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TELEPHONE SYSTEM

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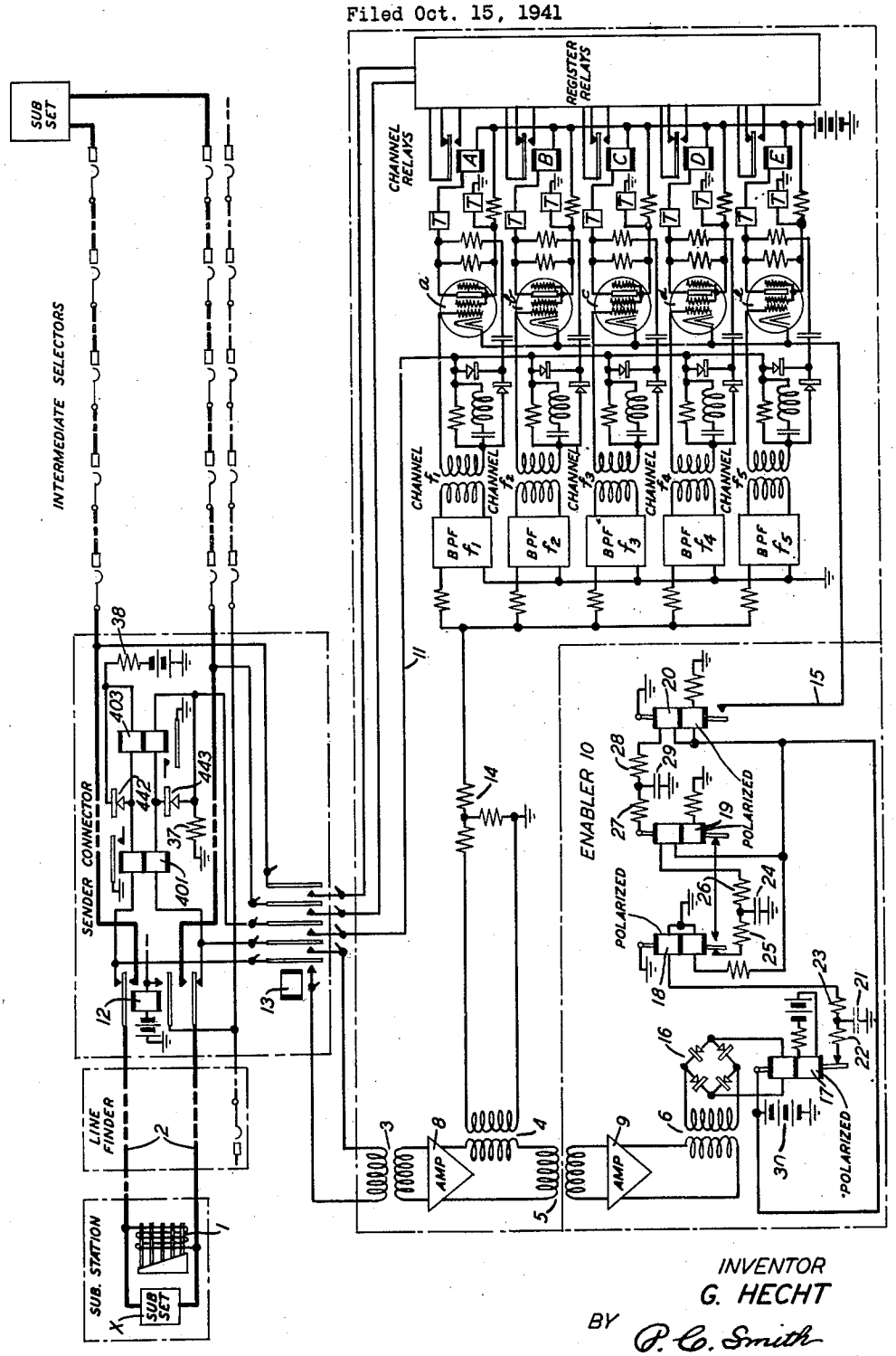

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TELEPHONE SYSTEM

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This invention relates to telephone systems and particularly to the receiving equipment of a transmission line over which alternating currents, preferably within the voice frequency range, are transmitted for effecting the operation of said equipment to control, in turn, the selective positioning of switching apparatus. More particularly, the invention has to do with means for controlling the degree of sensitivity-response of the detector channels of the receiving equipment of the telephone system shown and described in Patent 2,237,742, issued to A. A. Lundstrom on April 8, 1941, and utilized as part of the telephone system disclosed in my Patent 2,260,318, issued on October 28, 1941. In said last-mentioned patent the receiving channels of the telephone system are each adapted to respond to a particular frequency in an incoming signal composed of several frequencies, and an enabler circuit is provided which is adapted to activate the detector elements of said channels for response to the signal some time after its arrival in order to avoid possible false operation of the channels from the transient disturbance set up by the initial impact of the signal energy upon the filtering devices immediately preceding the detector elements of the channel. Since the duration of the disturbance depends upon the intensity of the signal which, in turn, depends upon the length of the transmission loop, the operation of the enabler circuit disclosed and claimed in said Patent 2,260,318 depends upon the application to the grid of a vacuum tube electronic device of a marking potential which is determined by a direct current flowing in the loop, the current in the cathode-anode circuit of said device being correspondingly altered to function relay means that activate the detectors on a time delay basis that corresponds to the quantity of cathode-anode current which is varied, through the potential applied to the grid, in accordance with the length of the loop.

In the preferred embodiment of the present invention the detector elements of the several detector channels are still activated by enabling means the constants of which may be determined by the delay desired in activating said elements after the arrival of the signal, but the amount of sensitivity of the several elements is controlled by the application to the grid elements thereof of a negative potential derived from the quantity of direct current flowing over the loop. By means of this control, the length of the loop over which the signal current can be transmitted may be considerably increased inasmuch as the just-operate sensitivity of the several detector elements may be adjusted for the maximum loop for which the negative bias to the grid electrodes of said elements will be a minimum when the direct current in the loop is a minimum. For the minimum loop when the direct current is a maximum, the just-operate sensitivity of the detectors may then be maintained to approximately the same value as before by applying to the grids thereof the proportionately greater negative bias derived from the loop direct current.

This and other features of the invention will be more readily ascertained from the following detailed description of said invention, appended claims and attached drawing in which is shown schematically certain elements of the telephone system completely disclosed in said above-mentioned Patent 2,260,318 and certain other elements to which my invention more directly relates.

Referring now to the drawing, X represents a subscriber's station in an automatic telephone system, said station being equipped with a device 1 suitably arranged to produce one or more currents of different frequencies in the voice frequency range in response to the depression of keys or the like that represent digits or other characters making up the wanted designation, and 2 represents a line extending from the station instrument to the central office and established therebetween by any suitable means such as, for instance, by line extending switches and the like. The conductors of said line extend to battery and ground serially through the upper and lower windings of relays 401 and 403, respectively, and resistances 38 and 37, respectively, with rectifier 442 bridged across the upper winding of relay 403 and rectifier 443 bridged across the lower winding of said relay. The line, for the purpose of switching control and further extension, is connected to a free sender through one of a plurality of selectable sender connector relays 13, said sender comprising coupling transformers 3, 4, 5 and 6, amplifiers 8 and 9, and the enabler circuit 10, the latter functioning to sensitize detector tubes *a*, *b*, *c*, *d* and *e* of the channels *f1*, *f2*, *f3*, *f4* and *f5* which are individually so designated to agree with the frequency notation of the frequency to which each of the channels is respectively assumed adapted to respond, which channels include, also, individually responding channel relays A—E, and the settable register relays (not shown), the latter following the operation of the channel relays in order to permanently register the operation of the same

when said channel relays operate to signalize an incoming impulse. The amplifiers 8 and 9 are commercially available circuit units while the channels *f1*—*f5* are completely disclosed in the above-mentioned Patent 2,237,742 to A. A. Lundstrom to which reference is made for a more complete understanding thereof, while the register relay circuit may be of the type disclosed in said patent or of any other suitable design. It is to be understood, however, that the invention is not limited to channels of the type described in the last-mentioned patent or to other apparatus herein used for purposes of illustrating the operation of the invention.

The enabler 10, the operation of which is completely described in Patent 2,277,228, issued on March 24, 1942, comprises the varistor bridge 16 and the polarized relays 17, 18, 19 and 20 with their intermediate capacitor-resistance networks controlling the operating times of said relays in the manner set forth in said last-mentioned patent.

In the operation of the invention, a call is initiated at station X by the removal of the station instrument from the switchhook, whereupon the line is then extended by any suitable means to the central office at which an available sender is then connected to said line through the medium of a sender connector 13 after which "key tone" is transmitted by a suitable circuit (not shown) back to the calling station X as a signal that the sending device 1 may be operated to transmit the number of the wanted station, all in the manner described in the above-mentioned Patent 2,237,742 to A. A. Lundstrom.

When any one of the ten keys of the sending device 1 is operated, two out of the five defined frequencies *f1*—*f5* are generated in the combination called for by a suitable code to designate the digit represented by the key depressed, and the resulting current produced thereby is transmitted over a circuit which may be traced from one side of the sending device 1, over the lower conductor of the looped pair 2, the lower back contacts of relay 12, the next-to-the-inner contacts of sender connector cut-in relay 13, the primary winding of transformer 3, the inner contacts of relay 13, the top back contacts of relay 12 and the upper conductor of looped pair 2 to the other side of the station sending device 1. The current composed of the two frequencies is induced in the secondary winding of transformer 3 and fed into the input side of amplifier 8 whence, after suitable amplification, it is applied, through transformer 4, to the input pad 14 from which, after passing through suitable band-pass filters BPF—it is made available for operating the channel vacuum tube detectors *a*—*e* when the cathode elements of the same are activated by the enabler 10 as explained hereinafter.

Considering, now, that portion of the signal energy which is transmitted through transformer 6, it will be observed that the enabler 10 comprises the varistor bridge 16 and the four polarized relays 17, 18, 19 and 20, each of said relays having a permanently closed polarizing circuit through their respective lower windings that causes their respective armatures to assume the positions indicated in the drawing. Between each two relays, beginning with relay 17 and ending with relay 20, there is an intermediate condenser-resistance network which joins a contact of the relay on the left with the upper winding of the relay on the right. Considering relays 17 and 18, for example, the network made up of resistances 22 and 23 and condenser 21 joins the right contact of relay 17 with the upper winding of relay 18. Since the armature of relay 17 is connected to the positive battery 30, condenser 21 is normally charged to the potential of this battery. Condenser 24 of the network between the left contact of relay 18 and the upper winding of relay 19, on the other hand, is normally at ground potential since one side of it is permanently connected to ground while its other side has ground applied to it through the armature and left contact of relay 18. Also, condenser 29 of the network between the contacts of relay 19 and the upper winding of relay 20 is charged to the potential of the positive battery 30 through resistance 28 and the upper winding of said relay 20 since the short-circuiting ground path for condenser 29 is normally open at the right contact of relay 18, which fact leaves condenser 29 exposed to the charging circuit that traces from the positive pole of battery 30 through the upper winding of relay 20, resistance 28 and condenser 29 to ground.

Assuming, therefore, that relays 17, 18, 19 and 20 have their respective armatures in the positions shown and that condensers 21, 24 and 29 are charged, discharged and charged, respectively as indicated above, ground is normally disconnected from conductor 15 at the right contact of relay 20, which conductor is, in turn, connected to the cathodes of the channel detector tubes *a*—*e* of the several channel detectors *f1*—*f5* and causes them to be normally unresponsive to the signal energy available at resistance pad 14.

The enabler 10, the elements of which have been described above, is identical with the enabler shown and described in Patent 2,277,228 to which reference has already been made, and the elements of the present enabler have been given designations identical with those of the enabler in said patent in order that, in the present specification, the operation of the enabler set forth in said patent may be followed without any additional description herein. Briefly recapitulated, however, it is the function of the enabler 10 to respond to the signal energy incoming over transformer 6 and to operate in consequence thereof relays 17, 18, 19 and 20 sequentially in a certain timed relation whereby, after a predetermined interval subsequent to the time when the signal energy is first applied to transformer 6, relay 20 is operated to apply ground to conductor 15 and continues to apply ground to said conductor for a definite interval thereafter subsequent to which ground is removed from said conductor (by the release of relay 20) even though signal energy is still available at transformer 6. The manner in which this is accomplished is immaterial to my present invention, and is for the enabler illustrated, fully described, as said before, in Patent 2,277,228. Suffice it to conclude that when relay 20 operates, ground is applied to conductor 15 which, being connected to the cathode of each of the several detectors *a*—*e*, causes said detectors to become activated for response to signal energy available at resistance pad 14.

The extent, or the degree, of sensitivity with which the several detectors will respond to the incoming signal will depend, however, upon the value of the biasing potential which is applied to their respective grids. That is, the quantity

of current that will flow in the cathode-anode circuit of each of the detector tubes for operating their respective channel relays A—E will depend, as is well-known, upon the value of a negative potential bias applied to their respective grid electrodes. The positive components of the signal energy applied to these grids will, of course, increase the cathode-anode current and, for the longest line loop, will be sufficient to increase this current to a value that will cause the corresponding channel relay to operate. It is evident, however, that if the cathode-anode current is just sufficient, on the longest loop, to cause the operation of the channel relays then, on the shortest or zero loop, this current will be considerably increased inasmuch as the positive bias then applied to the grids will be a maximum. Since the wave front of an incoming alternating current signal will, when striking the input side of impedance network of the band-pass filters BPF*f*1—BPF*f*5 produce a transient voltage on the output side thereof that will be applied to the grid of each of the detector tubes, then those tubes which lie on either side of the tubes in the channels that pass the frequencies of the signal may falsely respond and falsely operate their respective channel relays. In order to eliminate the possibility of this false operation it is necessary, therefore, to neutralize the positive grid voltage applied to all tubes by the transient voltage set up by the signal, by a negative potential that varies with the length of the loop so that the resultant bias will always be no more than sufficient to cause the operation of only those tubes in the channels that pass the frequencies of the signal. This potential is applied over conductor 11 which, on the one side is connected, through the middle set of contacts of relay 13, to one side of resistance 37 and, on the other side, is connected to the impedance network in each channel that extends to the grid of the detector tube thereof over the secondary winding of the transformer intermediate the band-pass filter (BPF*f*1 of channel 1, for instance) and the grid.

Now when the line loop is established, a direct current circuit is completed which may be traced from ground, through resistance 37, the lower windings of relays 403 and 401, respectively, the lower back contact of relay 12, over the loop, the top back contact of relay 12, the upper windings of relays 401 and 403, respectively, and through resistance 38 to negative battery. The current flowing through this loop is, of course, determined by its ohmic resistance the only variable element of which is the resistance of the loop itself. Since conductor 11 is connected to the line terminal side of resistance 37, a negative potential is available thereat which is applied to the grid of each of the detector tubes. The quantity of current which flows through the cathode-anode circuit of each tube is then effected by the value of this negative potential which, in turn, has a value determined by the length of the loop. The value of this potential, prior to the transmission of any of the signal impulses, is practically unaffected by the alternating current signal potential superimposed thereon when the signal impulses are transmitted inasmuch as the former is preponderately large in comparison to the unamplified signal voltage which is similarly superimposed thereon. Hence the value of the biasing potential derived from the direct current flow is substantially the only potential applied to the grid of each tube, that will determine the sensitivity of the tube response to the signal current. On a zero loop, for example, the direct current flowing through the loop is a maximum, the negative potential applied to the grid of each tube is a maximum and the sensitivity of each of the tubes is a minimum. Since, on a zero loop, the value of the signal current is a maximum, the application of the greatest available negative bias at this time will cut down the current that will flow through the cathode-anode circuit of the tube, which circuit includes, of course, the channel responding relay. Although this current is ample to cause the operation of the relay of a channel which passes a frequency of the signal energy, yet because conductor 11 extends to the grids of all the tubes, the heavy negative bias applied to the tubes of those channels which do not pass the signal frequency, protects these tubes from falsely operating on the transient disturbance set up in adjacent channels by the impact of the signal current upon all the channels. On a maximum loop, on the other hand, the loop current is a minimum, the negative potential derived from the loop and applied to the grids of all the tubes is a minimum and the tubes will be at their maximum sensitivity in order to permit full response on the weak signal current available for operation. Although, in this case, the transient disturbance is also produced, it is of considerably diminished intensity and the small negative bias applied to the grids of all the loops will be sufficient to protect the tubes which are adjacent to those responding to the signal current. Thus, the sensitivity of the detectors is varied in accordance with the length of the loop to provide for appropriate response of the particular channels involved to the frequencies of the incoming signal current, and to protect adjacent channels against false operation in consequence of the transient disturbance produced by the signal.

When the signal impulse is over (assuming the correct depression of a key at device 1), relay 17 will "release" and, according to operations described in my above-mentioned Patent 2,277,228, initiates a series of operations by which the relays of the enabler 10 are restored to their original positions. Since, by this time, relay 20 has already released to remove ground from conductor 15, the circuit is normally in readiness to receive the next signal when the operations described above are repeated.

While I have described my invention and the means for utilizing the same in connection with a specific embodiment thereof, it is to be understood that various other embodiments thereof may be made by those skilled in the art without departing from the spirit of the invention as defined within the scope of the appended claims.

What is claimed is:

1. In a telephone system in combination, a transmission line provided with a plurality of channel detectors adapted for response to alternating current signals, a source of direct current connected to said line, and means connected to said line and to said detectors for controlling the sensitivity-response of said detectors to incoming alternating current signal energy in accordance with the intensity of the direct current flowing through said line and through said means.

2. In a telephone system in combination, a transmission line provided with a plurality of channel detectors each including an electrode adapted for response to alternating current signals transmitted over said line, an enabler for said channel detectors adapted to activate the

same for response to said alternating current signals, a source of direct current potential for connection to said line, and means connected between said line and said electrodes for applying a negative potential to said electrodes which is derived from the direct current flowing over said line whereby the sensitivity of detector response to said alternating current signals is controlled by the value of said negative potential.

3. In a telephone system in combination, a transmission line provided with a plurality of channel detectors adapted for response to alternating current signals, a source of direct current potential connected to said line, an enabler for activating said channel detectors for response to said alternating current signals at a time subsequent to the arrival of said signals, and means effective in response to the direct current flowing over said line from said source of direct current potential for applying a control potential to each of said detectors in advance of said alternating current signals whereby the sensitivity response of said detectors to said signals is controlled by the value of said potential.

4. In a telephone system in combination, a transmission line connected to a plurality of channel detectors each including an electronic device provided with a grid electrode adapted to have applied thereto a positive potential derived from alternating current signals transmitted over said line, and a cathode-anode circuit the current flow through which is dependent upon the voltage applied to the grid, a source of direct current potential connected to said line, an enabler for activating all of said electronic devices for response to said alternating current signals in consequence of the voltage derived therefrom for application to the grid electrodes of said electronic devices, a conductor extending between said line and all of said grid electrodes for applying to said grid electrodes a negative potential the value of which is dependent upon the flow of direct current over said line, whereby the current flow in the cathode-anode circuit of an electronic device of a channel that passes a frequency of an alternating current signal is controlled by that voltage applied to the grid which is derived from said frequency and by that voltage applied to said grid which is derived from the direct current flow over said line.

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