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TELEPHONE SYSTEM

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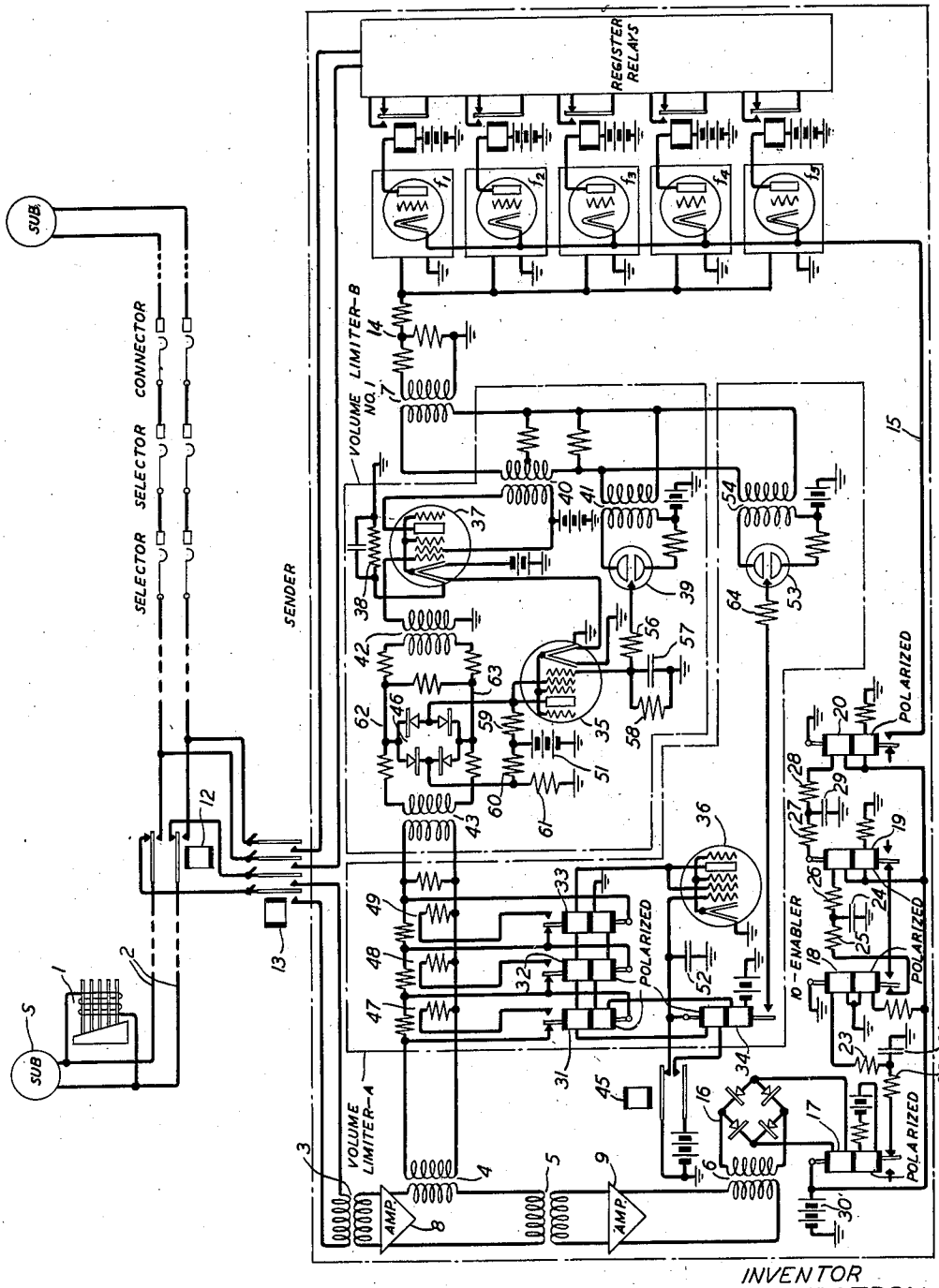

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TELEPHONE SYSTEM

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7 Claims. (Cl. 179—18)

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 which controls, 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 copending application of 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 which is provided with a plurality of channel detectors each selectively tuned to a different one of the frequencies and responsive thereto to operate a relay which, in combination with a relay operated over another channel detector, 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 plurality of keys or the like which are operated to produce the different combination of frequencies to which the channel detectors are respectively tuned to respond, it is difficult to keep the transmission line completely free of all frequencies except the signal frequencies generated. From an engineering standpoint it is very desirable to have the signal frequencies within the voice frequency range and, therefore, noises of all kinds will include said signal frequencies. It has been found, for example, that one of the sources of such noise is the current carrying contacts of the relays which establish the transmission line itself between the telephone station and the receiving channels. It is thought that this noise is produced by the small variations in the quantity of currents passing through the contacts, and since the frequency spectrum of the noise usually contains components of the different signal frequencies, the channel detectors, or some of them, are liable to respond to such frequencies and thereby produce a false registration even though the signal generating instrument may or may not have been operated to produce frequencies other than those produced by the noise and therefore cause the operation of other channels beyond those intended.

In accordance with a feature of this invention, the channel detectors are protected against false operation by the use of two volume limiting devices interposed between the line and the receiving channels, the first of which operates whenever the level of the signal energy is, on one signal, a predetermined number of energy increments above the predetermined signal level to which the channels are adapted to respond, to lock-in a definite loss so as to reduce the signal to within one or two increments above the predetermined signal level, after which it becomes unresponsive to further signals, and the second volume limiting device operates on every signal to introduce a further adjustment whereby the level of the signal is further reduced to the level of one increment above that to which the channels are adapted to respond.

In accordance with the invention one embodiment of which is disclosed herein by way of illustration, a transmission line is provided over which signal energy that fluctuates over a wide range may be transmitted. Connectable to the line is a plurality of channels each of which is adapted to respond to a particular frequency in the signal energy, while disposed between the channels and the line are two volume limiting devices the first of which is adapted to respond to any level of signal energy substantially above the level to which the channels are adjusted to operate, for the purpose of reducing the same to a value slightly higher than that to which the individual channels are adjusted to operate. The second volume limiter also responds to the signal energy but functions only to reduce what is left of the energy after the first volume limiter has acted upon it to further reduce the energy to the predetermined level to which the channels are adapted to respond. In both cases the volume limiters act to obtain this result by introducing appropriate losses in the line which subtract by that much from the total available energy; the total losses in all cases being such as to leave a residuum for the channels which is at the predetermined energy level for which they are adjusted to respond.

The invention will be more readily ascertained from the following detailed description of said invention, appended claims and attached drawings in which is shown schematically certain elements of the telephone system more completely disclosed in the copending application of A. A. Lundstrom, Serial No. 306,466, filed November 28, 1939, and in which certain other elements to

which my invention more directly relates, are shown in detail.

Referring, now, to the drawing, S 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 digit or other characters making up the wanted designation; 2 represents a line extending from the station instrument to the central office whence, through one of a plurality of selectable sender connectors 13, the line is extended to a free sender which comprises volume limiter A, volume limiter B, the enabler 10 and the channel detectors *f*1, *f*2, *f*3, *f*4 and *f*5 individually so designated in accordance with the frequency to which each of the channels is respectively assumed adapted to respond, which channels include suitable filters (not shown), individually responding relays and the settable register relays which follow the operation of the channel relays when operated to signalize an incoming impulse. The amplifiers 8 and 9, the vacuum and gas-filled tubes in the various portions of the apparatus as well as the coupling units and rectifiers are commercially available circuit elements while the channels *f*1—*f*5 are completely disclosed in the copending application of A. A. Lundstrom Serial No. 306,466, to which reference is made for a more complete understanding thereof although it is to be understood that the invention is not limited to channels of this description.

In the operation of the invention, a call is initiated at station S by the removal of the station instrument from the switchhook, the transmitter thereof being short-circuited or removed from the line in any suitable manner to prevent unwanted speech currents from entering the line, 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 relay 45 is operated in any suitable manner and "key tone" (not shown) is transmitted back to the calling station S 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 last-mentioned copending application of A. A. Lundstrom. Relay 45, in operating, connects positive battery to the top winding of polarized relay 34 of volume limiter B which is serially connected to the top windings of polarized relays 31, 32 and 33, the last-mentioned relay having the other terminal of its top winding connected to the plate and screen grid of vacuum tube 36. Now the filament of this tube is permanently connected to a local current source (not shown) and the cathode thereof is, therefore, permanently activated so that a circuit is completed through the top windings of all the above-mentioned relays, the plate and cathode of tube 36 to ground. Relays 31, 32, 33 and 34 operate since current flowing in this circuit overcomes the current in the series circuit through their lower or biasing windings, relays 31, 32 and 33 disconnecting resistance pad elements 47, 48 and 49 respectively from across the line by causing their armatures to engage their respective left contacts as shown before any signals are received while relay 34 connects the grid of tube 36 to the anode of gas-filled tube 53 in volume limiter A.

When any one of the ten keys of the sending device 1 is operated, two out of the five defined frequencies *f*1—*f*5 are produced in the combination required to designate the digit represented by the key, and the currents thus produced are 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 outer back contacts of relay 12, upper conductor of looped pair 2 to the other side of the station sending device 1. The current composed of the two frequencies generated by the device 1 as well as current of the frequencies arising from the contact noise as mentioned above, are induced in the secondary winding of transformer 3 and are fed into the amplifier 8 whence, after suitable amplification, these currents are fed, via the primary of transformer 4, and via the primary and secondary of transformer 5, into amplifier 9.

Considering that portion of the signal energy which passes through transformer 4, said energy is applied undiminished to transformer 43, whence it is transmitted to transformer 42 for application to the amplifier tube 37, the output of which is set in accordance with the voltage drop developed across resistance 38 applied to the grid of said tube as a bias therefor.

Upon the arrival of the first signal impulse several conditions are to be distinguished. If it is supposed that the voltage of the incoming signal, as determined by the output of tube 37 is, say, between E_0—E_1 which may be assumed to be two voltage limits, the first (E_0) defining the just operate voltage of the channel detectors *f*1—*f*5, while (E_1) defines the maximum voltage that the detectors will tolerate without falsely operating adjoining detector channels due to unwanted transients from the signal and limitations of the selective tuning of the channels, then neither volume limiter A nor B will operate, by which is meant that volume limiter A will not operate beyond the operation of relays 31—34 to remove the pad elements 47, 48 and 49 across the line when the sender is connected thereto as already described. In this case the signal voltage E_0—E_1 is applied to the input winding of transformer 40 and repeated in the loop comprising the secondary of said transformer, the primary of transformer 54, and the primary of transformer 7 whence it is applied through the secondary winding of transformer 7 to the resistance pad 14 and through it to suitable filtering devices (not shown) and to the grids of the detector tubes in each of the channels *f*1—*f*5. Since these tubes are normally inactive those channels that would be responsive to the two frequency components in the signal impulse transmitted through the resistance pad 14 do not operate until ground is connected to the cathodes via the contacts of polarized relay 20 and conductor 15 as more particularly explained hereinafter. Further, a portion of the signal voltage is also repeated into the secondary winding of transformer 54 the two terminals of which are connected to the control electrodes of gas-filled tube 53, but this voltage is not sufficient to break down the tube and no further operations result therefrom. The full voltage E_0—E_1 is further applied to the secondary winding of transformer 41 the two terminals of which are connected to the control electrodes of gas-filled tube 39, but here again, as with tube 53, the

voltage induced is not sufficient to break down the tube and no further operations result.

The next condition to be distinguished from the one above discussed is that arising from the assumption that the signal impulse voltage available on the primary side of transformer **40** is between E_1—E_2 by which is meant that the intensity of the signal is higher than the value assumed under the first condition. Since it is further assumed that the signal impulse is the first of the series which is to designate the wanted number, and, therefore, the voltage of the impulse for this particular call will not rise beyond E_2 since the terminal signal voltage is a function of the resistance of the calling loop, volume limiter A will not be called in because the voltage E_1—E_2 is assumed to be just high enough above E_1 to be reduced to this value by volume limiter B acting above.

Under the condition assumed, therefore, namely that the first signal impulse is between E_1—E_2, the signal voltage is applied across the control electrodes of gas-filled tube **39** and the value of this voltage is sufficient to break down the gap of this tube and cause it to become conducting whereupon the anode thereof applies a negative bias potential to the grid of vacuum tube **35**. Since plate current is normally flowing in the cathode-anode circuit of said tube the quantity of which is determined by the ground potential of the grid thereof as fixed by the potential at the terminal of resistance **56** applied to condenser **57** and resistance **58**, the conduction of the tube causes a negative voltage in respect to ground to be established across condenser **57** which acts as a negative bias to the grid and thus causes a corresponding reduction in the current through the cathode-anode circuit of said tube **35**. Resistance element **59** and the cathode-anode circuit of tube **35** are two elements of the bridge that comprises the following elements; resistance **59**, anode-cathode circuit to ground, resistance element **60** and resistance element **61**. Under normal conditions the resistance between element **59** and ground through the cathode-anode circuit of the tube is such that there is no potential difference between the terminal joining resistance elements **60** and **61** and that joining resistance element **59** and the anode. Consequently, under the condition that the intensity of the signal impulse is between E_0—E_1 no potential difference is applied between the two terminals of the varistor bridge **46** and, therefore, this bridge draws no current through it to establish a resistance loss across conductors **62** and **63**. This means that if the signal is within the normal voltage E_0—E_1 that voltage is applied undiminished to the terminals of the primary winding of transformer **42** wherefrom it is transferred to transformer **7** via transformer **40** for application to the pad **14**. Now if the signal impulse is higher in voltage; that is, between E_1—E_2, the current through the anode-cathode circuit of tube **35** is reduced as above set forth, a potential difference is established between resistance elements **60** and **61** on the one side and resistance element **59** and the cathode-anode circuit on the other which is applied to the two terminals of the varistor bridge **46**, thereby reducing its effective resistance and establishing a shunt across conductors **62** and **63** the effect of which is to reduce the potential of the signal impulse to the value E_1 and to hold it to this value for the duration of the signal.

When the signal terminates, tube **39** is extinguished since it has no sustaining voltage, the anode current through vacuum tube **35** is restored to its normal value and the potential difference between the two terminals of the varistor bridge **46** is eliminated thereby removing the shunt placed across the conductors **62** and **63**.

Every succeeding signal impulse which comes through having a voltage value E_1—E_2 will cause a repetition of the operation of volume limiter B as described above to reduce the value of the signal impulse voltage to be applied to the channel detectors to the value E_1.

Suppose, now, that the signal voltage available at the transformer **40** is between E_2—E_3 which value is assumed to be higher than E_1—E_2 and high enough to call for the connection of a permanent loss on the line. Under these circumstances, tube **39** will again operate but, in this case, the voltage available at transformer **54** is sufficient to cause a breakdown of gas-filled tube **53** which, since relay **34** is operated, will in turn apply a negative biasing potential across the terminals of condenser **52** for the grid of tube **36** via the anode of tube **53** and resistance **64**. Since current is normally flowing through the anode circuit of vacuum tube **36**, as described above, the establishment of the negative bias to the grid thereof has the effect of reducing the current flowing through this circuit which also includes the top windings of relays **31**—**34** inclusive. The reduction in current is sufficient to cause the current through the lower biasing windings of relays **31** and **34** to overcome the reduced current flowing serially through their top windings, whereupon the armature of relay **31** moves into engagement with its right contact and introduces pad **47** into the line to reduce the intensity of the incoming signal to a value lower than E_2 but greater than E_1. Volume limiter B, however, is concurrently operating in the manner already described to reduce the signal voltage from any value between E_2 and E_1 to E_1 so that the signal voltage available at the channel detectors is no higher than E_1.

Relay **34** releases and opens the charging path from tube **53** to condenser **52** which, in turn, has the effect of maintaining the charge on said condenser for the duration of the entire signal period; that is, for the remaining signal impulses still to be forthcoming. This relay **34** is locked in a released condition, so to speak, inasmuch as the anode current flowing through tube **36** and the top windings of relays **31**—**34** is reduced by the permanent bias potential applied to the grid thereof by the permanent charge condition on condenser **52**. Tube **53** as well as tube **39**, extinguish when the signal impulse is terminated.

In this way, pad **47** is locked in across the transmission line for the duration of the signalling period and all subsequent signals which come in will have voltages E_1—E_2 which volume limiter B will reduce to value E_1 for application to the channel edtectors *f1*—*f2*.

If the initial signal is, say, between E_3—E_4 which is assumed to be higher than E_2—E_3, then since relay **34** is operated, and tube **53** will be rendered conducting by the portion of the voltage available at transformer **54**, the anode current applied to condenser **52** is higher than when the signal impulse had a potential value E_2—E_3, the negative charge on condenser **52** is correspondingly higher, the negative bias for the grid of tube **36** is, therefore, also higher and the anode current flowing through tube **36** and the upper windings of relays **31**—**34** is now reduced

to the value where not only relays 34 and 31 will release but also relay 32, whereupon the armature of relay 31 will engage its right contact to insert pad 47 in the transmission line and the armature of relay 32 will engage its right contact to insert pad 48 in said line. Pad 48 reduces the voltage impulse to a point between E_2 and E_3 and pad 47 to some value between E_1 and E_2 while volume limiter B further reduces it to E_1.

If the signal voltage is, say between E_4—E_5 which is assumed to be higher than E_3—E_4 the same operation as above described will take place except that, now, the anode current of tube 36 is further reduced to allow the release of relay 33 whose armature now engages its right contact to insert pad 49 in the line the purposes of which is to reduce the impulse voltage between E_3 and E_4. Thus in all cases volume limiter A always reduces the signal voltage to some value between E_1 and E_2 while volume limiter B further reduces it to E_1.

When the sender has received its full complement of signal impulses, relay 45 is released in any suitable manner, thereby disconnecting battery from the upper windings of relays 31—34 causing the same, under the influence of the current flowing permanently through their respective lower windings, to swing their respective armatures into engagement with their respective right contacts and incidentally place in the transmission line the pads 47, 48 and 49. Since the circuit is not in use when relay 45 is released this disposition of the pads is immaterial to the operation of the circuit. Ground is further applied through the back contact of relay 45 to the upper terminal of condenser 52 causing the same to be discharged in readiness for the next call.

Considering, now, that portion of the signal energy which is transmitted at each impulse to the enabler circuit 10 via transformer 6, it will be observed that said enabler comprises a rectifier bridge 16 and four polarized relays 17, 18, 19 and 20, each having a permanently closed polarizing circuit through its lower winding which causes the armature thereof to assume the position indicated in the drawing. Further, 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 to the right. Considering relays 17 and 18, for instance, 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 positive battery 30, condenser 21 is normally charged through resistance 22 to the potential of this battery. Condenser 24 of the network between relays 18 and 19, on the other hand, is normally at ground potential since it has ground applied to it through the left contact of relay 18 and resistance 25. Contrariwise, condenser 29 of the network between relays 19 and 20 is charged to the potential of the battery 30 through the upper winding of relay 20 and resistance 28 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, upper winding of relay 20, resistance 28, 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 detector tubes of the several channel detectors $f1$—$f5$, and causes them to be normally unresponsive to signal energy incoming over the resistance pad 14.

Now when a portion of the incoming energy is applied to the rectifier bridge 16, said energy is rectified and the current thereof is applied to the upper winding of relay 17. The combined effect of the current now flowing through the upper winding of this relay and that always flowing through its lower winding is such as to cause its armature to swing from the right contact into engagement with its left contact. Since condenser 21 is normally charged to the potential of battery 30 through the armature and right contact of relay 17, the opening of these contacts immediately causes the condenser to discharge to ground through resistance 23 and the upper winding of relay 18 to prolong the flow of current normally flowing through this relay winding. The direction of the discharge current flowing as well as the normal current through the upper winding of relay 18 opposes that of the current normally flowing through its lower winding, and since the discharge current is initially of greater intensity through the proper control of the ohmic value of resistance 23, the release of relay 18 is delayed and the armature thereof is caused to break away from its left contact at a time subsequent to the operation of relay 17 and to engage its right contact.

During the time that the armature of relay 18 is engaged with its right contact, and remembering that condenser 24 is kept at ground potential while the armature of this relay is making with its left contact, then, as soon as the armature breaks with its left contact, condenser 24 immediately begins to charge over a circuit traced through resistance 26, the upper winding of relay 19 to battery 30 to continue to maintain the flow of normal current over this path for a short time subsequent to the operation of relay 18, whereupon the effect of the current through its lower winding continues to be neutralized for a short time by this changing current rather than by the normal current and the armature of relay 19 is thus caused to break with its left contact at a time subsequent to the operation of relay 18.

At the instant that the armature of relay 18 engages its right contact and before the armature of relay 19 leaves its left contact, a discharge path is completed for condenser 29 which traced from ground, condenser 29, resistance 27, left contacts of relay 19, right contact of relay 18 to ground. The energy accumulated on condenser 29 as a result of the charging circuit through the upper winding of relay 20 is quickly drained off through the low resistance 27 and a current flow is quickly established in the upper winding of relay 20 to cause it quickly to operate and connect ground to conductor 15 to sensitize the detectors, so that when the armature of relay 19 breaks its left contact, condenser 29 is in an uncharged condition and immediately starts recharging through the upper winding of relay 20 to prolong the current flow for a subsequent period. This charging current overcomes the effect of that normally flowing through lower winding of relay 20 and causes the armature thereof to engage its right contact, thus applying ground to conductor 15 which, as said be-

fore, is connected to the cathode of each of the detector tubes in the channel detectors *f1—f5*. The channel detectors are now made responsive and the two which are adapted to respond to the two frequencies in the input current that flows into their respective input side through resistance pad 14 operate, in turn causing the operation of their respective anode relays which, in their turn, cause the operation of relays in the register which designate the digit or character marked by the two frequencies.

It is to be noted that relay 18 will make its right contact at a time subsequent to the energizing of relay 17 by the current through rectifier bridge 16. This time is, of course, determined by the discharge time of the condenser 21 through resistance 23 which causes the normal current through relay 18 to endure for a time (let us say, for example, 20 milliseconds), after the operation of relay 17. At this time relay 18 releases and closes its right contact whereby condenser 29 is quickly discharged through the low resistance 27 and establishes a current through the upper winding of relay 20 to cause its immediate operation. This, as explained, places ground on conductor 15 to sensitize the detectors at a time 20 milliseconds after the signal was first applied. This delay is for the purpose of allowing the unwanted spectrum energy in adjoining channels to dissipate itself in order to avoid unwanted channel operation from this source. It is the purpose of the condenser 24 to maintain, by its discharge current through the upper winding of relay 19, the normal current flowing to hold relay 19 operated on its left contact for a time sufficient to permit the complete discharge of condenser 29 through resistance 27, left contacts of relay 19 and right contacts of relay 18 to ground. Relay 19 then operates to break its left contact and thereafter relay 20 is maintained on the charging current from battery 30, top winding of relay 20, resistance 28, to condenser 29. When this discharge current has dissipated itself, relay 20 will operate and break its right contact to remove ground from conductor 15 regardless of how long thereafter that energy is delivered to relay 17 by the signal.

The length of time during which the armature of relay 20 engages its right contact to cause the channel detectors to remain activated depends, of course, upon the constants of condensers 24 and 29 and resistances 26 and 28, which may be chosen to provide any interval desired, most of the time being determined by the charging time of condenser 29 through resistance 28. However, when the condenser 29 is completely charged, the current through the lower winding of relay 20 again becomes effective, the armature of the relay breaks away from its right contact and ground is removed from conductor 15 and, therefore, from the cathodes of the detector element of the several detector channels which, in consequence, will no longer respond to any signal energy forthcoming over resistance pad 14 and thereby cause their separate anode relays to release.

The circuit conditions prevailing in the enabler during the presence of signal energy in bridge 16 and after the armature of relay 20 has again made its left contact, is that relay 17 will have its armature making with its left contact, relay 18 will have its armature making with its right contact, while relay 19 will have the armature on its right contact which will in no way affect the charge on condenser 29 or the condition of the armature of relay 20 which is out of engagement with its right contact. Hence it makes no difference how long signal energy prevails upon the line subsequent to the armature of relay 20 breaking away from its back contact, said energy will be ineffective to operate the channel detectors inasmuch as ground is disconnected from the cathodes of their several detector elements. This feature is of chief value in avoiding the false operation of adjoining channel detectors due to spectrum transient set up at the channel inputs when the signal is suddenly removed.

When the signal impulse is over, relay 17 will "release," reestablishing quickly thereby the charging circuit of condenser 21 and the current through the top winding of relay 18 to cause it to make its left contact. Relay 18 operates and causes the quick establishment of current through the top winding of relay 19 to cause it to quickly make its left contact. In this operation the condenser 29 has not been discharged since ground via the contacts of relays 18 and 19 has not been made. The enabler circuit is now ready for another cycle of identical operations upon the reception of the next impulse.

While we have described our 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. The combination with a transmission line adapted for transmission thereover of signal energy fluctuating over a wide range, of a plurality of channel detectors each adapted to respond to a signal of a definite frequency and predetermined energy level, and two volume limiting means interposed between said line and said channels of which one is responsive to an incoming signal having an energy level higher than said predetermined level to reduce said signal to some value within a defined energy increment above the predetermined level and of which the other is responsive to the same signal to further reduce the level thereof to said predetermined level.

2. The combination with a transmission line adapted for transmission thereover of signal energy fluctuating over a wide range, of a plurality of channel detectors each adapted to respond to a signal of a definite frequency and predetermined energy level, and two volume limiters both interposed between said line and said channels of which one is responsive to an incoming signal having an energy level higher than said predetermined level to reduce said signal to some value within a defined energy increment above the predetermined level and the other of said volume limiters is responsive to the same signal to further reduce the level therof to said predetermined level, and means in said first volume limiter for rendering said limiter unresponsive to the other succeeding signals.

3. The combination with a transmission line adapted for transmission thereover of signal energy fluctuating over a wide range, of a plurality of channel detectors each adapted to respond to a signal of a definite frequency and predetermined level, and two volume limiting devices

both simultaneously responsive to an incoming signal having an energy level higher than said predetermined level for reducing said signal to said predetermined level, one of said volume limiting devices comprising a thermionic device responsive to said signal, a plurality of relays, a plurality of resistance elements controlled by said relays for connection into said line, each of said resistance elements having a value capable of reducing the signal level by some determined energy increment, and means responsive to said thermionic device for operating one or more of said plurality of relays for connecting a corresponding number of said resistance elements into said line to reduce the level of said signal by as many determined energy increments as there are elements connected.

4. The combination with a transmission line adapted for transmission thereover of signal energy fluctuating over a wide range, of a plurality of channel detectors each adapted to respond to a signal of a definite frequency and predetermined level, and two volume limiting devices both simultaneously responsive to an incoming signal having an energy level higher than said predetermined level, one of said volume limiting devices comprising a thermionic device responsive to said signal, a plurality of relays, a plurality of resistance elements controlled by said relays for connection into said line, each of said resistance elements having a value capable of reducing the signal level by some determined energy increment, and means responsive to said thermionic device for operating one or more of said plurality of relays for connecting a corresponding number of said resistance elements into said line to reduce the level of said signal by as many determined energy increments as there are elements connected, the number of said relays operated depending upon the value of the signal voltage applied to said thermionic device.

5. The combination with a transmission line adapted for transmission thereover of signal energy fluctuating over a wide range, of a plurality of channel detectors each adapted to respond to a signal of a definite frequency and predetermined energy level, and two volume limiting devices both simultaneously responsive to an incoming signal having an energy level higher than said predetermined level, one of said volume limiting devices comprising a thermionic device responsive to said signal, a plurality of resistance elements each capable when connected into said line of reducing the signal level by some determined increment, a plurality of relays for controlling the connection of said resistance elements into said line, each of said relays having a first winding through which flows a normal current adapted to position the relay to normally connect its associated resistance element into the line, an electronic device having its cathode-anode circuit connected serially through a second winding of each of said relays, means responsive to said line being taken into use for the transmission of signals thereover for establishing a cathode-anode circuit through said electronic device including said other winding of each of said relays whereby the current flowing therein opposes the current in the first winding of each of said relays for operating said relays to disconnect their associated resistance elements from said line, and means responsive to said thermionic device for reducing the current in the cathode-anode circuit thereof whereby one or more of said relays are operated to connect their associated resistances into the line, the reduction in the current of said cathode-anode circuit and the number of relays so operated depending upon the value of the signal voltage applied to said thermionic device.

6. The combination with a transmission line adapted for transmission thereover of signal energy fluctuating over a wide range, of a plurality of channel detectors each adapted to respond to a signal of a definite frequency and predetermined energy level, and a first volume limiter responsive to an incoming signal having an energy level higher than said predetermined level, for reducing said signal to some value within one energy increment above the predetermined level, and a second volume limiter responsive to the same signal to further reduce the level thereof to said predetermined level, said second volume limiter comprising a thermionic device responsive to said signal, a variable resistance element connected across said line, and means responsive to the operation of said thermionic device for applying a potential difference across said variable resistance element whereby a shunt is established therethrough to reduce the signal to said predetermined level.

7. The combination with a transmission line adapted for transmission thereover of signal energy fluctuating over a wide range, of a plurality of channel detectors each adapted to respond to a signal of a definite frequency and predetermined energy level, and a first volume limiter coupled to said line and responsive to an incoming signal having an energy level higher than said predetermined level for reducing said signal to some value within one energy increment above the predetermined level, and a second volume limiter coupled to said line and responsive to the same signal to further reduce the level thereof to said predetermined level, said second volume limiter comprising a thermionic device responsive to said signal, an electronic device, three resistance elements forming a resistance bridge with the resistance of the cathode-anode of said electronic device, a variable resistance bridge two vertices of which two are connected to said line and the other vertices of which are connected to terminals of said resistance bridge, means for normally producing a current flow through said bridge whereby no difference of potential is applied to said variable resistance element connected thereto, and a network for the grid of said electronic device responsive to the operation of said thermionic device whereby said grid is negatively biased to reduce the current flowing through said resistance bridge including the cathode-anode branch of said bridge for producing a difference of potential to be applied to the terminals of said variable resistance element whereby a shunt is established across the transmission line therethrough to reduce the signal to said predetermined level.

ALEXIS A. LUNDSTROM.