

June 22, 1937.

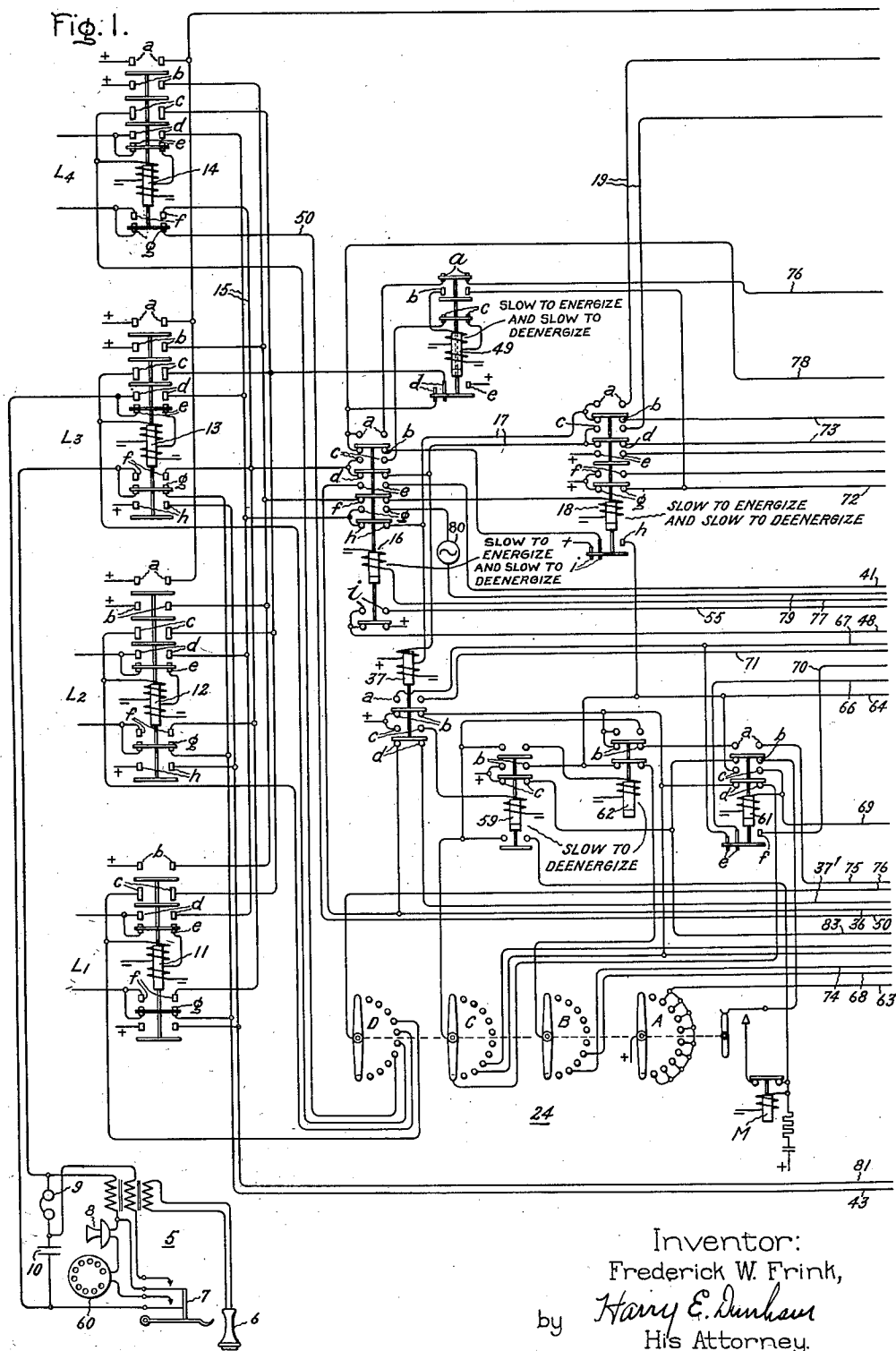
F. W. FRINK

2,084,903

SIGNAL SYSTEM

Filed Nov. 14, 1934

2 Sheets-Sheet 1



Inventor:  
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by *Harry E. Dunham*  
His Attorney.

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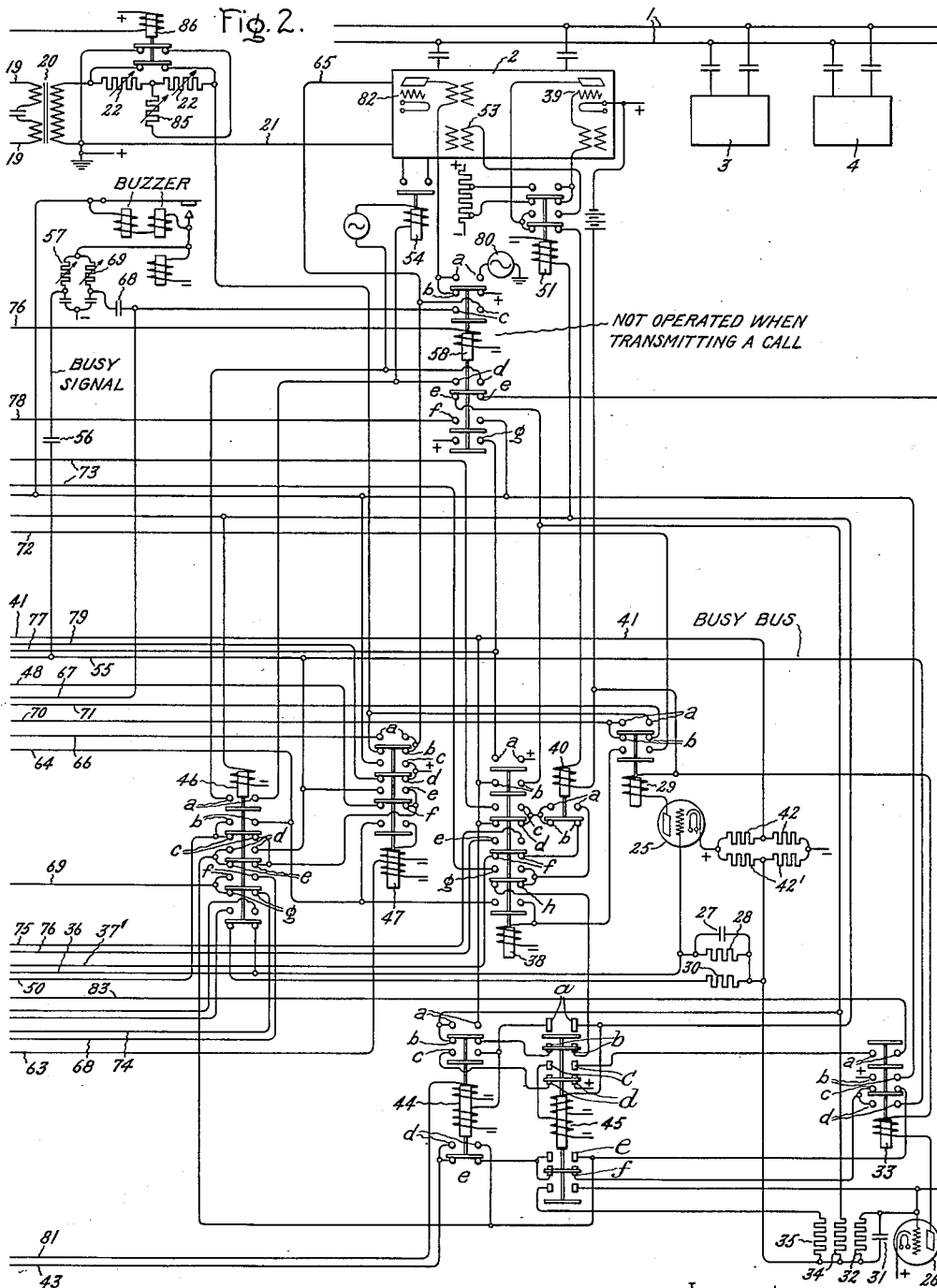
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## UNITED STATES PATENT OFFICE

2,084,903

## SIGNAL SYSTEM

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Application November 14, 1934, Serial No. 753,010

13 Claims. (Cl. 179—15)

My invention relates to signaling systems and more particularly to carrier current signaling systems, such for example, as those used for communication over the lines of a power distribution system.

In connection with carrier current communication systems frequently a number of operators' stations may be connected to any one, or all, of the different carrier current stations. That is, a plurality of ordinary telephone lines, for example, may be connected to a carrier current station and so arranged that a telephone operator on any of said lines may call and communicate with any remote carrier station of the system, or any such operator may be selectively called from a remote station.

It is desirable, in such a system, that means be provided whereby when communication is being carried on between an operator's station on a telephone line and a remote carrier station, or between different carrier current stations all other stations are prevented from interfering with such communication. One of the objects of my invention is to provide means whereby the initiation of a call through any carrier station is prevented while other carrier stations on the line are busy.

In the event that one or more of the telephone stations is provided primarily for use of one, such as a power dispatcher, who has occasional immediate and exigent use for the carrier current apparatus, it is desirable to provide means whereby by use of such a telephone station an operator may break into any conversation which may be carried on the system, and, thereby, request the use of the system. Another object of my invention is to provide means whereby an operator, at such a station, provided with this preferential service, is prevented from interfering with the reception of a call at the respective carrier station from any remote carrier station. A further object of my invention is to provide means whereby when a call is initiated by any station it may be completed without interference by any other station.

Still further objects of my invention relate to the use in such a system of busy and answer back signals, and to the means for properly timing various operations of the equipment to obtain a maximum facility in the use of the system and a minimum of confusion or annoyance resulting from operation of the various preventing means.

The novel features which I believe to be characteristic of my invention are set forth with

particularity in the appended claims. My invention itself, however, both as to its organization and its method of operation, together with further objects and advantages thereof may best be understood by reference to the following description taken in connection with the accompanying drawings in which Figs. 1 and 2 taken together represent an embodiment of my invention.

Referring to the drawings, my invention may best be understood by placing Figs. 1 and 2 side by side, Fig. 1 at the left of Fig. 2 with the lines coinciding at the adjacent edges of the drawings.

Referring first to Fig. 2 of the drawings, I have shown in the upper right hand corner thereof a power line 1 having a number of carrier current stations 2, 3, 4 connected thereto. These carrier current stations may be identical in their construction each of them comprising a carrier current transmitter and receiver for two way telephone communication, for example, on a single carrier frequency. Each station is provided with means whereby calls may be effected between stations through any of the common means for calling. The calling system employed in the circuit to be described is one in which the call is effected by transmitting a tone modulation upon the carrier wave, this tone being interrupted in accordance with code combinations by which the desired selection is effected, the tone being uninterrupted for a certain interval both prior to and subsequent to the code interruptions.

The relays, selective circuits, and operator's stations associated with the station 2 are shown in detail in the drawings. Similar circuits are associated with each of the other stations 3, 4, etc.

At the left side of Fig. 1 of the drawings are indicated a number of telephone lines L<sub>1</sub>, L<sub>2</sub>, L<sub>3</sub>, and L<sub>4</sub>. Each of these lines extends to a conventional telephone instrument such, for example, as that which is conventionally indicated at 5, as connected to the line L<sub>3</sub>. These instruments, of course, are of a type in which when the receiver 6 is removed from the hook 7 a direct current circuit is completed through the line whereas when the receiver is on the hook this circuit is interrupted leaving only an alternating current circuit through the telephone set. The direct current circuit may be established through the lower switch controlled by the hook for receiver 6 and transmitter whereas the alternating cur-

rent circuit may be through the ringer 9 and condenser 10.

Lines L<sub>1</sub>, L<sub>2</sub>, and L<sub>3</sub>, as shown in the drawings, are connected for what I shall term as "non-preferential" service whereas line L<sub>4</sub> is connected for the "preferential" service referred to above. These terms have reference to the ability of the operators on the corresponding lines to establish communication through the carrier station 2.

Due to connections presently to be described, the operators on lines L<sub>1</sub>, L<sub>2</sub>, and L<sub>3</sub> are prevented from establishing communication through the carrier equipment 2 when (1) calls are being received by the carrier current receiver of the equipment 2, (2) when conversation is being carried on between remote stations, as for example 3 and 4 on the power line, and (3) when any remote station 3, 4 is talking with an operator on one of the other lines L<sub>1</sub> to L<sub>3</sub>. The operator on line L<sub>4</sub> may establish communication through the system 2 at any time except when calls are being received in the carrier receiver of the equipment 2.

Each of the lines L<sub>1</sub>, L<sub>2</sub>, L<sub>3</sub>, and L<sub>4</sub> is provided with a corresponding line relay 11, 12, 13, 14, which is operated either by removal of the receiver from the hook, or in response to a call from a remote station 3, 4, and which upon operating extends the respective telephone line through conductors 15, certain contacts on relay 16, conductors 17 and thence, after certain operations later to be described, through contacts on relay 18 to conductors 19 leading to the input transformer 20 in the audio channel of the carrier current equipment. The right hand winding of this transformer is connected with the carrier current equipment through a circuit including conductor 21, right hand winding of transformer 20, resistances 22 of an attenuation network which may or may not be employed, as will later be described, to contacts b on relay 47 and conductor 65.

In the lower portion of Fig. 1 is shown a selector switch 24 having a number of banks A, B, C, and D of contacts whereby the different lines L<sub>1</sub>, L<sub>2</sub>, L<sub>3</sub>, and L<sub>4</sub> may be selected in response to calls received from remote stations.

In Fig. 2 are shown a pair of electron discharge devices 25 and 26 each of which has an anode circuit including a relay and a grid circuit including a parallel combination of capacitance and resistance. These electron discharge devices 25 and 26 are employed to effect certain timing operations, the time intervals determined thereby being preset by the adjustment of the condenser and resistance. That is, between the grid and cathode of the discharge device 25 is connected the condenser 27 and resistance 28, which when the condenser is charged, as by connecting it to a negative point on bias potentiometer 42, holds a negative potential upon the grid after the connection to this bias potentiometer 42 has been interrupted thereby determining the time interval for the operation of the relay 29 connected in the anode circuit of the discharge device. Resistance 30 is adapted under certain conditions to be connected in parallel with the resistance 28 thereby to alter the time interval fixed by the discharge device.

In the same way discharge device 26 is provided with a grid circuit including the condenser 31 and resistance 32 connected in parallel, these elements being adjusted to determine a predetermined interval for operation of the relay 33

connected in the anode circuit of the discharge device. Resistances 34 and 35 are also arranged to be connected in parallel with resistance 32 to fix certain other intervals of operation of the discharge device.

A slight negative bias from potentiometer 42' is continuously maintained on the grids of discharge devices 25 and 26 thereby to prevent excessive current from flowing in the respective anode circuits at any time.

The manner in which these results are brought about and the use which is made of them in the system will best be understood by reference to the operation of the system which now may be explained.

Throughout the drawings points of the various circuits, which are connected to terminals of the energizing source of potential are indicated by + and - signs.

In the drawings the apparatus is shown in its normal condition; that is, in the condition which it occupies when not in use. It will be observed that in this condition condenser 27 is charged through a circuit which extends from the grid of the discharge device through conductor 36, contacts d on relay 37, conductor 37', contacts f on relay 38, contacts b on relay 40, contacts d on relay 38, conductor 41, to a point on bias control potentiometer 42. This potentiometer has one end connected to the cathode of the discharge device and to the positive terminal of a source of potential, not shown, while its opposite end is connected to the negative side of the source of potential. By means of this potentiometer the grid of the discharge device is biased strongly negative so that relay 29 in its anode circuit is deenergized.

Relay 33 in the anode circuit of discharge device 26 on the other hand is normally energized since the grid of this device is, in the normal condition, disconnected from the bias potentiometer and the condenser 31 is discharged.

Also in the normal condition the lower conductors of all the lines L<sub>1</sub>, L<sub>2</sub>, L<sub>3</sub>, and L<sub>4</sub> are connected through contacts g of the respective line relays to the positive side of a source of potential at the lower contacts of relay 16. The circuit from the lower side of lines L<sub>1</sub>, L<sub>2</sub>, L<sub>3</sub> may be traced as follows. Through contacts g of the respective line relay, conductor 43, contacts e of relay 44, contact f of relay 45, contacts c on relay 33, contacts e on relay 46, contacts f on relay 47, conductor 48, and lower contacts on relay 16 to the positive side of the source of potential. The circuit from the lower side of line L<sub>4</sub> may likewise be traced to positive potential at the lower contacts on relay 16 through contacts g on relay 14, conductor 50, contacts c on relay 46, contacts f on relay 47, conductor 48 and lower contacts of the relay 16. When any receiver 6 is removed from the hook the respective circuit is extended through the telephone instrument to the opposite side of the line and thence through contacts e on the respective relay and the lower winding of the relay to the negative side of the source of potential. The respective relay then partially operates.

For example, if the receiver of the telephone instrument connected to the line L<sub>3</sub> be removed from the hook relay 13 operates sufficiently to complete a circuit extending through its upper winding, contacts c on line relay 13, contacts d on relay 49, contacts b on relay 16 and contacts i on relay 18, to the positive side of the source of potential. Relay 13 now operates completely

and by means of its contacts *d* and *f* extends the line conductors through conductors 15, contacts *d* and *h* on relay 16, conductors 17, and the two windings of relay 37 to opposite sides of the source of potential. Relay 13, also by means of its contacts *b* completes a circuit from the positive side of the source of potential through contacts *f* of relay 16 and the winding of relay 18. Relay 18 now operates and extends the telephone line from conductors 17 through conductors 19 to transformer 20 of the audio channel of the transmitting apparatus. Relay 18 by means of its contacts *e* energizes the buzzer through an obvious circuit, and by means of its contact *f* it energizes relays 46, 51, and upper winding of relay 45 also through an obvious circuit.

The buzzer is utilized for generating a busy tone which is heard in the receivers of the telephone instruments when the equipment is in use and the particular line is locked out, that is, prevented from gaining access to the equipment. Relay 51 effects certain operations within the equipment 2 whereby the receiver thereof is conditioned for operation. By means of its upper armature a proper bias condition is established upon the grid of discharge device 39 and by means of its lower armature the anode of this discharge device is connected to an output audio transformer 53 in the audio channel of the equipment. This discharge device is a receiving tube of the system and in its normal condition has the calling relay 40 connected in its anode circuit. Relay 51, however, when operated, disconnects this relay and connects speech transformer 53 in this anode circuit. Relay 46 by means of its contacts *a* energizes relay 54 which operates and supplies energizing current to the carrier current equipment whereby the system is conditioned for operation.

The effect of the energization of relay 45 will later be explained.

When relay 13 operated the upper winding of relay 44 was energized through the lower contacts of that relay. This relay operates and interrupts at its contacts *e* the previously traced circuit extending from the lower conductors of lines *L*<sub>1</sub>, *L*<sub>2</sub> and *L*<sub>3</sub> and these conductors are connected through contacts *d* on relays 44 and 46 to conductor 55, which is the busy signal bus of the equipment, it being connected through condenser 56 and resistance 57 to the buzzer. Thus if after the receiver 6 of the instrument connected to line *L*<sub>3</sub> is removed from the hook, an operator at a station on line *L*<sub>1</sub> and *L*<sub>2</sub> attempts to gain access to the equipment, he merely receives the busy signal.

The lower conductor of line *L*<sub>4</sub> is connected to the positive side of the source of potential at contacts *b* of relay 59. This connection extends through contacts *g* on relay 14, conductor 50, contacts *b* on relay 46, conductor 64 and contacts *b* on relay 59 to the positive side of the source of potential. Relays 59 and 37 operated immediately upon operation of relay 13. Thus if the operator on line *L*<sub>4</sub> at this time removes his receiver from the hook, his line is immediately connected in parallel with the line of the calling party, whereby he is enabled to request the immediate use of the system.

Relay 37 is the dialing relay of the system and controls the selector. It, as above stated, operates immediately after operation of line relay 13 and by means of its contacts *c* energizes relay 59 which immediately operates.

The operator proceeds now to dial the number of the station which he desires to call by means of his dial 60. This dialing device interrupts the direct current circuit through the telephone instrument a number of times dependent upon the digit dialed. For example, if we assume that the first digit be 8, the telephone line will be interrupted eight times and relay 37 will momentarily release its armatures a corresponding number of times. Relay 59, however, is slow to release and remains energized throughout the dialing. Upon the first interruption of the telephone line relay 37 becomes deenergized and by means of its contacts *b* completes a circuit through contacts *d* on relay 61, last contact and wiper of the bank C of the selector switch 24, and thence through the upper contacts of relay 59 and winding of relay 62 to the negative side of the source of potential. A parallel branch of this circuit also extends from the wiper of bank C through the lower contacts of relay 59 and winding of the motor magnet M. When the next impulse is received relay 37 again picks up causing magnet M to become deenergized thereby stepping the selector onto its first contact. Relay 62 does not respond because it, too, is slow to deenergize. During the next interruption a circuit is completed through contact *b* of relay 37, upper contacts of relay 62, lower contacts of relay 59 and the motor magnet, the parallel branch also extending through the upper contacts of relay 59 and the winding of relay 62. In this way the motor magnet is operated in accordance with the number of impulses in the first digit thereby stepping the selector to a position corresponding to the number dialed, or in the case assumed to its eighth contact. Relay 62 remains energized throughout the dialing of the digit.

The wiper of bank A is connected to positive potential and all contacts except the first and last of this bank are connected together and through conductor 63 and the lower winding of off normal relay 47 to the negative side of the source of potential. Relay 47 is therefore operated whenever the wiper of bank A engages one of the connected contacts. This relay therefore operates and establishes a holding circuit for itself through its upper winding and lower contacts, conductor 64 and contacts *b* on relay 59. By means of its *a* contacts relay 47 connects conductor 65 of the input channel of the carrier apparatus through conductor 66, contacts *e* on relay 61, conductor 67, condenser 68 and resistance 69 to the buzzer. The buzzer is already energized as previously described. Thus as soon as the selector reached its second position a tone was transmitted to the station being called.

This tone continues during the dialing of the first and second digits which may be dialed in the manner already described. With the connection shown the second digit is zero, whereupon the wipers come to rest upon the seventh contacts of their respective banks. Relay 62 now drops out since its circuit is opened at the contacts *b* of relay 37. A circuit is now completed which extends from the positive side of the source of potential through contacts *b* of relay 59, lower contacts of relay 62, wiper and contact 7 of the bank B, conductor 68, contacts *f* of relay 46, conductor 69, and winding of relay 61 which now operates and establishes a holding circuit for itself through its own contacts *c* and contacts *b* of relay 59. Relay 61, also by means of its contact *f* and right hand contact *e*, alters the tone circuit

previously traced to include contacts on the dialing relay 37 whereby during dialing of the successive digits the tone transmitted to the remote station is interrupted in accordance with the digits dialed. This circuit now extends from the audio channel of the transmitter through conductor 65, contacts *a* on relay 47, conductor 66, right hand contact *e* and contact *f* of relay 61, conductor 70, contacts *b* on relay 29, conductor 71, upper contacts on dialing relay 37 and conductor 67 to the buzzer. Thus the tone transmitted to the called station is interrupted in accordance with any further digits dialed.

It will be observed that during the dialing of the various digits the condenser 27 associated with vacuum tube 25 is kept charged through the lower contacts of relay 37 and a circuit previously traced. The intervals during dialing when relay 37 is operated are not sufficient to permit condenser 27 to discharge. After the dialing of the last digit dialing relay 37 remains energized, since the receiver is still removed from the hook, thereby disconnecting the grid from the source of biasing potential for an indefinite time interval. Since relay 46 is at this time energized the only discharge path for condenser 27 is resistance 28. This resistance is so adjusted that about four seconds is required before the charge on condenser 27 sufficiently leaks off to permit relay 29 to become operated. Thus after the dialing of the last digit the tone continues for about four seconds after which time relay 29 operates and interrupts the tone circuit previously described. It at the same time connects the input conductor 65 of the carrier apparatus to the upper terminal of the right hand winding of transformer 20. This connection may be traced as follows:—conductor 65, contacts *a* on relay 47, right hand contact *e* and contact *f* on relay 61, conductor 70, contacts *a* on relay 29, and resistances 22 to the upper terminal of transformer 20. The system is now in condition for communication.

It will be observed that the lower conductor of each of lines *L*<sub>1</sub> and *L*<sub>2</sub> is still disconnected from positive potential and is connected to the busy bus through conductor 43 and contacts *d* on relays 44 and 46. The lower conductor of line *L*<sub>4</sub>, however, is not so connected but is still connected to positive potential through conductor 50, contacts *b* on relay 46, conductor 64 and contacts *b* on relay 59. Accordingly the operator on line *L*<sub>4</sub> may, by removing the receiver from the hook and thereby operating relay 14, cause the telephone line to be extended to conductors 15 and 17 whereupon this line is connected in parallel with line *L*<sub>3</sub>. The operator on line *L*<sub>4</sub> may, if he so desires, request the use of the equipment.

At the close of the conversation let us assume that the operator on the line *L*<sub>3</sub> is first to replace his receiver on the hook. This operation restores the equipment in the respective station, with the exception of relays 45 and 33 to the normal condition. It might happen, if relays 45 and 33 did not remain in the position to which they are actuated, that the operator at the remote station in replacing his receiver on the hook produces a click which when received by the equipment 2 causes operation of the relay 40, which immediately applies a negative potential to the grid of discharge device 26 through the circuit extending from said grid of discharge device 26, through contacts *e* of relay 58, contacts *b* of relays 44 and 45, contacts *h* of relay 38, contacts *a* of relay 40, contacts *d* of relay 38 and conductor

41 to the bias potentiometer. Relay 33 would then be maintained in its deenergized condition and would connect the lock-out conductor 43 to the busy bus and disconnect it from the source of positive potential for a predetermined time interval. This would unnecessarily lock out lines *L*<sub>1</sub> to *L*<sub>3</sub> and produce annoyance to the operator of line *L*<sub>3</sub> if he wished immediately to make another call. This operation is prevented, however, by relay 45 which is maintained energized by relay 33 through a circuit extending from the negative side of the source of potential through lower winding of relay 45, contacts *c* on relay 45, contacts *a* on relay 33, conductor 83, and contacts *c* on relay 59. Thus after relay 44 deenergizes the lock-out bus is connected through the lower contacts of relay 44, contacts *e* of relay 45, contacts *e* of relay 46, contacts *f* of relay 47, conductor 48 and lower contacts of relay 16 to the source of positive potential. Relay 45, by its lower contacts connects resistance 35 in parallel with resistances 32 and 34 which reduces the required interval for discharge of condenser 31 to about five seconds. After this five second interval relay 33 operates and deenergizes relay 45 which drops out. The system is now in the normal condition.

Now let us assume that the equipment is in its normal condition and a call is received from a remote station. Relay 40 becomes operated and immediately disconnects the grid of device 25 from the source of bias potential and simultaneously connects the grid of device 26 to the bias potentiometer. Relay 33 immediately releases its armatures and disconnects the lower conductor of all the lines *L*<sub>1</sub>, *L*<sub>2</sub>, and *L*<sub>3</sub> from positive potential and connects them to the busy bus. Line *L*<sub>4</sub> however, is not immediately affected. After the necessary time has elapsed to permit operation of relay 29, preferably about one second, this relay operates and closes a circuit extending from positive potential at contacts *g* of relay 18 through conductor 72, lower contacts on relay 29 and winding of relay 38. Relay 38 then operates and connects contacts *a* of relay 40 through contacts *c* and *g* of relay 38, conductors 73, contacts *b* and *d* of relay 18, conductors 17 and windings of relay 37 to the opposite sides of the source of potential. Relay 37 thus becomes energized and subsequently follows the operation of relay 40.

The operation of the selector during the reception of the first digit is the same as previously described in connection with the transmission of a call. A holding circuit for relay 38, however, is established upon operation of relay 59, this circuit extending from the positive side of the source of potential through contacts *b* of relay 59, conductor 64, and lower contacts of relay 38, and the winding thereof, to the negative side of the source of potential.

Let us assume that the first digit is 9. Relay 61 becomes operated upon completion of the first digit. This circuit extends from the source of positive potential through contacts *b* of relay 59, lower contacts of relay 62, wiper and ninth contact of bank B, conductor 74, contacts *g* on relay 46, conductor 69 and winding of relay 61. Relay 61 operates and completes a holding circuit through its contacts *c* and contacts *b* of relay 59.

Off-normal relay 47 became operated from bank A when the wiper reached its second contact and interrupted at its contacts *f* the previously traced circuit from the lower side of *L*<sub>4</sub>

to positive potential, and at its contacts *e* it applied the busy signal to this line. This relay also completes a holding circuit for itself through its lower contacts, conductor 64, and contact *b* of relay 59, and at its contacts *c* energizes the buzzer.

With the connections shown the second digit is 6, 7, 8, or 9. At the end of the digit, if the digit be, for example, 8, the wipers come to rest upon the sixth contact of the respective banks and relay 62 drops out. Soon thereafter the tone is permanently interrupted at the remote station and relays 40 and 37 drop out. A circuit is then completed from the positive side of the source of potential through contacts *b* of relay 37, contacts *b* of relay 62, contacts *a* on relay 61, conductor 75, contacts *e* on relay 38, conductor 76, wiper and sixth contact of the bank D, and upper winding of relay 13. Relay 13 operates and extends the above-traced circuit through its contacts *c*, contacts *d* on relay 49, contacts *a* on relays 16 and 49, conductor 76, and winding of relay 58 to the negative side of the source of potential. Relay 58 then operates and connects the input of the transmitter to the buzzer through conductor 65, contacts *c* on relay 58, condenser 68 and resistance 69. Relay 58 also by means of its contacts *d* energizes relay 54 which in turn operates and energizes the carrier current equipment.

This operation causes a buzzer signal to be sent to the calling station informing the operator that his call has been received. At its upper contacts relay 58 applied alternating energization to audio amplifier 80 of the audio channel of the transmitter. The buzzer signal is thus modulated onto this alternating energizing current and transmitted to the remote station.

When relay 37 drops out it deenergizes relay 59 which subsequently drops out and at its contacts *b* breaks the holding circuit for relay 61 which drops out. Relay 59 also at its contacts *c* establishes a buzzer circuit for the motor magnet M through contacts *b* of relay 61. The selector now restores itself to normal whereupon the off-normal relay 47 drops out.

At contacts *e* relay 58 interrupts the circuit between the grid of discharge device 26 and the bias potentiometer 42 thereby permitting the condenser 31 to start discharging through resistance 32. At this time resistances 34 and 35 are disconnected from resistance 32. Relay 58 by means of its lower contacts also establishes a new holding circuit for relay 16 through conductor 77. Relay 58 at its contacts *f* also establishes a holding circuit both for itself and for relay 13. The circuit of the windings of both of these relays was previously traced through the contacts *d* of relay 49, from which point the holding circuit for these relays now extends through conductor 78, contacts *f* on relay 58, and contacts *b* on relay 33. This latter relay is now in its deenergized condition because of the charge in condenser 31. A ringing circuit is now established which extends from the source of positive potential at contacts *d* of relay 47, which is now deenergized, through said contacts *d*, conductor 79, source of ringing current 80, contacts *g* on relay 16, left hand conductor 15, contacts *d* on relay 13, thence through the upper side of the line, ringer 9 and condenser 10 of the telephone instrument, lower side of the line, contacts *f* of relay 13, contacts *c* on relays 16 and 49, and the lower winding of the latter relay, to the negative side of the source of potential. Only alternating current flows in this circuit by reason of

the condenser 10, and relay 49 does not respond to alternating current because of its construction. The ringer 9, however, of the telephone instrument is operated.

The lower sides of all the other telephone lines are, in this condition, disconnected from the positive potential and connected to the busy bus. The circuit from the lower side of line L<sub>1</sub> may be traced through conductor 50, through contacts *c* of relay 46 and contacts *f* of relay 47, conductor 48, and contacts *i* on relay 16, to the busy bus, and the circuit from the lower side of lines L<sub>1</sub> and L<sub>2</sub> may be traced through conductor 43, contacts *d* on relay 44, contacts *e* on relay 46 and contact *f* on relay 47, conductor 48, contacts *i* on relay 16 to the busy bus. Accordingly all lines including line L<sub>4</sub> are locked out during reception of the call and are prevented from interfering with the reception of the call.

If the call be answered by the operator removing the receiver 6 from its hook, while the bell is ringing, the direct current circuit is then completed through the lower winding of relay 49 and this relay becomes operated sufficiently to close its contacts *b*, thereby completing a circuit through its upper winding and contacts *g* of relay 18 whereby it becomes operated completely. By means of its contacts *c* relay 49 breaks the circuit through the telephone line, and by means of its contact *e* it establishes a new holding circuit for relay 13. It, at the same time, breaks the holding circuit for relay 58 which now drops out. The energization of relay 54, however, is maintained by contacts *a* of relay 46.

Relay 58, by means of its contacts *b*, energizes the audio amplifier with direct current. By means of its contacts *c* it interrupts the tone transmitting circuit. By means of its contact *e* it again connects the grid of tube 26 to the source of negative potential, and by means of its contacts *g* it opens the holding circuit for relay 16.

Relay 16 drops out and establishes an energizing circuit for relay 18 through its contacts *f* and contacts *b* of relay 13. Relay 18 now becomes energized and extends the audio channel of the transmitting apparatus from transformer 20 through conductors 19, conductors 17, and conductors 15 to the telephone line. A conversation may now be carried on.

During the conversation lines L<sub>1</sub> and L<sub>2</sub> are maintained in the locked out condition, their lower conductors being connected through conductor 43, contacts *d* on relays 44 and 46 to the busy bus. Line L<sub>4</sub>, however, now has access to the equipment since its lower conductor is connected to positive potential through conductor 50, contacts *b* on relay 46, conductor 64 and contacts *b* on relay 59. Accordingly, if the operator on this line desires immediate use of the apparatus he may lift the receiver from the hook and request such use from the conversing parties.

In the event that the call is not answered while the bell is ringing, the ring will be interrupted after a predetermined interval, for example, 30 seconds, determined by condenser 31 and resistance 32. This is by reason of the fact that after condenser 31 has become sufficiently discharged to permit relay 33 to operate it opens at its contacts *b* the holding circuits for relays 58 and 13 and simultaneously deenergizes the buzzer. Relay 58, in releasing, at its lower contacts interrupts the holding circuit for relay 16 which also releases and the apparatus, with the exception of relay 44, is therefore restored to the normal condition.

Relay 44 remains energized after interruption of the ringing current if the call is not answered, the holding circuit extending through its contacts *c* and contacts *d* on relay 45. The purpose of this is to permit the called party to answer at any later time irrespective of the position of relay 33. This relay 44 in its energized condition connects all of the lines having non-preferential service to positive potential through conductor 43, contacts *d* on relay 44, contacts *e* on relay 46, contacts *f* on relay 47, conductor 48 and lower contacts of relay 16. Thus the called party may, after the bell stops ringing, answer by removing his receiver from the hook. This prevents the called party from being locked out after the bell stops ringing by any sound which is received in the receiver of the equipment 2 which may cause operation of relays 40 and hence relay 33.

Electron discharge device 26 performs a further function in that it causes all lines *L*<sub>1</sub>, *L*<sub>2</sub>, *L*<sub>3</sub> not having preferential service to be locked out during conversations between remote stations 3, 4. Relay 40 is, of course, intermittently energized during conversation between remote stations and accordingly intermittently applies negative potential to the grid of device 26. This causes immediate deenergization of relay 33, which, at contacts *c*, removes positive potential from these lines and at contacts *d* applies buzzer signal thereto. The buzzer is energized through contacts *b*. After termination of the conversation, or during sufficiently long pauses therein, when, of course, in single frequency systems as above mentioned, no carrier is impressed on the line, the charge leaks out of condenser 31 through resistances 32 and 35, which are now connected in parallel, and thus relay 33 operates and removes the lock out condition. In this case the lock out period is desirably about 10 seconds and, hence, greater than the pauses normally occurring during conversation.

Resistances 22 and 85 comprise an attenuation network which is connected in the audio channel of the equipment during communication with certain lines having less attenuation than other of the lines. For example, lines *L*<sub>2</sub>, *L*<sub>3</sub>, and *L*<sub>4</sub> may be short relative to line *L*<sub>1</sub>. Accordingly during communication over these lines the attenuation network 22, 85 is inserted in the audio channel and is proportioned to equalize the signal intensities received from all of the lines. This is effected by relay 86, which is energized in response to relay 12, 13, or 14 over an obvious circuit.

While I have shown a particular embodiment of my invention it will of course be understood that I do not wish to be limited thereto since different modifications may be made and that I contemplate by the appended claims to cover any such modifications as fall within the true spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States, is:

1. The combination, in a system for carrier current intercommunication by voice between a plurality of stations arranged to intercommunicate by carrier current and for interruption in the transmitted carrier during pauses in said voice communication, the combination of an operator's station connected to one of said carrier current stations, means whereby an operator at said operator's station may signal a remote carrier station through said one carrier station, means responsive to currents received in said one

carrier current station to disable said signal means during intercommunication between two of said carrier stations, and means to maintain said signal means disabled for a predetermined interval subsequent to reception of said currents at said one carrier current station, said predetermined interval being of greater duration than the normal pauses in said voice communication.

2. The combination, in a system for carrier current intercommunication by voice between a plurality of stations arranged to intercommunicate by carrier currents of a single frequency and for interruption of the transmitted carrier during pauses in said voice communication, of an operator's station connected to one of said carrier current stations, and means whereby an operator at said operator's station may signal a remote carrier station through said one carrier station, means to signal and to communicate by voice between two remote carrier stations, means continuously to disable said first means during voice communication between said remote stations, notwithstanding said interruptions in the transmitted carrier occurring during normal pauses in said voice communication.

3. In combination, a plurality of carrier current stations arranged for intercommunication, a plurality of operators' stations connected with one of said carrier current stations, means to transmit a call through said one carrier current station to an operator's station from another of said carrier stations, means subsequently to communicate between the calling and called stations, and means to prevent an operator at another of said operators' stations from interfering with said call by any operations performed at said other operator's station during reception of said call and means to enable said operator to join in said communication solely by effecting an operation normally performed in calling when other stations are not in use.

4. In combination, a plurality of carrier current stations arranged for intercommunication, a plurality of operators' stations connected with one of said carrier current stations, means to transmit a call through said one carrier current station to one of said operator's stations from another of said carrier stations, means subsequently to communicate between the calling and called stations, means to prevent an operator at a second of said operator's stations from interfering with said call and communication by any operation performed at said second operator's station during said call and communication, and means to enable an operator at a third of said operator's stations to join in said communication solely by effecting an operation normally performed in calling from said third station when other stations are not in use.

5. In combination, a plurality of carrier current stations arranged for intercommunication, an operator's station connected with one of said carrier current stations, means to signal said operator's station in response to currents received from another carrier station through said one carrier station, means to transmit a signal from said one carrier station to said other carrier station during transmission of said signal to the signaled operator's station in response to currents received from said other carrier station and means at said one station to interrupt transmission of said signal to said other carrier station after a predetermined interval or when said signal is answered in said operator's station if said signal be answered within said predetermined interval.

6. In combination, a number of intercommunicating carrier stations greater than two, an operator's station connected with one of said carrier stations, means to transmit signaling current to said operator's station in response to signals received from a remote station, means including a time delay relay to interrupt said signaling current after a predetermined interval, and means for rendering said time delay relay responsive to currents received in said one station during intercommunication between other of said stations to disable said operator's station.

7. In combination, a number of intercommunicating carrier stations greater than two, an operator's station connected with one of said carrier stations, means to transmit a signaling current to said operator's station in response to signals received from a remote station, means including a time delay relay to interrupt said signaling current after a predetermined interval, means for rendering said time delay relay responsive to currents received in said one station during intercommunication between other of said stations to disable said operator's station for a predetermined time interval, and means whereby said last time interval is different from said first mentioned predetermined time interval.

8. In combination, three or more carrier current stations arranged for intercommunication, an operator's station connected to one of said stations, means responsive to current received from another station to disable said operator's station, and means to disable said last means for a predetermined time interval subsequent to operation of said operator's station.

9. In combination, three or more carrier current stations arranged for intercommunication, a telephone station connected to one of said carrier current stations, means to communicate between said telephone station and a remote carrier station through said one carrier station, means to disable said telephone station during intercommunication between carrier stations other than said one, and means to disable said last means for a predetermined time interval subsequent to interruption of communication with said telephone station.

10. In combination, a plurality of carrier current stations arranged for intercommunication, an operator's station connected to one of said stations, timing means at said one carrier current station responsive to signal current received from another carrier current station to prevent an operator at said operator's station from transmitting signals through said one station for a predetermined interval, means in said one car-

rier current station responsive to current received from another carrier current station to transmit calling current to said operator's station, and means utilizing said timing means to interrupt said calling current after a predetermined interval.

11. In combination, a plurality of carrier stations arranged for intercommunication, an operator's station connected to one of said carrier current stations, and means whereby an operator at said operator's station may signal a remote carrier station through said one carrier station, means responsive to current received in said one carrier station to disable said signaling means for a predetermined interval, and means to disable said current responsive means for a predetermined interval subsequent to signaling between said operator's station and a remote carrier station.

12. In combination, a plurality of carrier current stations arranged for intercommunication, an operator's station connected to one of said carrier current stations to call a different carrier station therethrough and to communicate therethrough with said different station, means responsive to currents received in said one carrier station to prevent calling by said operator's station, and means operative for a predetermined interval subsequent to communication between said operator's station and a remote carrier station to condition said one carrier current station to transmit a call therethrough from said operator's station notwithstanding that currents are received during said interval in said one carrier station from a remote carrier station.

13. In combination, a plurality of carrier current stations arranged for intercommunication, each of said stations including a telephone instrument, means to signal other stations, a switch operated to initiate and terminate signaling between said stations, means whereby operation of said switch causes currents to be transmitted to other stations, means in each station responsive to currents received therein from another station to disable said signaling means of the respective station, and means in each station operative to prevent said last means from disabling said signal means for a predetermined interval following operation of said switch in the respective station to terminate signaling between said station and another station, whereby said signaling means is not disabled by currents received in said station due to operation of said switch at said other station during said predetermined interval.

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