

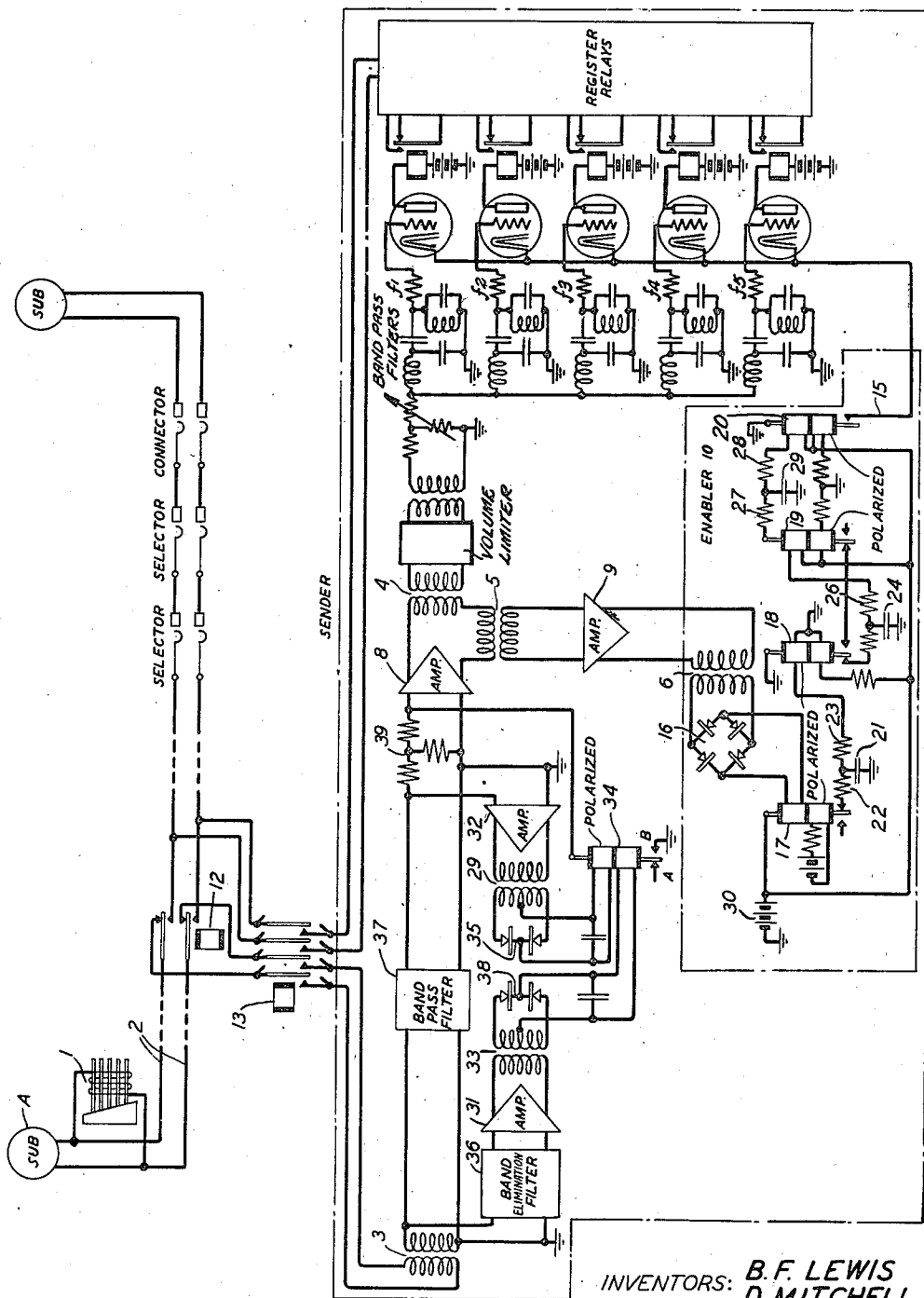
Dec. 22, 1942.

B. F. LEWIS ET AL

2,306,067

TELEPHONE SYSTEM

Filed Oct. 16, 1940



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2,306,067

TELEPHONE SYSTEM

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Application October 16, 1940, Serial No. 361,382

6 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 Patent 2,269,022 granted to G. Hecht and A. A. Lundstrom on January 6, 1942. 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 provided with a plurality of channel detectors each selectively tuned to a different band of frequencies and responsive thereto to operate a relay which, in combination with a relay operated over another channel detector responsive to another frequency band, 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, speech and noise probably will include said signal frequencies. Should speech or noise become impressed upon any sound energy translating device connected to the line such as, for instance, the telephone transmitter and receiver of the telephone station, or should the noise be line noise or "contact noise"; that is, noise generated at the relay contacts included in the built-up transmission line, due to the small variations in the quantity of currents passing through the contacts, then, since the frequency spectrum of speech or 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 not have been operated.

In accordance with a feature of this invention, the channel detectors are protected against false operation by the use of a guard channel tapped to the transmission line and responsive to the entire voice spectrum frequency which necessarily includes, of course, the signal frequencies themselves. The guard channel comprises a band elimination filter adapted to pass all frequencies intermediate the several different signal frequency bands as well as all other frequencies on either side of the entire signal frequency range, two amplifier detectors of which one is placed after the band elimination filter and the other is tapped to the transmission line after the pass-band filter disposed thereon to pass the signal frequencies only, and a polarized relay interposed between the two amplifier detectors and adapted to clear or block the channels depending upon whether or not the noise level passing through the band elimination filter is higher or lower than signal energy level passing through the signal pass-band filter.

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 the above-mentioned patent to G. Hecht and A. A. Lundstrom and in which certain other elements to which our 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 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 whence, through one of a plurality of selectable sender connectors 13, the line is extended to a free sender which comprises coupling transformers 3, 4, 5, 6, 7, 29 and 33, band elimination filter 36 and pass-band filter 37, amplifiers 8, 9, 31 and 32, the polarized relay 34, volume limiter 11, the enabler circuit 10, and the channel detectors f1, f2, f3, f4 and f5 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 amplifiers 8 and 9, 31 and 32, and the volume limiter 11 are commercially available circuit units while the channels f_1 — f_5 are completely disclosed in Patent 2,237,742 issued to A. A. Lundstrom on April 8, 1941, 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 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 apparatus 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, the transmitter and receiver of the station instrument are short-circuited or otherwise removed from the line in any suitable manner, two out of the five defined frequencies f_1 — f_5 are produced in the combination required to designate the digit represented by the operated key, or when currents are present in the line produced therein by any means responsive to speech or noise energy or consequent thereto, the same 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 or produced by the speech or noise, is induced in the secondary winding of transformer 3 and fed into the input side of band-pass filter 37 and band elimination filter 36. Now band-pass filter 37 will pass only five bands of frequencies each of which includes one of the signal frequencies that can be produced by generator device 1 and block out all intermediate frequency bands as well as those on the outer side of the first and the outer side of the fifth of the five signal frequency bands. On the other hand, band elimination filter 36 will pass only the frequencies intermediate each signal frequency band as well as those on the outer side of the first and the outer side of the fifth of the five signal frequency bands but will block out each of the signal frequency bands passed by the band-pass filter 37. Assuming that the incoming signal comprises two signal frequencies only, then the same will be applied from the output side of band-pass filter 37 to amplifier 32 and pad 39. The portion of the energy which is applied to amplifier 32 is passed, via transformer 29, to the rectifying element 35 and the direct current produced thereby flows through the upper winding of polarized relay 34 over an obvious circuit which includes the winding of this relay. The flow of this current is in such a direction as to move the armature of the relay to its contact A, if it is not already in that position, in which event the signal energy will be applied to the input side of amplifier 8. The energy applied to amplifier 8 will be suitably amplified and applied, 75

through transformer 4, to the input side of the volume limiter 11 and is also applied, through transformer 5, to amplifier 9 whence, after suitable amplification, it is applied, via transformer 6, to the enabler circuit 10 to perform functions discussed hereinafter.

Assume, now, that the incoming current comprises a broad band frequency spectrum such as would be produced, for example, by noise, and that this frequency spectrum includes frequencies within the outside limits of the signal frequency band, including also the signal frequency bands themselves as well as other frequencies outside of the limits of the entire signal frequency band. Since band-pass filter 37 blocks all frequencies except those in the signal frequency band, the same will get through to amplifier 32, the latter operating to cause the armature of relay 34 to be operated against its contact A as already described. The band elimination filter 36, on the other hand, will pass all frequencies except those in the several signal frequency bands. Hence that portion of the entire noise frequency spectrum which does not include signal frequencies will pass through band elimination filter 36 for application to the input side of amplifier 31 when, after suitable amplification, the amplified energy is applied to the primary of transformer 33 to the secondary terminals of which is connected the rectifying device 38 to whose mid-point as well as the mid-point of the secondary winding of transformer 33 is connected the lower winding of relay 34, wound differentially with respect to its upper winding.

The gain of amplifier 31 may be set at a somewhat higher level than that of amplifier 32 just to make certain, in the event that the filtered noise energy getting through filter 36 is no greater than the filtered signal energy getting through filter 37, that the quantity of rectified current resulting from the noise and which flows through the lower winding of relay 34 is sufficiently large to overcome the rectified current flowing through the upper winding of said relay in consequence of the filtered frequencies passing through filter 37 and into the amplifier 32. Since the windings of the relay are opposed to each other, the resultant effect upon the relay is that, due to the current flowing through its lower winding, the armature is moved into engagement with contact B. Ground is now applied by the armature of the relay to the upper input terminal of amplifier 8 and since the lower input terminal is already grounded, said amplifier is short-circuited, thus preventing the signal frequencies which are included in the noise frequency spectrum from being transmitted to the amplifier. In this way the channels are protected from false operation since the signal frequencies present in the noise spectrum are now passed on to ground on the input side of amplifier 8 without any of them getting through to transformer 4 and hence to the volume limiter 11.

Assuming, now, that the incoming signal comprises the two signal frequencies only, as would be the case if no noise were upon the line and the frequencies present would be only those generated by device 1, then, as said before, a part of the energy will be applied to amplifier 32 to cause the operation of relay 34 over its upper winding whereby its armature is held against contact A and amplifier 8 is kept open, and another part would be applied to amplifier 8 where, after suitable amplification, the amplified energy is applied

to the volume limiter 11 and, through transformer 5, to amplifier 9.

It should be remembered that prior to the depression of each key in the generating device 1, the transmitter and receiver of the station instrument are exposed to room noises, speech and the like. In such a case the currents generated by the transmitter will, of course, be transmitted over the guard channel, part of said currents going through filter 36 and amplifier 31 to cause rectified current to flow through the lower winding of relay 34 and such components of said currents which comprise signal current components will pass through filter 37 and amplifier 32 to cause rectified current to flow through the upper winding of relay 34. Since it may be safely assumed that quantity of energy carried by the frequencies other than the signal frequency components thereof is of the same order of magnitude as that carried by the signal frequency components themselves, the armature of relay 34 will engage contact B, in which event amplifier 8 is short-circuited and the signal frequency components of the speech or noise are prevented from passing into the channels. When one of the keys of generating device 1 is depressed, however, and, in consequence, the transmitter and receiver are disabled, speech and noise can no longer affect said transmitter and receiver and the frequencies transmitted are only those generated by the operation of the generating device 1. Since, in this case, practically no energy flows into amplifier 31 but practically all of it passes through amplifier 32, the current through the upper winding of relay 34 will greatly exceed any current that may flow through the lower winding, and the armature of relay 34 will shift from engagement with contact B into engagement with contact A, the short circuit is removed from amplifier 8 and the signal frequencies generated by the operation of device 1 allowed to pass into the channel detectors.

Considering, now, that portion of the signal energy which passes into the volume limiter 11, the energy causes said volume limiter to operate and regulate the energy output in accordance with its adjustment which may be such as to limit the 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 cause false operation of adjoining channel detectors by currents present in the frequency spectrum generated thereby and thus cause the registration of a false number. Hence by adjusting the volume limiter to a suitable level of output energy above the operate level of the channel detectors, their false operation upon heavy signal currents is avoided.

The energy output from the volume limiter 11 is applied, through transformer 7, to the variable resistance pad 14 whence it is applied through suitable filtering devices to the grids of the detector tubes in the channels. These tubes are normally unresponsive, being under the control of the enabler circuit as described below.

Considering, now, that portion of the signal energy which is transmitted 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, the armatures of which normally assume the positions indicated

in the drawing either in consequence of the current flowing through the polarizing windings as in the case of relays 17 and 20, or in consequence of the currents flowing through the lower winding and upper winding as in the case of relays 18 and 19. 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 since the short-circuiting ground path for condenser 29 is normally open at the right contact of relay 18, which fact leaves condenser 29 exposed to the charging circuit that traces from the positive pole of battery 30, through the upper winding of relay 20, resistance 28 and condenser 29 to ground.

Assuming, therefore, that relays 17, 18, 19 and 20 have their respective armatures in the positions shown, and that condensers 21, 24 and 29 are charged, discharged and charged, respectively, as indicated above, ground is normally disconnected from conductor 15 at the right contact of relay 20, which conductor is, in turn, connected to the cathodes of the 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 start discharging to ground through resistance 23 and the upper winding of relay 18 to prolong the flow of current that is normally flowing through this relay winding. The direction of the discharge current 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 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 charging 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 through condenser 29, resistance 27, left contact 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 therefor 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 before, is connected to the cathode of each of the detector tubes in the channel detectors f_1 — f_5 . 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 the 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 there-through 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 is 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 become disengaged from its right contact, is that relay 17 will have its armature making with its front contact, relay 18 will have its armature making with its right contact, while relay 19 will have its armature on its right contact which will in no way effect 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 right contact, said energy will be ineffective to operate the channel detectors inasmuch as ground is disconnected from the cathodes of their several detector elements.

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 applied. 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. In a telephone system, in combination, a transmission line terminating in a plurality of channel detectors each adapted to respond to a signal within a definite frequency band transmitted over said line, and a guard channel for said channel detectors connected in parallel with said transmission line comprising means responsive to an energy frequency band including one or more signal frequencies for preventing said

signal frequencies from entering said channel detectors.

2. In a telephone system, in combination, a transmission line terminating in a plurality of channel detectors each adapted to respond to a signal within a definite frequency band transmitted over said line, and a guard channel for said channel detectors comprising a first filter adapted to pass signal frequency bands only, a second filter adapted to pass all frequencies excluding those which comprise said signal frequency bands, and means responsive to energy transmitted over said line including signal frequencies passed through said first filter and other frequencies passed through said second filter for preventing said signal frequencies from entering said channel detectors.

3. In a telephone system, in combination, a transmission line terminating in a plurality of channel detectors each adapted to respond to a signal within a definite frequency band transmitted over said line, and a guard channel for said channel detectors comprising a first filter adapted to pass signal frequency bands only, an amplifier connected to said first filter, a second filter adapted to pass all frequencies excluding those which comprise said signal frequency bands, another amplifier connected to said second filter, and differentially operated means responsive to energy transmitted over said line including signal frequencies passed through said first filter and amplified by the amplifier connected thereto and other frequencies passed through said second filter and amplified by said other amplifier connected thereto for preventing said signal frequencies from entering said channel detectors.

4. In a telephone system, in combination, a transmission line terminating in a plurality of channel detectors each adapted to respond to a signal of a definite frequency transmitted over said line, and a guard channel for said channel detectors comprising a first filter adapted to pass signal frequency bands only, a first amplifier connected to said first filter, a second filter adapted to pass all frequencies excluding those which comprise said signal frequency bands, a second amplifier connected to said second filter, and a polarized relay having one winding coupled to the output of said first amplifier and another winding coupled to the output of said second amplifier, said windings being connected in a differential sense with respect to each other, whereby said relay operates in response to the signal frequency currents passed through said first filter and amplified by the first amplifier connected thereto to allow signal currents to

reach said channel detectors and to all other frequency currents passed through said second filter and amplified by the second amplifier connected thereto to prevent said signal frequencies from entering said channel detectors.

5. In a telephone system, in combination, a transmission line terminating in a plurality of channel detectors each adapted to respond to a signal within a definite frequency band transmitted over said line, and a guard channel for said channel detectors comprising a first filter adapted to pass signal frequency bands only, a first amplifier connected to said first filter, a second filter adapted to pass all frequencies excluding those which comprise said signal frequency bands, a second amplifier connected to said second filter, the gain of said second amplifier being set at a higher level relative to the gain of said first amplifier, a polarized relay having two windings, transformers coupling one winding of said relay with the first amplifier and the other winding with said second amplifier in a differential sense, and rectifying means intermediate each winding and its related coupling transformer whereby the signal frequency currents passed through said first filter and amplified by the first amplifier connected thereto are rectified for passage through one winding of said relay and the other frequency currents passed through said second filter and amplified by the second amplifier connected thereto are rectified for passage through the other winding of said relay for operating said relay on the differential currents to prevent said signal frequencies from entering said channel detectors.

6. In a telephone system, in combination, a transmission line terminating in a plurality of channel detectors each adapted to respond to a signal within a definite frequency band transmitted over said line, and a guard channel for said channel detectors comprising a first filter adapted to pass signal frequency bands only, a second filter adapted to pass all frequencies except those within said signal frequency bands, and means responsive to energy transmitted over said line when the energy carried by said other frequencies is of the same order of magnitude as that carried by said signal frequencies for preventing said signal frequencies from entering said channel detectors, said means also being operative to permit said signal frequencies to enter said channel detectors when the energy carried by said signal frequencies is much greater than that carried by said other frequencies.

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