the sending end. When this voltage is reached, the condenser 116 discharges across the gap of tube 70 and current flows through the resistance 117 in such a direction that the pulse conductor 119 is made negative with respect to ground. This negative potential on conductor 119 is transmitted through condenser 120 and resistance 121 and is applied to the control electrode 95 of the tube 62. Thus, the control electrodes 94 and 95 of tube 62 are made positive and negative, respectively, at the same instant in response to the potential impulses, one of which is transmitted from the tube 21 and the other from the tube 70 during the positive half-cycle of the alternating current of phase No. 1. The control gap of tube 62 ionizes, and current flows from the positive pole of battery 122, secondary winding of transformer 98, indicating relay 97, anode 96, cathode 123 to ground. Hence the voltages of the battery 122 and transformer 98 combine to cause the flow of current in the anode circuit through the winding of relay 97 in phase with the ionization of the control gap of the tube. For each successive impulse delivered by the tube 21 and the corresponding impulse delivered by tube 70, the indicating tube 62 ionizes and an impulse of current flows through the winding of relay 97. Relay 97 operates after a number of these impulses have been delivered and retains its armature until the impulses cease.

Later in the cycle of sources 5 and 6 the voltage in supply circuit 124 rises to its maximum amplitude in its positive half-cycle and current flows through the resistance 125, condenser 126, battery 127 to ground. When the condenser 126 reaches the required voltage, it discharges through the tube 23 and resistance 128, and a positive impulse is transmitted through condenser 153, resistance 59 and thence over the sleeve connection to the common conductor 89. The phase of this impulse is No. 11 in the series of forty phases or No. 1 in the hundreds group 44. This impulse appearing on conductor 89 is also applied to the control electrodes of all forty of the indicating tubes. At the same instant voltage of phase No. 11 appears in the supply circuit 129, condenser 130 is charged, and the tube 72 is ionized to produce a negative impulse which is applied to the control electrode 131 of tube 64. Since the control electrode 132 of this tube is at positive potential at this instant, the tube ionizes, and current flows from battery 133 and transformer winding 109 through the indicating relay 101 and the anode-cathode gap of the tube to ground. After a succession of impulses of this phase, relay 101 operates and remains operated as long as the impulses continue.

In like manner for each cycle of sources 5 and 6 the tube 25 produces a positive impulse of phase No. 23, or No. 3 in the tens group, and tube 27 produces a positive impulse of phase No. 32, or No. 2 in the units group, and these impulses are transmitted over the sleeve conductor and applied to the electrodes of the indicating tubes 62, 63, 64. Also in like manner tube 74 produces a negative impulse of phase No. 23 and tube 76 produces impulses of phase No. 32, and these impulses are applied to indicating tubes 66 and 68, resulting in the operation of indicating relays 134 and 135.

Thus the number of the calling line, 1132, is identified by the operation of relays 97, 101, 134 and 135, and none of the other indicating relays in the group of forty relays operates because the impulses applied to the associated indicating tubes are not in phase with each other. Relays 97, 101, 134 and 135 apply ground potential over conductors 136, 137, 138 and 139 to the control mechanism 4 associated with the trunk 3. These ground potentials may serve to operate a printer to print the number of the line 2 on a message ticket. After the information concerning the calling line as well as the information concerning the called line has been recorded in the control mechanism 4, the identifying mechanism may be disconnected from the trunk by releasing the connecting device 86.

Should the subscriber of line 1 extend a connection requiring the preparation of a ticket the number of this line is identified in the manner already described, except that the positive impulses for identifying the number of line 1 are transmitted by the generating tubes 22, 24, 26 and 28, and the phases of these impulses correspond to the number 7689.

Although the invention has been illustrated as applied to an automatic system in which the numbers of subscribers' lines are identified for the purpose of preparing message tickets, it will be understood that it may also be used for identifying the numbers of lines at operators' positions.

What is claimed is:

1. In a signaling system, a plurality of lines each of which has an identifying designation, means for generating a multiplicity of signal impulses of different phases, connecting means between said generating means and said lines for applying to each line a plurality of said signal impulses in a combination of phases representing the line designation, a circuit for transmitting the impulses pertaining to a particular one of said lines, and means for receiving and utilizing the transmitted impulses to identify said particular line.

2. In a signaling system, a plurality of lines each of which has an identifying designation, means for generating a multiplicity of signal impulses of different phases, connecting means between said generating means and said lines for applying to each line a plurality of said signal impulses in a combination of phases representing the line designation, means for establishing a connection including a particular one of said lines, said established connection serving to transmit the impulses applied to said particular line, and means associated with the established connection selectively operated in accordance with the phases of the transmitted impulses for identifying said particular line.

3. In a signaling system, a plurality of lines each of which has an identifying designation, means for generating a multiplicity of signal impulses of different phases, a plurality of leads permanently connecting said generating means to said lines for applying to each line a group of signal impulses in a combination of phases representing the line designation, a circuit for transmitting the impulses pertaining to a particular one of said lines, and means for receiving and utilizing the transmitted impulses to identify said particular line.

4. In a signaling system, a line having a control conductor, means for generating a plurality of signal impulses of different phases, connecting leads permanently connected between said generating means and the control conductor of said line for transmitting to said conductor a group of said impulses the phase combination of

which represents the designation of said line, means for establishing a connection from said line, said established connection serving to transmit the impulses applied to said control conductor, and means for receiving and utilizing the transmitted impulses for determining the designation of said line.

5. In a signaling system, a line having a control conductor, means for generating a plurality of signal impulses of different phases, connecting leads permanently connected between said generating means and the control conductor of said line for transmitting to said conductor a group of said impulses the phase combination of which represents the designation of said line, means for establishing a connection from said line, said established connection serving to transmit the impulses applied to said control conductor, and a receiving mechanism comprising a plurality of discharge tubes selectively responsive to said transmitted impulses in accordance with the phases thereof.

6. In a signaling system, a line having a control conductor, means for generating a plurality of signal impulses of different phases, connecting leads permanently connected between said generating means and the control conductor of said line for transmitting to said conductor a group of said impulses the phase combination of which represents the designation of said line, means for establishing a connection from said line, said established connection serving to transmit the impulses applied to said control conductor, a receiving mechanism comprising a plurality of discharge tubes each having control electrodes, a second impulse generating means for generating impulses of different phases and applying them to the control electrodes of said tubes, and means for applying to the control electrodes of said tubes the impulses transmitted over said established connection to selectively operate said tubes.

7. In a signaling system, a line having a control conductor, a source of alternating current, means responsive to said source for generating a plurality of successive signal impulses during each cycle of said current, means for applying to said control conductor a group of the impulses generated in each cycle, said group being selected to characterize the designation of said line, means for establishing a connection from said line, said established connection serving to transmit the impulses applied to said control conductor, and means for receiving and utilizing the transmitted impulses for determining the designation of said line.

8. In a signaling system, a line having a control conductor, a source of alternating current, means responsive to said source for generating a plurality of successive signal impulses during each cycle of said current, means for applying to said control conductor a group of the impulses generated in each cycle, said group being selected to characterize the designation of said line, means for establishing a connection from said line, said established connection serving to transmit the impulses applied to said control conductor, a plurality of discharge tubes, means responsive to said source of alternating current for generating successive signal impulses during each cycle and for applying said impulses to the control electrodes of said tubes, and means for applying the impulses transmitted over said control conductor to the control electrodes of said tubes to selectively operate said tubes in accordance with the designation of said line.

WILLIAM H. T. HOLDEN.