

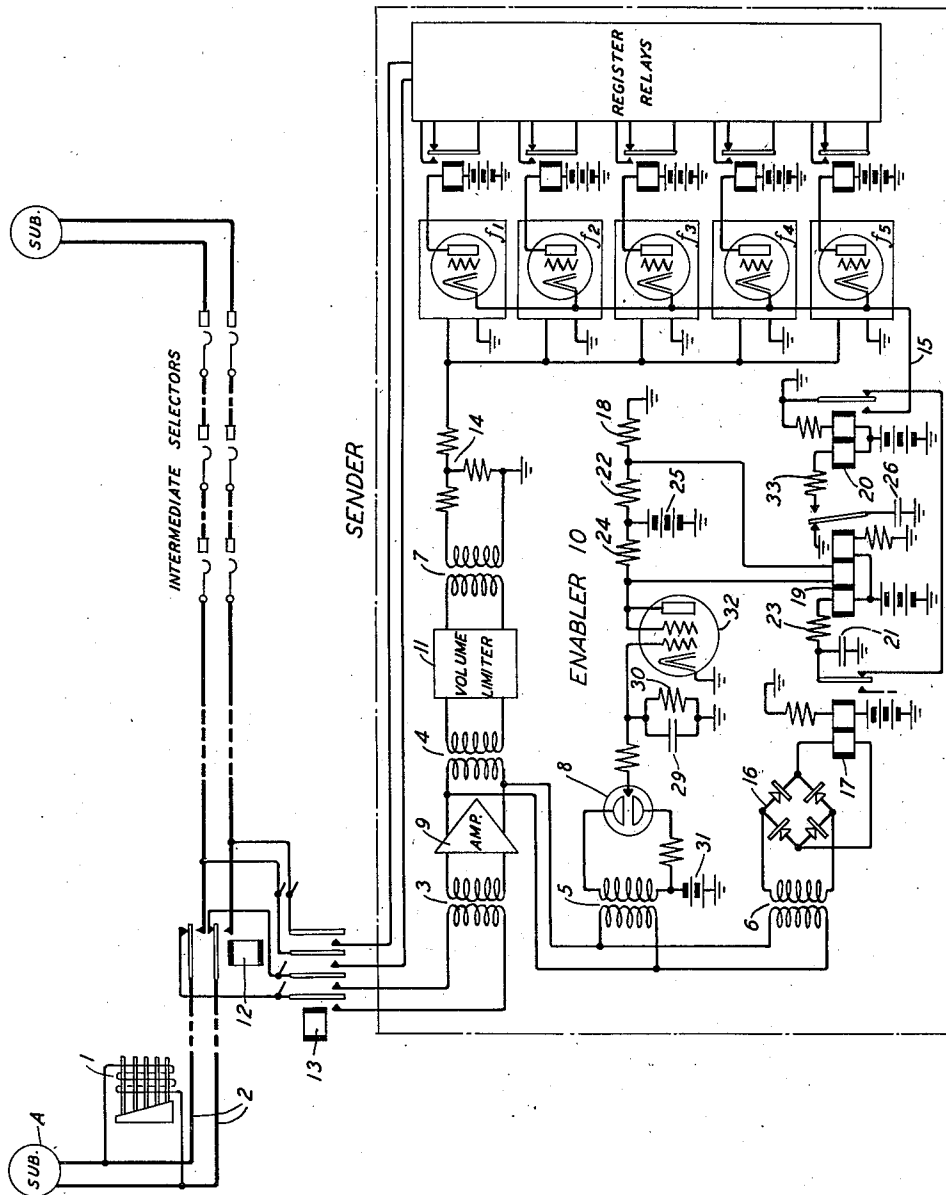
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TELEPHONE SYSTEM

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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 is in the nature of an improvement in the receiving equipment of the telephone transmission line disclosed in the co-pending application of G. Hecht and A. A. Lundstrom, Serial No. 355,712, filed September 7, 1940. In said application is disclosed a telephone system of the type in which automatic switches are controlled by means responsive to alternating currents of different frequencies generated at a subscriber's station and transmitted over a line terminating in a plurality of channel detectors each selectively tuned to a different one of the signal frequencies and responsive thereto for operating a relay which, in combination with a relay operated over another channel detector responsive to a current of another signal frequency, serves to function a settable register, or sender, in which is locked-in a record of the digit indicated by the two operated relays; that is, by the two frequencies transmitted from the subscriber's station.

In systems of this kind where the signal generating instrument is, usually, a device comprising a plurality of keys or the like which are operated to produce the different combinations of frequencies to which the channel detectors are respectively tuned to respond, the quantity of signal energy available for operating the channel detectors is a function of the voltage generated by the manipulation of the signal generating instrument and the impedance of the line between it and the channel detectors. The impact of the energy at the input side of the filtering devices preceding the channel detectors is usually productive, on the output side, of a spectrum frequency which may result in the operation of channel detectors other than those which are responsive to the two signal frequencies generated by the generating instrument, in which event a wrong registration will result.

In order to avoid the damaging effect of the spectrum transient, the detecting element in each of the channel detectors may be kept insensitive to response until the transient has decayed to a negligible value. However, since the intensity of the transient and the extent of its duration depends upon the value of the signal voltage available at the input side of the filtering devices, it

being a maximum at zero loop and a minimum at longest loop, the length of time during which the detectors are to be kept insensitive to the incoming signal is a variable one depending upon the length of the loop.

In accordance with a feature of this invention, therefore, means are provided whereby the incoming signal energy operates a circuit network herein called the "enabler" which controls the activation of the channel detectors, and the time at which the enabler sensitizes the detectors subsequent to the arrival of the signal energy is made dependent upon the length of the line loop, the time at which activation of the detectors takes place being inverse to the length of the loop; that is, being a maximum on the shortest loop and a minimum on the longest loop.

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 more completely disclosed in Patent 2,237,742, issued to A. A. Lundstrom, on April 8, 1941, and in which certain other elements to which my invention more directly relates, are shown in detail.

Referring now to the drawing, A 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, 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 line, for the purpose of switching control and further extension, is connected to an idle sender, through one of a plurality of selectable sender connector relays 13, said sender comprising coupling transformers 3, 4, 5, 6 and 7, amplifier 9, volume limiter 11, and the enabler circuit 10, the last functioning to sensitize the channel detectors $f1$, $f2$, $f3$, $f4$ and $f5$ which are individually so designated in accordance with the frequency to which each of the channels is respectively assumed adapted to respond, which channels include individually responding relays and the settable register relays which follow the operation of the channel relays when operated to signalize an incoming impulse. The amplifier 9 and the volume limiter 11 are commercially avail-

able circuit units while the channels $f1-f5$ are completely disclosed in Patent 2,237,742, already mentioned and to which reference is made for a more complete understanding thereof although it is obvious and therefore to be understood that the invention is not limited to channels of this description. The enabler 10 comprises the gas-filled tube 8 and its associated network, the vacuum tube 32 and its associated network, the bridge type varistor 16 and the polarized relays 17, 19 and 20 with their intermediate capacitor-resistance networks controlling the operating times of said relays in the manner described hereinafter.

In the operation of the invention, a call is initiated at station A 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 back to the calling station A by circuits not shown, 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 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 required to designate the digit represented by the key depressed, and the resulting current produced is transmitted over a circuit which may be traced from one side of the sending device 1, lower conductor of the looped pair 2, lower back contacts of relay 12, next to the inner contacts of sender connector cut-in relay 13, primary winding of transformer 3, inner contacts of relay 13, top back contacts of relay 12, upper conductor of the 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 9 whence, after suitable amplification, it is applied through transformer 4 to the volume limiter 11 and, through transformer 7 at a suitable level, to the input resistance pad 14 from which, after passing through suitable filters (not shown) it is available for operating the channel detectors $f1-f5$ when the detector elements of the same have been sensitized by the enabler 10 as explained hereinafter.

Considering that portion of the signal energy which passes into the volume limiter 11, the energy causes the volume limiter to operate and regulate the energy output in accordance with its adjustment which may be such as to limit the final magnitude of output to that required for the satisfactory operation of the channel detectors and no more regardless of the magnitude of the input energy. The reason for doing this is, of course, to prevent overloading any of the channel detectors which, should it occur in the event of a heavy input signal due, say, to a very short loop 2, would be productive of a heavier transient than is actually present when the signal level is reduced. Hence by adjusting the volume limiter to a suitable ceiling of output energy above the operate level of the channel detectors, the transient disturbance will simply be due to that produced by a signal current within the limits of the just operate level of the detectors.

Considering now that portion of the signal

energy which is transmitted to the enabler circuit 10 via transformers 5 and 6, it will be observed that said enabler comprises an energy level detector branch made up of gas-filled tube 8 and the vacuum tube 32 with their respectively associated networks, and the channel detector control branch made up of varistor bridge 16, the three polarized relays 17, 19 and 20 and the associated networks. It will be further observed that the middle winding of relay 19 is bridged around resistances 22 and 24 of the plate circuit of the output network of vacuum tube 32. This tube is normally in an operative condition, the filament of the tube being heated in any suitable manner, so that current normally flows from the positive pole of battery 25, through resistance 24, over the anode-cathode path of tube 32 to ground. Current also flows through resistances 22 and 18 to ground. Now resistances 24, 22, 18 and the resistance of the anode-cathode path of tube 32 constitute a bridge and the values of resistances 24, 22 and 18 are so chosen that, under normal conditions, the currents which flow through the above-named resistance elements will cause no potential difference to exist between the junction between resistances 22 and 18 and the junction between resistance 24 and the anode of tube 32. Since the middle winding of relay 19 is connected to these junction terminals, no current will flow through said winding.

Normally each of the relays 17, 19 and 20 has its armature engaged with the left or right contacts as shown in the drawing by virtue of biasing currents established in permanently closed circuits through one or more of their respective windings. Thus relays 17 and 20 have their armatures engaging their respective right contacts because of the current flowing through the circuits established through their respective right windings while relay 19 which has current flowing through its right winding over an obvious circuit and current flowing through its left winding over a circuit established from ground over the armature and right contact of relay 20, the armature and right contact of relay 17, resistance 23 and the left winding of relay 19 to negatively grounded battery. The resultant effect of the current flowing through the two outer windings is such as to cause the armature of relay 19 to engage its left contact thereby maintaining a short circuit around condenser 26.

To describe the manner in which the intensity of the incoming signal controls the time when the enabler 10 will sensitize the detector elements of the channel detectors $f1-f5$, let it be assumed that the loop between station A and the sender connected to the line via relay 13 is substantially 0, in which event the signal energy is at its greatest intensity. The potential across transformer 5 is, in this case, more than sufficient to break down gas-filled tube 8. The energy is thus rectified and since the anode of the tube 8 is connected to condenser 29 and the parallel leak resistance 30 and the grid of vacuum tube 32, a charge is applied to said condenser which is further applied as a negative bias to the grid of said vacuum tube. As mentioned before, the anode of this latter tube is serially connected through the middle winding of relay 19 to the junction between resistances 22 and 18. The circuit which includes the cathode-anode of the tube and resistances 24, 22 and 18 constitutes a bridge across resistances 22 and 24 to the outer terminals of which is connected the middle wind-

ing of relay 19. The arm including the anode-cathode circuit of the tube constitutes the adjustable arm of the bridge so that, when the bias on the grid is at the same potential as the cathode and tube 32 operates to produce maximum current through the anode-cathode circuit, the resistances 24, 22 and 18 are so chosen that, as stated before, no potential difference is applied between the junction of resistance 24 and the anode of tube 32 and the junction of resistances 22 and 18 which might be effective in establishing a current flow through the middle winding of relay 19.

On the shortest loop, then, when the incoming signal is at its greatest intensity, the negative bias on the grid of tube 32 is a maximum, the reduction in current flow through the anode-cathode circuit of tube 32 and resistance 24 to battery is a maximum and the potential difference between resistances 24 and 22 is also a maximum inasmuch as nothing has occurred to change the quantity of current flowing through resistances 22 and 18. The value of this potential difference is applied to the middle winding of relay 19 and causes it to swing its armature from the left to the right contact in the maximum time allowable. The reason for this is as follows:

A portion of the signal energy is applied through transformer 6 and to the varistor bridge 16 whereupon the energy is rectified and the potential difference arising therefrom is applied to the left winding of relay 17 which now operates to remove the normally applied short-circuiting ground to condenser 21 which thereupon begins to charge over the charging circuit extending from battery, left winding of relay 19, resistance 23, condenser 21 to ground, and temporarily maintains the flow of current through the left winding of relay 19 which is normally established through the front contacts of relay 17 to ground on the front contact of relay 20. When condenser 21 is fully charged, the current flow ceases and if current is flowing through the middle winding of relay 19 as above described, said relay will release but its time of release is, under the conditions described, a maximum because the decaying charging current is added to by the aiding flux of the current through the middle winding. Relay 19 thus releases in its maximum time and, in so doing, connects the normally discharged condenser 26 in a charging circuit through the left winding of relay 20 and resistance 33. The charging current operates relay 20 which applies ground to conductor 15 and over said conductor to the cathodes of the detector tubes of the channel detectors $f1-f5$ causing them to become activated and respond to the signal energy incoming over pad 14. The length of the closure will, of course, depend upon the capacity of condenser 26 which may be chosen for any value desired.

For a maximum loop, the signal current is a minimum. This value of current is sufficient to just render tube 8 conducting, but since the value of current drawn through the anode to charge condenser 29 from negative battery 31 is a function of the conductivity of the tube which, in turn, depends upon the signal voltage applied across the control electrodes thereof, it is evident that, on a signal of minimum intensity, the negative charge on condenser 29 is correspondingly smaller, the grid bias on tube 32 is changed to a minimum negative value and the normal anode-cathode current is reduced by a

minimum amount. Under these circumstances, the potential difference between the junction of resistances 22 and 18 and that of resistance 24 and the anode is a minimum, the current flowing through the middle winding of relay 19 is a minimum and the relay will release in a minimum time to connect condenser 26 to the left winding of relay 20. Between the extreme of maximum signal current at zero loop when relay 19 operates in the maximum time fixed by the capacity of condenser 21 and the minimum signal current at maximum loop when relay 19 operates in minimum time, the time of operation of said relay will progressively and inversely vary with the intensity of the signal current fixed by the length of the loop.

The length of time during which the armature of relay 20 engages its front contact to cause the channel detectors to remain activated depends, of course, upon the constants of condenser 26 and resistance 33 which may be chosen to provide any interval desired within the duration of a minimum signal impulse. However, when the condenser 26 is completely charged, the current through the right winding of relay 20 again becomes effective, the armature of the relay breaks away from its left contact and ground is removed from conductor 15 and, therefore, from the cathodes of the detector element of the several detector channels $f1-f5$ which, in consequence, will no longer respond to signal energy of the signal impulse forthcoming over resistance pad 14 and thereby cause their separate anode relays to release.

When the signal impulse is over (assuming the correct depression of a key at device 1), tube 8 will restore, the charge on condenser 29 will leak to ground through resistance 30, and normal current will again be reestablished through the cathode-anode circuit of tube 32 whereby no potential difference will exist across the middle winding of relay 19 and, therefore, no current will flow therethrough. Relay 17 will restore to its normal condition, reestablishing the short circuit around condenser 21 and the circuit through the left winding of relay 19 to cause it to make its left contact. Since relay 20 has already reestablished its armature on its right contact, the circuit is normally in readiness to receive the next signal which is timed for transmission after the above-described operations have been completed and which, when transmitted, causes said operations to be repeated.

While I have described my invention and the means for utilizing the same in connection with its specific application to a particular kind of a transmission line, it is to be understood that various other applications and 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. An enabler circuit for the channel detectors of a transmission line adapted to apply a potential to the detector elements of said channel detectors for activating the same to respond to incoming signal energy, comprising a gas-filled electronic device operative in response to incoming signal energy, a vacuum tube provided with a cathode-anode circuit over which current normally flows, timing means included in said cathode-anode circuit for applying a potential to the detector elements of said channel detectors, and means responsive to the current intensity in

the anode circuit of said gas-filled electronic device for reducing the current flow in the cathode-anode circuit of said vacuum tube whereby the operating time of said timing means is controlled for applying a potential to the detector elements of said channel detectors.

2. An enabler circuit for the channel detectors of a transmission line adapted to activate the detector elements of said channel detectors for response to incoming signal energy, comprising a vacuum tube, three resistance elements forming a resistance bridge with the cathode-anode resistance of said tube, a source of potential applied to two terminals of said bridge which is normally productive of no difference of potential between the other two terminals of said bridge, a relay connected across said other two terminals of said bridge, and a gaseous conductor electronic device having its anode connected to the grid of said vacuum tube and operative in response to an incoming signal for applying a potential to said grid whereby the current flow in that arm of the said bridge which includes the cathode-anode of said vacuum tube is reduced to produce a difference of potential across the two terminals of said bridge to which said relay is connected, and whereby said relay operates on said difference of potential to activate said channel detectors for response to said incoming signal, the operating time of said relay being a maximum on a maximum difference of potential across the terminals of said bridge and a minimum on a minimum difference of potential across the terminals of said bridge.

3. An enabler circuit for the channel detectors of a transmission line adapted to activate the detector elements of said channel for response to incoming signal energy comprising a polarized relay having two differential windings, means for producing a current flow through each winding whereby the resultant magnetic effect causes the armature thereof to assume one of two positions, a third winding for said relay, means connected

to said line and responsive to the transmission of signal energy thereover for producing a difference of potential between said means, and means responsive to said difference of potential for producing a current flow through the third winding of said relay whereby the armature thereof assumes the other of said two positions for activating said channel detectors.

4. An enabler circuit for the channel detectors of a transmission line adapted to activate the detector elements of said channel for response to incoming signal energy comprising a polarized relay having two windings differentially disposed with respect to each other, means for producing a current flow through each winding whereby the resultant magnetic effect causes the armature thereof to assume one of two positions, a third winding for said relay, means in said line responsive to the transmission of signal energy for producing a difference of potential between said means, a vacuum tube provided with a cathode-anode circuit having current normally flowing therethrough, a network connected to said anode between which and said network the third winding of said relay is connected, a gaseous conducting electronic device coupled to said line having its anode connected to the grid of said vacuum tube and operative in response to said difference of potential for applying a bias potential to said grid whereby the current flow in the cathode-anode circuit of said vacuum tube is altered to produce a difference of potential across the third winding of said relay for operating the same to move its armature to the other of said two positions wherefrom said channel detectors are activated, and an impedance network connected to one of said differential windings and operative when current is established through said third winding for delaying the operation of said relay by an interval fixed by the constants of said network and the intensity of the current flowing through said third winding.

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