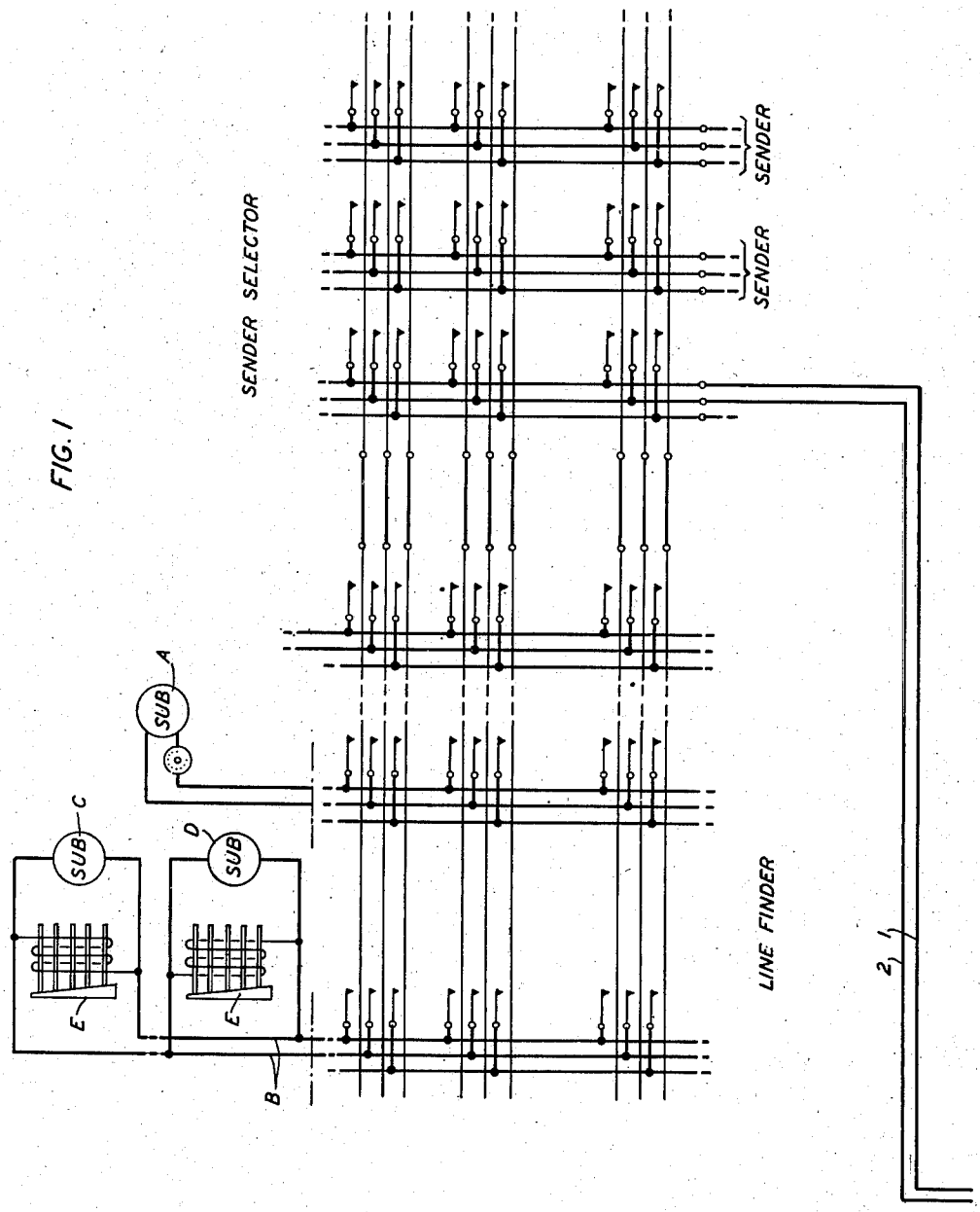
Oct. 23, 1945. A. A. LUNDSTROM 2,387,671

ALTERNATING CURRENT SIGNAL RECEIVER

Filed Oct. 20, 1942 2 Sheets-Sheet 1

FIG. 1



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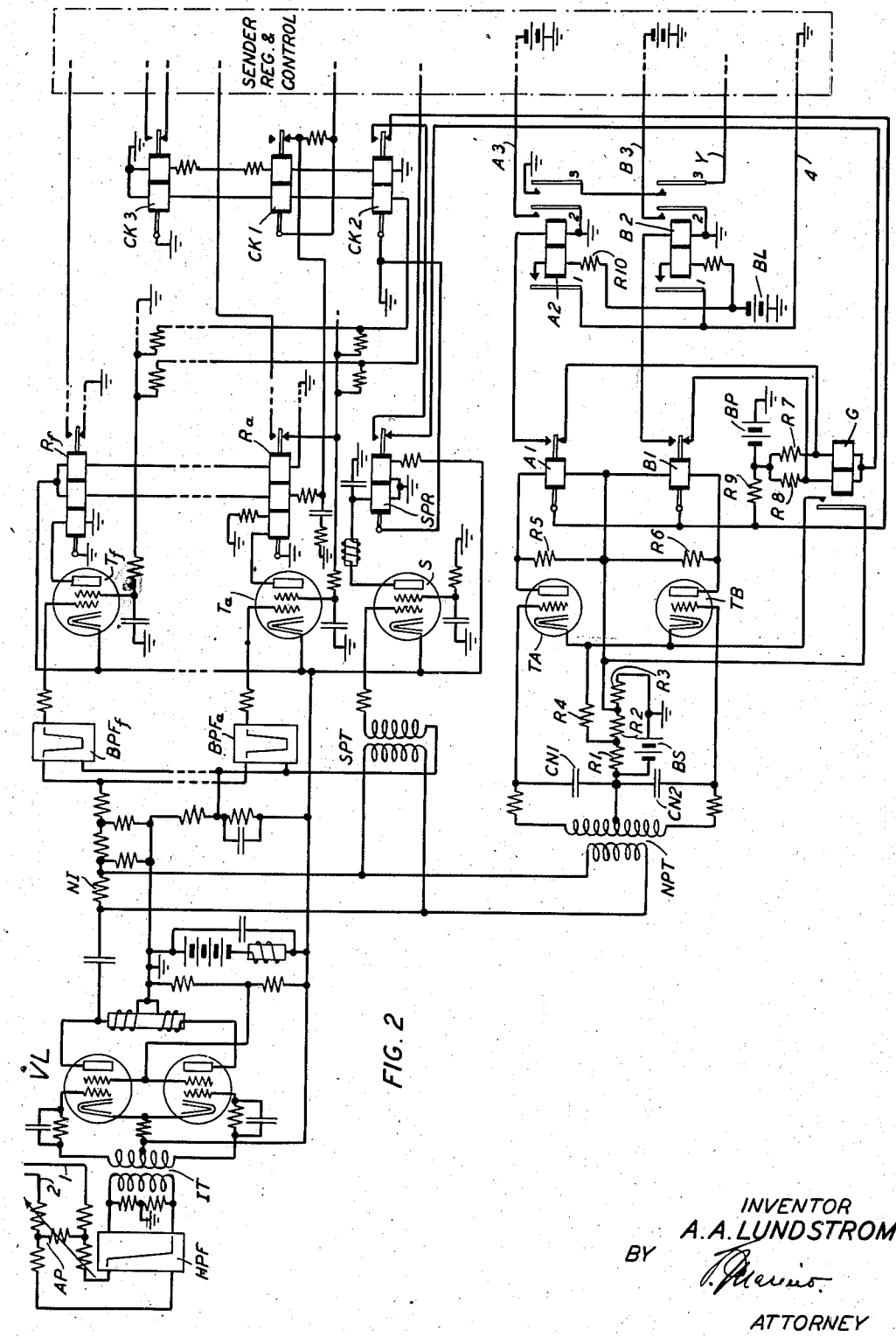

FIG. 2

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UNITED STATES PATENT OFFICE

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ALTERNATING CURRENT SIGNAL RECEIVER

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Application October 20, 1942, Serial No. 462,706

4 Claims. (Cl. 179—17)

This invention relates to signal receivers and more particularly to an alternating current signal receiver of the type disclosed in Patent No. 2,332,912, issued on October 26, 1943 to Messrs. G. Hecht, A. A. Lundstrom and E. R. Taylor. A broad object of the invention is to include in a receiver of the type mentioned and when utilized for receiving alternating current signal impulses from automatic telephone stations, means responsive to the first half cycle of succeeding incoming pulses to discriminate between noise-induced pulses and pulses generated at the station and, also, to identify each of two party stations bridged across the same pair of line conductors.

The receiver to which the present invention is adapted as an improvement thereon comprises a plurality of signal channels each responsive to a particular frequency in the signal frequency band and a "signal present" channel which is responsive to all frequencies within the band as well as those outside of the band. The latter channel, when activated, conditions for operation a register which is settable in response to the operation of two of the various signal channels when the same respond to pulses made up of two signal frequencies according to a code, the register ignoring any pulse of one frequency as having been produced by noise rather than by the manipulation of the signal producing instrument, and closing the circuit of a suitable alarm for a received pulse of more than two frequencies, the alarm, in the latter case, being intended to call attention to the fact that the signal producing instrument probably has been incorrectly manipulated as, for instance, by pressing two keys at one time, since the production of more than two frequencies is more likely to arise from this cause rather than from any other.

The receiver, as disclosed in the above-mentioned patent, is part of a complex circuit organization called the sender used in telephone switching systems for registering wanted designations and for selectively positioning switching apparatus in response thereto. The sender, in turn, is part of an automatic telephone system wherein a calling line is extended to an operator's position from which it is further extended to a wanted line in other offices through the utilization thereat of a free sender which is set by the coded plural frequency pulses designating the wanted member and, in response to the setting, selectively positions a selector train to reach that line. The device for generating these pulses, which is located at the operator's position, comprises a plurality of digit keys, the individual keys of which are connected, on the one hand, to suitable sources of signal frequencies and, on the one hand, to the line conductors over which, upon the closure of any key, the required number of signal frequencies sources are momentarily applied to the line. The receiver in the sender connected at the remote end of the line completes the circuit of the several signal currents and responds thereto with effects already noted. The transmitting keys are not, ordinarily, exposed to noise and, therefore, are protected only against such noise as might occur, for instance, at the contact of the switch train over which the connection is established or at the contacts of the keys themselves.

In seeking to apply such a receiver to a sender for use in a telephone system in which the alternating current pulses of a wanted designation are generated by a device at a subscriber's station rather than at one operator's position, great care must be exercised to guard the receiver against responding to noise generated currents inasmuch as the transmitter of the telephone set, being connected to the line at the same time as the receiver, and being exposed to the immediate surroundings, will pick up whatever sounds are present, which sounds, in affecting its diaphragm, will produce noise currents within the frequencies to which the receiver is adapted respond. Safeguards against such false operations are usually provided for either through a manually operated key which disconnects the transmitter from the line during pulsing operations or through a rectifying device in series with the transmitter which offers a very high loss to the noise generated currents.

Where the central office must be arranged for duplex operation, that is, for using common equipment to serve new lines equipped with devices for producing alternating current pulses and old lines equipped with a dial for producing direct current pulses, the problem of discriminating against noise currents becomes greater. While the lines equipped for keying alternating current pulses are protected by rectifying devices against the generation and transmission of noise currents, the older dial lines, having no such or equivalent devices, have no such protection. Since the sender must serve both types of lines indiscriminately, the receiver part of the sender may be exposed to false operation when the sender becomes connected to a dial equipped line since the sender, at the time of such connection, has no way of determining whether the line to which it is connected is a dial equipped line or

a key equipped line. It is possible, of course, to provide each dial line with a rectifying network for the protection of the receiver, but the multiplying factor for such a network would make the cost prohibitive in comparison with the cost of providing adequate safeguards in the receiver itself, since there are less receivers than lines.

One of the objects of the present invention, therefore, is an alternating current receiver for use in a sender adapted for the selective positioning of a train of switches, which shall be capable of discriminating between a calling dial line and a calling key line through the recognition of the polarity of the first half cycle of the pulses produced by the calling key line.

It is another object of this invention to produce a receiver which shall be capable of discriminating between each of two party stations equipped with keying devices, through the recognition of the polarity of the first half cycle of the first pulse produced by the station originating the call.

These and other objects of the invention may be more clearly ascertained from the following description, appended claims and attached drawings in which:

Fig. 1 shows two telephone lines, line A equipped with the usual dial and line B with party stations C and D connected thereto each having alternating current generating devices E. Both lines are shown as capable of connection in the known manner through crossbar switching facilities to a sender selector through which an idle sender becomes connected to the calling line. Inasmuch as the extension of a calling line to an available sender through crossbar switches (or other types of switches) is old in the art and forms no part of this invention, the same is only conventionally indicated;

Fig. 2 shows parts of the receiver disclosed in the G. Hecht et al. patent as modified to include the elements which constitute the present invention.

The alternating current generating device E with which stations C and D are provided is of the type disclosed in Patent 2,147,710 issued to R. F. Mallina on February 21, 1939 but is provided with an additional or sixth reed. The six reeds are disposed between the poles of a permanent magnet, each of the reeds having a natural period of vibration equal to the periodicity of one of the six signal frequencies which, for convenience, may be designated *a*—*f*. Surrounding the reeds is a coil which is connected to the line conductors, and a key-set having ten digit keys is so mounted with respect to the reeds that the depression of any key will pluck two of the reeds and set them into vibration within the field of the magnet thereby generating in the coil currents each having a frequency determined by the natural period of one of the reeds. The depression of different keys will, of course, result in the plucking of different reeds according to a prearranged code so that each digit will be indicated by a pulse of two distinct frequencies. The polarity of the first half cycle of the current produced by the depression of any key will be determined, of course, by the manner in which the coil of the devices E are connected to the line. Where they are connected in the same sense, the polarity of the first cycle of the current produced by each device will be the same, that is, either both positive or both negative. Where they are connected in the opposite sense, the polarity of the first half cycle of each current will be opposite. Since, in the present invention, it is contempleted that the receiver shall recognize the identity of each of two party stations equipped to produce plural frequency pulses by the polarity of the first half cycle of the first pulse generated, the coil of device E for station C is connected across the line opposite to that of device E for station D.

Referring, now, more particularly to Fig. 2, there is shown the volume limiter VL which, on the input side is coupled to the preceding high pass filter HPF connected to the manually adjustable pad AP and, on the output side, to the receiving channels indicated by the vacuum tubes T*a*—T*f*, each channel being reserved for response to the frequency designated by the subscript designation of the tube of that channel. Tapped across the resistance NI is the primary winding of transformer SPT to the secondary winding of which is connected to the grid of the vacuum tube S of the "signal present" channel. All of these elements of the circuit are the same as those disclosed in the above-mentioned patent to G. Hecht et al. and have been herein similarly designated as, also, have been similarly designated the elements shown connected to the signal channel tubes T*a*—T*f* except that the connections to the contacts of the check polarized relay CK2 and the signal present relay SPR have been slightly changed for operation with the present invention.

In parallel with the primary winding of transformer SPT is the primary winding of transformer NPT. This transformer has two secondary windings connected in series, and to the mid-point thereof is connected the negative pole of the battery supply BS, as is also connected the common terminal of condensers CN1 and CN2 and the potentiometer resistors R1, R2 and R3. The upper terminal of the series connected transformer windings is connected over an undesignated resistor to the grid of gas-filled tube TA while the lower terminal is similarly connected, also through an undesignated resistor, to the grid of gas-filled tube TB.

The anode of tube TA is connected in parallel to the winding of polarized relay A1 and to resistor R5 while the anode of tube TB is connected in parallel to the winding of polarized relay B1 and resistor R6, all of said resistors and relays being joined together and to the common terminal of potentiometer resistors R2 and R3 whence is obtained the positive potential derived from battery BS to operate the tubes TA and TB and the relays A1 and B1 as hereinafter described.

The armatures of relays A1 and B1 obtain ground through the armature and lower contact of relay CK2, and this ground is normally connected to the two windings of the relay G via the lower contacts of relays A1 and B1. Inasmuch as the common terminal of the two windings of relay G is grounded via the armature and lower contact of the "signal present" relay SPR, relay G is normally short-circuited, the battery BP for supplying current to the windings of said relay G having a path to ground through resistors R7 and R8 and the aforesaid lower contacts of relays A1 and B1.

Relays A2 and B2 are local relays operating over the front contacts of relays A1 and B1, respectively, and when either of the latter relays operates, it connects ground to an individual conductor which extends to a relay in the register. Since, as will be shown shortly, re-

lay A2 signifies that party C calling and relay B2 signifies that party D is calling, it is obvious that when either relay operates to operate its locally controlled relay in the register, said register is informed of the party identification of the calling line.

Having described the component elements of the circuit of my invention its mode of operation will now be described.

Assume, first, that the office is arranged for duplex operation and that, therefore, lines typified by dial line A and party line B are both to be served by the same central office equipment. Now let it be assumed that station C of line B initiates a call by removing the receiver from the hook and that, in consequence, the line is extended over the line finder switches and sender selector switches to an idle sender, designated at the selector by conductors 1 and 2 and that portion of its equipment shown in Fig. 2. By means of well-known operations, the sender then proceeds to transmit a tone over the calling loop to indicate to the calling station that the wanted number may be keyed (or dialed).

It will be remembered that, in the case of two party stations, the magnetizing coils of the signal generating instruments E are oppositely connected to the line for each station so that the operation of a key in each instrument will cause the production of an alternating current of opposite polarity to that produced by the other. That is, if we assume that the coil of device E at station D is wired so that the operation of a key of the device will generate a current having a positive first lobe, then the coil of device E at station C is wired so that the operation of a key of the latter device will generate a current having a negative first lobe. We may now assume for simplicity that the energizing coils of both devices E are so wired that the depression of a key of device E at station C produces a current which consists of two superimposed frequencies (depending upon the code used) within the signal frequency band each of which has a first negative lobe. Since the circuit is completed over conductors 1 and 2 through the primary winding of transformer IT, the signal voltage is induced in the secondary winding of said transformer and applied to the grids of the tubes of the volume limiter VL whence, according to the teachings of the above-mentioned G. Hecht et al. patent, the signal energy is amplified (or reduced if its intensity is above the ceiling of the limiter), and applied to the channel filters BPF_A—BPF_F whence it is directed through the filters tuned to the frequencies in the signal pulse to cause the operation of the corresponding signal channels.

The portion of the signal voltage which is available across resistor N1 is applied to the primary winding of transformer SPT of the "signal present" channel and to the primary winding of transformer NPT. The former results in the operation of the tube S and relay SPR while the latter results in the operation of either tube TA or tube TB depending upon the polarity of the first half cycle of the incoming pulse. If the polarity of the first half cycle is negative (as assumed), the voltage induced in the secondary of transformer NPT will be of opposite polarity so that the voltage thereof will be positive at the upper terminal of the secondary windings and negative at the lower terminal. This positive voltage is applied to the grid of tube TA, overcomes the negative bias thereat from battery BS over the upper winding of the transformer, and renders the voltage on the grid sufficiently positive to fire the tube. In consequence, a flow of current is then established over the path extending from the positive pole of battery BS, resistor R3, winding of relay A1 and paralleled resistor R5, the cathode-anode space path within tube TA, resistor R4, resistor R1 to the negative pole of battery BS. The firing of tube TA and the current flowing in consequence thereof through the above-traced circuit immediately causes a high negative bias to be applied to the grids of both tubes TA and TB over the relatively high resistance R4 which is located in the common anode and grid circuit path. The establishment of this high negative bias locks out tube TB since any positive potential which may be thereafter applied to the grid thereof will not be sufficient to overcome the bias so that, for any particular signal pulse, one and only one of the two tubes TA and TB can be fired.

The current flowing through the winding of relay A1 will cause its operation, the parallel path through resistor R5 being provided merely to insure the fast establishment of the above-mentioned lock-out negative bias.

In the same manner, when station D initiates a call and a key of the device E thereat is depressed, then, since the magnetizing coil of this device is connected to the line oppositely from that of the device at station C, the first half cycle of the generated current will be positive, in consequence of which a positive potential is induced at the lower terminal of the secondary winding of transformer NPT and tube TB is caused to fire in the same manner as already described for tube TA.

Up to this point any signal of a frequency above the cut-off frequency of band-pass filter HPF and of sufficient magnitude will cause the operation of either relay A1 or B1 depending upon the initial polarity of the first received pulse. From hereon, however, the operation of the circuit depends largely on the reactions of the receiver as determined by the operation of relays SPR, CK2 and CK3, relay SPR operating upon any frequency passing through the limiter VL, relay CK2 operating when any received pulse contains two signal frequencies, and relay CK3 operating when any received pulse contains three or more signal frequencies. With these relay operations in mind four circuit reactions are possible.

The first reaction is that the received pulse may be of such a short duration that none of the above relays will operate. The pulse, however, can never be short enough to prevent the firing of tube TA or TB and the operation of their respectively associated relays A1 and B1 since the pulse need be only a fractional part of a half cycle to alter the potential on the grid of either tube. It will be observed that with relay SPR normal and relays A1 and B1 also normal, relay G is maintained short-circuited. However, upon the operation of either relay A1 or B1, short-circuiting ground removed from resistor R7 or R8, causes relay G to operate on the winding in series with the resistor R— from which the short circuit has been removed. For example, if relay A1 is operated, ground is disconnected from resistor R7 and a circuit is completed for relay G extending from battery BP, resistor R7, right winding of relay G, armature and lower contact of relay SPR to ground. On the other hand, if relay B1 is operated, ground is disconnected

from resistor R8 and relay G will then operate through its left winding over an easily traceable circuit. The operation of relay G short-circuits the potential applied between the anode and cathode of both tubes TA and TB, causing whichever one is conducting to become extinguished, in turn causing the release of its locally operated relay A1 or B1. Thus, if the pulse is too short to operate relay SPR, the circuit is returned to normal without registering any party designation. In other words, a signal which does not operate the "signal present" channel of the receiver but does fire either tube TA or TB of the polarity detector is ignored.

The second condition to be noted is that which results in the operation of relay SPR but not of relays CK2 or CK3. This results from a signal impulse which, though of sufficient duration, has but one frequency. For this condition, the operation of relay SPR merely delays, for the duration of the signal pulse, the operation of relay G, at which time the operation of the latter relay causes the conducting tube TA or TB to be restored as above described. This delay is desirable because it keeps the operated tube in a conducting state for the duration of the particular signal pulse pending the possibility of an operation of two or more signal channels T*a*—T*f*. However, should two or more of these channels fail to operate, relay G will operate upon the release of relay SPR and restore the ignited tube to normal.

The third condition to be noted is that which results in the operation of relay SPR and relay CK2. This is the normal condition responsive to a pulse of sufficient duration and composed of two frequencies since each digit or character transmitted from the calling station is assumed to be represented by a combination of two out of the six signal frequencies *a*—*f* to which the signal channels T*a*—T*f* are respectively adapted to respond. If two of the channels T*a*—T*f* are operated, then, according to the teaching of the abovementioned G. Hecht et al., patent, relay CK2 is operated. Remembering that relay A1 is operated (or relay B1 if the call is initiated by station D), then, since the operation of relay CK2 disconnects ground from its lower contact, a circuit is completed for relay A2 which extends from ground through the right winding of relay A2, upper contact and armature of relay A1, resistor R9, to battery BP. Relay A2 operates, extends ground over its No. 2 contacts and conductor A3 to a relay (not shown) in the register which operates to record the fact that party C is making the call, and completes a locking circuit for itself from battery BL, through resistor R10, No. 1 contacts, conductor 4 to off-normal ground in the register, said off-normal ground being applied to said conductor by the register when the latter has registered the character or digit designation indicated by the two operated signal channels T*a*—T*f*.

When the first signal pulse has terminated, relays SPR and CK2 release and since relay A1 is still operated, relay G is now operated in the manner described to cause the extinguishing of tube TA. Relay A2, however, remains locked for the duration of the signaling period, that is, during the transmission of the remaining signal pulses from station C. These signal pulses will, of course, cause tube TA to be refired and extinguished with each pulse, cause relay A1 alternating to operate and release and thereby cause battery BP alternately to be applied to and disconnected from the right winding of relay A2. However, since this relay is locked up under the control of the register, no further action takes place since the register has noted the party registration as party C by virtue of the ground applied to conductor A3.

The condition above noted for operating two signal channels and the "signal present" channel may be equally satisfied by speech or noise currents if the latter contain any two of the signal frequencies. The circuit, however, discriminates between noise and actual signal operation by the fact that the signals, originating at station C, comprise a series of alternating current pulses all of whose first half cycles have identical polarity. Since the probability of the noise or speech pulses of just two frequencies having identical polarity is extremely small while that of having some of the pulses of one polarity and other pulses of opposite polarity is extremely high, the noise pulses will cause the operation of both tubes TA and TB (after each tube is extinguished by relay G subsequent to its operation) and the consequent operation of relays A2 and B2 in the manner described. The operated condition of relays A2 and B2 causes ground to be applied to conductor Y which extends to a circuit (not shown) in the register to inform the latter that the receiver has operated on speech or noise currents. Since no speech or noise currents are possible from stations transmitting alternating current impulses because their transmitters are appropriately guarded by rectifiers or other circuit or mechanical means, the elements which operated both branches of the polarity detector could only have come from a telephone line using a dial such as station A since the transmitter of such a line is not guarded against noise or speech pick-up. Under these circumstances, ground on conductor Y informs the register that the calling line is a dial rather than a key line and proceeds in a manner not herein shown to remove the alternating current receiver portion of the sender from conductors 1—2 and to replace it by the direct current pulsing relay for response to the forthcoming dial pulses.

The fourth condition to be noted is that which results from the operation of relays SPR, CK2 and CK3, which occurs when three or more signal channels are operated as a result of the inadvertent displacement of two keys of the keyset associated with the device E or if transmitter currents due to speech or noise are on the line. The operation of relay CK3 indicates the abnormal condition of three or more simultaneous channel operations. As described in the abovementioned patent, the operation of relay CK3 immediately causes "recorder" tone to be furnished to calling subscriber. Since these operations and the means for carrying them out form no part of this invention, the same are neither shown nor described herein.

In the duplex area, if dial pulses appear first at the sender, it is recognized immediately by virtue of the operation of the pulsing relay as a dial phone and the alternating current receiver equipment is then immediately removed and information received via the pulsing relay is used for switching operations.

What is claimed is:

1. A polarity detector for the first half cycle of an alternating current wave comprising two gas-filled electronic devices, each of said devices including a grid, a cathode and an anode, a source of potential connected in parallel between the

cathode and anode of each device, a power transfer device serially connected between the grids of said two devices, means responsive to an alternating current wave applied to said power transfer device for rendering the grid of one of said devices positive with respect to the potential of the cathode thereof whereby said device is rendered conducting, means responsive to the conductivity of said device for applying a high negative bias to the grid of said other device whereby the resultant potential on said grid due to the application of a positive half cycle to the power transfer device remains relatively negative so as to render said other device unresponsive to said positive half cycle, and a relay in the anode circuit of each device responsive to the flow of current therethrough for short-circuiting the anode potential to said device whereby the latter is restored to its original responsive condition.

2. A circuit for response to plural frequency alternating current pulses comprising in combination a channel adapted for response to each frequency in the pulse, and a channel adapted for response to the first half cycle of each pulse, a register settable in response to the operation of said frequency-responding channels, and means responsive to the operation of said last-mentioned channel in response to two pulses each of whose first half cycles are of opposite polarity for transmitting a signal to said register.

3. In a telephone system, the combination with a plurality of lines, some of which are equipped with a dial device to transmit direct current pulses when calling and others are equipped with alternating current generators for producing plural frequency pulses indicative of wanted line designations when calling, of a sender comprising an alternating current receiver having a channel adapted for response to each frequency in a pulse and a channel adapted for response to the first half cycle of each pulse, and means responsive to the operation of said last-mentioned channel in response to two pulses each of whose first half cycle is of opposite polarity for indicating to the sender that the calling line is equipped with a dial and not with an alternating current generator.

4. In a telephone system, the combination of a two-party station line, each of the stations on said line being equipped with an alternating current generator for producing plural frequency pulses indicative of wanted line designations when calling, the field winding of each of said generators being oppositely connected to said line, of a sender comprising an alternating current receiver having a channel adapted for response to each frequency in a pulse, and a channel adapted for response to the first positive or negative half cycle of a pulse, whereby the operation of said last-mentioned channel in response to either a positive or negative first half cycle indicates the station on said line from which the call has originated.

ALEXIS A. LUNDSTROM.