

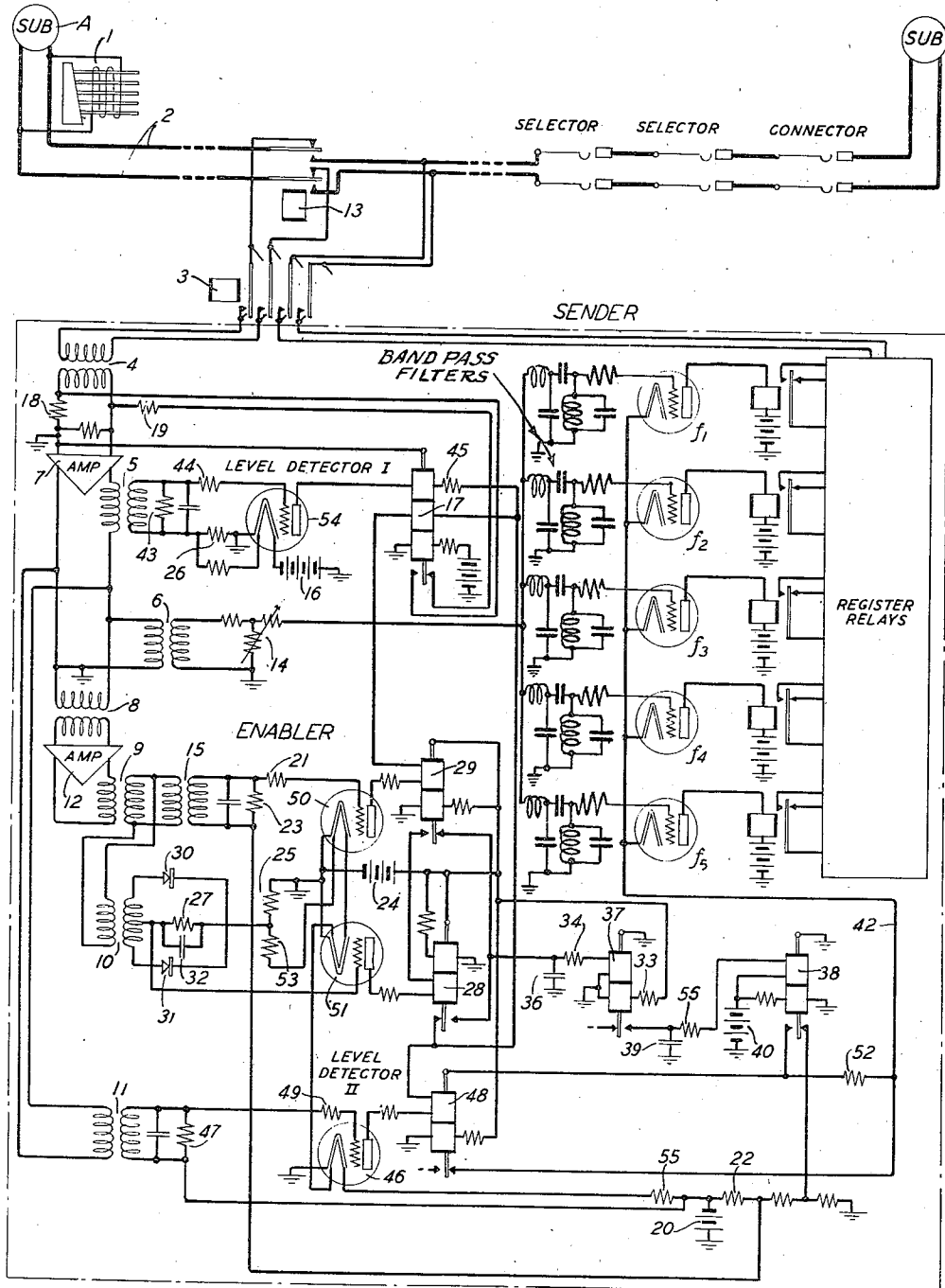
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TELEPHONE SYSTEM

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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 signaling 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 and claimed in Patent No. 2,237,742 granted to A. A. Lundstrom April 8, 1941. In said patent 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, to lock in a record of the digit designated by the two operated relays; that is, by the two frequencies transmitted from the subscriber's station.

In systems of this kind where frequency discriminating channel detectors are used for operative response to the different frequencies which compose the signal impulse, it is necessary for their safe operation to insure that the intensity of the impulse in all of its frequency components is within certain controllable limits in order to guard against false operation of adjoining channels in the event that a frequency spectrum is produced by a high intensity signal. Since the signal currents are generated at different subscriber stations which are at various distances from the channel response mechanism at the central office, the quantity of current received by said mechanism from the different stations will depend upon the length of the different station loops, being very large in the case of a station proximate to the central office and the allowable minimum in the case of the station located at the maximum prescribed distance from the central office. Obviously if the signal current produced over the longest station loop is just sufficient to insure satisfactory response of the different channel detectors, it will be in excess of this amount for any station more proximate to the office, the danger of false channel detector operation obviously increasing with the electrical nearness of the station to the office.

Moreover, due to variations in the duration of

the signal current upon the line, resulting from the different speeds with which different subscribers will manipulate the signal generating instrument, it is necessary to insure the complete operation of the channel detectors up to and including their respective signal relays with the shortest pulse of signal current; otherwise the registering equipment will act as if the full number had not been transmitted from the station and will fail to set up the connection. The channel detectors are, of course, sensitized for signal reception through what is known as an "enabler" circuit which, responding initially to a portion of the incoming signal energy, sensitizes the channel detectors for response to the remainder of the signal current which thereupon operate to set the registers to the value of the digit represented by the signal pulse. However, if the pulse is too short and, in consequence, endures only for a period sufficient to operate the enabler circuit and to sensitize the channel detectors, there will be no current thereafter to which the detectors can respond in which event, although the receiving equipment has received the pulse transmitted from the station, the digit designated thereby will not be registered therein.

Accordingly, one of the objects of the present invention is the provision of means whereby the response sensitivity of the detector channels is reduced whenever the energy level of the incoming signal rises above a first predetermined point.

Another object of the invention is the provision of a second means whereby if the signal energy level rises beyond a second but higher level, an artificial loss is introduced into the transmission line which will reduce the quantity of energy available to operate the detector channels to a definite value above their just operate requirements.

Yet another object of the invention is the provision of means in the enabler circuit whereby the channel detectors will remain sensitized for a definite period after the signal current is removed from the line in order that said detectors may operate thereafter from the electrical energy stored in the electromagnetic elements of the circuit.

These and other features of our 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 the above-mentioned patent to A. A. Lundstrom and in which certain other elements to which our inven-

tion more directly relates, are shown more 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 a plurality of different frequencies in response to the depression of keys that represent digits or characters, 2 represents a line extending from the station instrument to the central office whence, through one of a plurality of selectable sender connectors 3, the line is extended to a free sender which comprises coupling transformers 4, 5, 6, 8, 9, 10, 11 and 15, amplifiers 7 and 12, energy level detectors I and II, the enabler circuit, the five channel detectors f_1 — f_5 and band pass filters intermediate the detector tubes and resistance pad 14, their individual responding relays and the settable register relays (diagrammatically indicated) which are adapted to respond to said channel relays when the same operate in response to an incoming pulse. The amplifiers, the level detectors, the channel detectors are either commercially available circuit units as the following description will indicate or are completely disclosed in the above-mentioned patent to A. A. Lundstrom to which reference is made for a more complete understanding thereof.

In the operation of the invention, a call is initiated at station A by the removal of the receiver from the switchhook whereupon the line is then extended by any suitable means, to the central office at which an available sender is connected to said line through the medium of a sender connector 3 and "key" tone is then transmitted from the sender back to the calling station 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.

When any one of the ten keys of the sending device 1 is operated, two out of five defined frequencies f_1 — f_5 are produced in the combination required to designate the digit represented by the key operated, over a circuit which may be traced from one side of the sending device 1, lower conductor of the loop 2, lower back contacts of relay 13, next to the inner contacts of sender connector cut-in relay 3, primary winding of transformer 4, inner contacts of relay 3, top outer back contacts of relay 13, upper conductor of loop 2, to the other side of the station instrument 1. The current composed of these two frequencies is induced in the secondary winding of transformer 4 and momentarily passes through resistance 18 bridged by resistance 19 via the armature and right contact of polarized relay 17 and is fed into the input side of amplifier 7 whence, after suitable amplification, part of it is applied, through transformer 5, to the level detector I, part of it is applied, through transformer 6, to adjustable resistance pad 14 and channel band pass filters connected thereto, part of it is applied, through transformer 11, to level detector II and part of it, passing by induction through transformer 8 to the amplifier 12 for suitable amplification therethrough, is applied, via transformers 9, 10 and 15 to various parts of the enabler circuit.

From this point on the operation of the circuit may best be described in relation to the length of loop or, more accurately, in relation to the intensity of the incoming signal current between which and the electrical constants of the loop there exists that correlation by which the meas-

urement of the latter determines the quantity of the former. Let it be supposed, therefore, that the loop 2 from station A to the transformer 4 is a maximum and that for this reason, the quantity of signal current generated by device 1 and flowing through the loop in the manner described is at the allowable minimum value to which the channel f_1 — f_5 detectors may be adapted to respond.

Level detector I comprises a gas-filled tube 54 whose grid bias is applied by the voltage drop across resistance 26 from the negative side of the filament battery 16, and the value of resistance 26 is so chosen that the incoming signal voltage up to a certain maximum value represented by the maximum operate voltage allowable for the detector channels will not be sufficient to lower the negative bias to the critical point at which the tube will ionize and become conducting. In consequence, relay 17 which is polarized and, under the influence of its lower winding which has current permanently flowing through it, has its armature engaged with its right contact, will not be affected by the failure of the tube to operate on the signal. This means that the incoming signal current must traverse resistances 18 and 19 before being applied to the input side of amplifier 7. As will be shown, however, this is but a condition which prevails until the enabler circuit functions, at which time relay 17 is operated to short-circuit the pad resistance 18 and remove resistance 19 from the circuit.

Tubes 50 and 51 of the enabler circuit are also of the gas-filled type and will ionize and become conducting when their respective grid biases are at a low negative value. The circuit over which negative bias is applied to tube 50 traces from negative battery 20, resistances 22, 23 and 21, while that of tube 51 traces from negative battery 20, resistance 55, filaments of tubes 46, 51 and 50, resistance 53, to develop a negative voltage drop across resistance 25, to in turn apply this as bias on the grid of tube 51 via resistance 27. Now when the signal current is present in the secondary winding of transformer 15, the bias on the grid of tube 50 is lowered to the critical value which renders the tube conducting since positive battery 24 is present on the anode thereof over a path which traces from the positive pole of said battery, armature and left contact of relay 28, middle winding of relay 17, upper winding of relay 29 to the anode of tube 50. Therefore, upon said tube becoming conducting, relays 17 and 29 operate, the former overcoming the effects of its biasing lower winding to bring its armature into engagement with its left contact to thereby short-circuit resistance 18 and remove resistance 19 from the circuit, and the latter to connect positive battery 24 to the anode of tube 51 via the armature and left contacts of relay 29 and lower winding of relay 28.

Signal current through transformer 10 is rectified in the negative sense because of the presence of the copper-oxide rectifiers 30 and 31 causing thereby a negative potential to be built up across condenser 32 which will persist, of course, for the time that signal current is present. Hence, although positive battery is connected to the anode of tube 51 by the operation of relay 29, the bias of its grid is not decreased by the application of signal current thereto but, in fact, is increased, in consequence of which tube 51 fails to operate while signal current is flowing through the secondary winding of transformer 10 and the rectifiers 30 and 31.

It will be observed that relay 37, which is polarized, has two permanent circuits of which one extends from positive battery 24, resistance 33, lower winding of said relay to ground, and the other extends from positive battery 24, right contact of relay 29, resistance 34, upper winding of said relay 37 to ground. This latter circuit is also effective in charging condenser 36 to the potential of battery 24 and since the two windings of the relay are series aiding when considered relative to their common ground connection, the effect of the two circuits is to keep relay 37 in that operated position which causes the armature thereof to make with its left contact as long as relay 29 is not operated although the circuit through the lower winding will be sufficient by itself to cause the relay to assume the opposite operated position wherein the armature makes with the right contact. When, however, relay 29 operates in consequence of the incoming signal as described above, the charging circuit for condenser 36 is opened at the right contact of said relay and the charge accumulated upon said condenser now discharges through the upper winding of relay 37.

The time of condenser discharge depends, of course, upon the capacity of the condenser and the value of resistance 34 both of which may be so chosen as to give any desired interval between the beginning of the discharge flow and the end thereof, at which time only the circuit through the lower winding of relay 37 is effective to cause the armature of said relay, as already mentioned, to leave its left contact and make with its right contact.

It will be further observed that relay 38, which is also polarized, has an obvious permanent circuit through its lower winding which causes its armature to engage with its right contact. There is also present an obvious charging circuit for condenser 39 through the upper winding of this relay which normally causes said condenser to be charged to the potential of the battery 40. Now when the armature of relay 37 engages its right contact as above described, ground is connected through said right contact to quickly discharge condenser 39 and also quickly cause the operation of relay 38 through the establishment of the circuit through the upper winding of relay 38 to said ground, at which time the combined effect of the two circuits through the windings of relay 38 will cause the armature to pull away from engagement with the right contact into engagement with the left contact.

By making its left contact, relay 38 applies ground to conductor 42 via the right contact of relay 48, and this ground is connected to the cathode of each of the detector tubes of the five channel detectors f_1 — f_5 , causing them to be sensitized for response to that portion of the signal energy which is transmitted thereto via resistance pad 14 and their associated band pass filters. Inasmuch as the operation of the channel detectors forms no part of this invention beyond the sensitizing control exercised over them by the enabler circuit, such operations are omitted, reference again being made to the above-mentioned patent of A. A. Lundstrom for a complete description of their further operation.

In the event of a short signal pulse, that is, of a pulse which is long enough to operate relays 37 and 38 but not long enough to allow for the full operation of the channel detectors, ground on conductor 42 will, nevertheless, be maintained for a period sufficient to permit the detectors to

function from the magnetic energy stored in the impedances of the circuit. As is well known, the passage of current through any circuit that includes electromagnetic and electrostatic elements will cause a certain quantity of energy to be stored in the form of a magnetic field surrounding each of the inductive elements and in the form of a charge on each of the capacitive elements. When the current ceases to flow, each of the magnetic fields collapses and each of the condensers discharges and the energy stored therein will be dissipated in producing an electromotive force that opposes the decay of the current thereby prolonging, in effect, the current flow and causing it gradually to decline to zero. This lengthening out of the current, so to speak, after the signal energy is no longer upon the line is, therefore, only the effect of the energy stored in the electromagnetic and electrostatic elements of the circuit when current first passes through the circuit. Referring to the drawing, when the signal current is transmitted through transformer 6 to the channels, the two frequencies of which the current is composed pass through whichever two band-pass filters are tuned to such frequencies, and a certain amount of energy will be stored in the form of a magnetic field around the coils and in the form of a charge on the condensers of the band-pass filter networks connected to the grid of the two respective channel tubes. It is obvious that if the tubes are sensitized for response as they would be by the application of ground on conductor 42, then, if the signal current ceases to flow before the tubes operate on said current but after the energy has been stored in the filters associated therewith, the tubes can, nevertheless, operate in response to the prolongation of the current that follows the decay of this energy, and will remain operated until the energy is dissipated below the operate point of the tubes. It is evident, therefore, that for a very short current pulse which, if applied to the circuit without the feature of delayed enablement would not be of sufficient duration to allow the tubes to operate, the operation of said tubes will nevertheless be insured if the sensitivity of the tubes is maintained by causing ground to be applied to the cathodes thereof over conductor 42 until the magnetic fields surrounding the coils of the band-pass filter networks will have collapsed and the charges on the condensers of the band-pass filter networks will have been dissipated. Hence, if ground is maintained on conductor 42 after the signal current is no longer on the line, the particular tubes involved can still function. As said before, ground is maintained on conductor 42 and the reason for this is the fact that when the signal disappears, the negative potential built up on condenser 32 discharges and the additional negative grid bias set up by the signal across resistance 25 for tube 51 will reduce to zero whereupon said tube becomes conducting and causes the operation of relay 28 in its anode circuit which, upon breaking its left contact, removes anode battery from tube 50 causing it to restore and to further restore the armature of relay 29 to its right contact.

When the armature of relay 29 makes with its right contact, the circuit through the upper winding of relay 37 is reestablished. The circuit through the upper winding of relay 37 becomes quickly effective in pulling the armature to its left contact because the condenser 36 is quickly

charged and does not appreciably slow up the establishment of current in this winding.

When the armature of relay 37 breaks with its right contact an obvious charging circuit is effective for condenser 39 through the upper winding of relay 38, and since the direction of the charging current is opposite to that of the current flowing through the lower winding of this relay and is sufficiently powerful to overcome its effect, said relay will not respond to the influence of the current flowing through its lower winding, which is to cause its armature to engage its right contact, until the condenser is fully charged to the potential of the charging battery 40, which is to say, until there is no further flow of charging current, at which time the armature, in breaking with its left contact, removes ground from conductor 42 and, therefore, from the cathode of the channel detector tubes. As in the case of relay 37, the time when the armature of relay 38 functions under the control of the lower winding of said relay depends upon the capacity of the condenser 39 and the value of resistance 56 which may and should be so chosen as to provide any suitable interval consistent with causing the detector channels to remain activated to respond to whatever of the signal energy was stored in the reactive elements of the channel filters after the signal disappears from the line.

As the line loop becomes shorter the quantity of signal energy available for the detector channels becomes greater and it may be conceived to reach the level for which the grid of tube 54 of level detector I is biased by the potential of negative battery 16 as applied by the voltage drop across resistance 26 which is applied to the grid via resistances 43 and 44. It will be observed that the armature of relay 17 is normally engaged with its right contact under the influence of current flowing through its lower winding but that when a signal comes in which does not affect tube 54, relay 17 operates serially with relay 29, as already described, to effectively remove resistance pads 18 and 19 from the line. Now when the intensity of the signal current rises above the biasing level of the grid of tube 54, said tube ionizes and becomes conducting whereupon the anode circuit which is established through the upper winding of relay 17, resistance 45, left contact of relay 28 to battery 24 becomes effective in immediately releasing relay 17 or holding it released in opposition to the current flowing from battery 24 through its middle winding, upper winding of relay 29, anode and cathode of tube 50, to the negative side of battery 24. The releasing or holding released of relay 17 causes its armature to be positioned on its right contact so that resistance pads 18 and 19 are cut into the line between transformer 4 and amplifier 7 to reduce the intensity of the signal by an amount measured by the value of the resistance pads 18 and 19.

Assume, now, that the loop becomes still shorter and that the intensity of the signal rises correspondingly notwithstanding that a portion of its energy is dissipated through resistances 18 and 19 once the energy reaches the level where these resistances are maintained in circuit as above described. The grid of gas-filled tube 46 is biased by negative battery 20 via resistances 47 and 49, the value of which bias is determined by the energy level of the incoming signal at which it is desired to cause level detector II to become responsive. When this level is reached,

tube 46 ionizes and becomes conductive whereupon the space current between its cathode and anode flows to the positive pole of battery 24 via the upper winding of relay 48 and left contact of relay 28. Relay 48 operates to cause its armature to break with its right contact and engage its left contact whereupon the detector channels sensitizing ground which heretofore was applied to conductor 42 via the right contact of relay 48, as previously explained, is now applied through resistance 52 which, of course, is short-circuited by the contacts of relay 48 when the energy level is not sufficiently high to cause the operation of level detector II.

The introduction of a resistance 52 in the electron path of the cathode of the channel detectors causes them, of course, to be less responsive and reduces in each of them the quantity of cathode-anode current that will flow for a given energy level. The quantity of this current may be kept within any operating limits desired by choosing an appropriate value for resistance 52.

When the signal disappears, the circuit is released as heretofore and, in addition, the detector tubes 50 and 46 are quenched to cause, respectively, relay 17 to maintain its armature in engagement with its right contact and relay 48 to move its armature into engagement with its right contact. On the next incoming signal, the enabler circuit and the two level detectors will function again in the manner described.

While we have described our invention and the means for utilizing the same in connection with its specific application to one kind of 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. A transmission line comprising a detector channel, means for activating said channel to respond to incoming signal energy for an interval subsequent to the removal of said signal from said line, and means responsive to a plurality of different levels of said signal energy for maintaining the energy response of said channel at a predetermined level.

2. A transmission line comprising a plurality of detector channels each adapted to respond to a signal of a definite frequency transmitted over said line, means responsive to a signal for activating said channels for response to said signals for a period longer than the duration of the signal, and means responsive to a plurality of different levels of said signal energy for maintaining the energy response of said channels at a predetermined level.

3. A transmission line comprising a plurality of detector channels each adapted to respond to a signal of a definite frequency transmitted over said line, means responsive to a signal for activating said channels for response thereto for a predetermined period longer than the duration of the signal, a resistance pad, means responsive to a predetermined energy level of said signal for applying said resistance pad to the line to reduce the energy level of said signal, means for reducing the sensitivity of said channel to energy applied to the input side thereof, and means responsive to another predetermined energy level for applying said sensitivity reducing means to said channels for keeping the output thereof within a predetermined level as determined by said sensitivity reducing means.

4. In combination, a transmission line terminating in a plurality of detector channels each tuned to respond to a signal of a definite frequency transmitted over said line, means responsive to a signal of a first predetermined intensity above the just operate level of said detectors for reducing the response sensitivity of said detectors, and means responsive to a signal of a second predetermined intensity above the just operate level of said detectors for introducing an energy drop in said transmission line.

5. An enabler circuit for the channel detectors of a transmission line comprising a timing circuit adapted for applying a potential to the detector elements of said channel detectors for activating the same to respond to incoming signal energy, a first thermionic device operative in response to incoming signal energy for initiating the operation of said timing circuit, and a second thermionic device operative in response to the termination of said incoming energy for initiating the termination of the operation of said timing circuit, whereby said timing circuit remains operated for a predetermined interval subsequent to the termination of said incoming signal energy.

6. An enabler circuit for the channel detectors of a transmission line comprising a timing circuit for applying a potential to the detector elements of said channel detectors for activating the same to respond to incoming signal energy, a first thermionic device, a polarized relay in the anode circuit thereof operatively responsive to the operation of said device consequent to signal energy incoming over said transmission line to initiate the operation of said timing circuit, a second thermionic device having a normal grid bias at the operating point of said device, a rectifier network interposed between said grid and said transmission line for applying rectified signal energy incoming over said transmission line to said grid whereby said normal grid bias is overcome and said device prevented from operating so long as there is signal energy flowing over said transmission line, and a polarized relay in the anode circuit of said second thermionic device responsive to the operation of said device

upon the termination of signal energy over said transmission line for initiating the termination of the operation of said timing circuit, whereby said timing circuit remains operated for a predetermined interval subsequent to the termination of said incoming signal energy.

7. The combination with a transmission line provided with a plurality of channel detectors, of an enabler circuit for activating the detector elements of said channel detectors to respond to incoming signal energy, a first energy level detector for applying a line loss whenever the incoming energy is above a first predetermined level and a second energy level detector for reducing the activation of said detector elements whenever the incoming energy is above a second predetermined level, comprising a source of potential, a timing circuit adapted to apply said source of potential to said detectors, a resistance network, a thermionic device in said first level detector, a relay in the anode circuit thereof adapted to apply said resistance network to said transmission line, a resistance, a thermionic device in said second level detector, a relay in the anode circuit thereof adapted to apply said resistance serially to said source of potential for reducing the amount of potential applied to said detector elements, means responsive to incoming energy for initiating the operation of said timing circuit whereby activating potential is applied to said detector elements for response to said incoming energy, and whereby when the incoming energy reaches said first predetermined level said thermionic device in said first level detector is rendered conducting to operate said relay in the anode circuit thereof to apply said resistance network to said transmission line, and whereby when said incoming energy reaches said second predetermined level, said thermionic device in said second level detector is rendered conducting to operate said relay in the anode circuit thereof for applying said resistance serially to said source of potential.

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