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TELEPHONE SYSTEM

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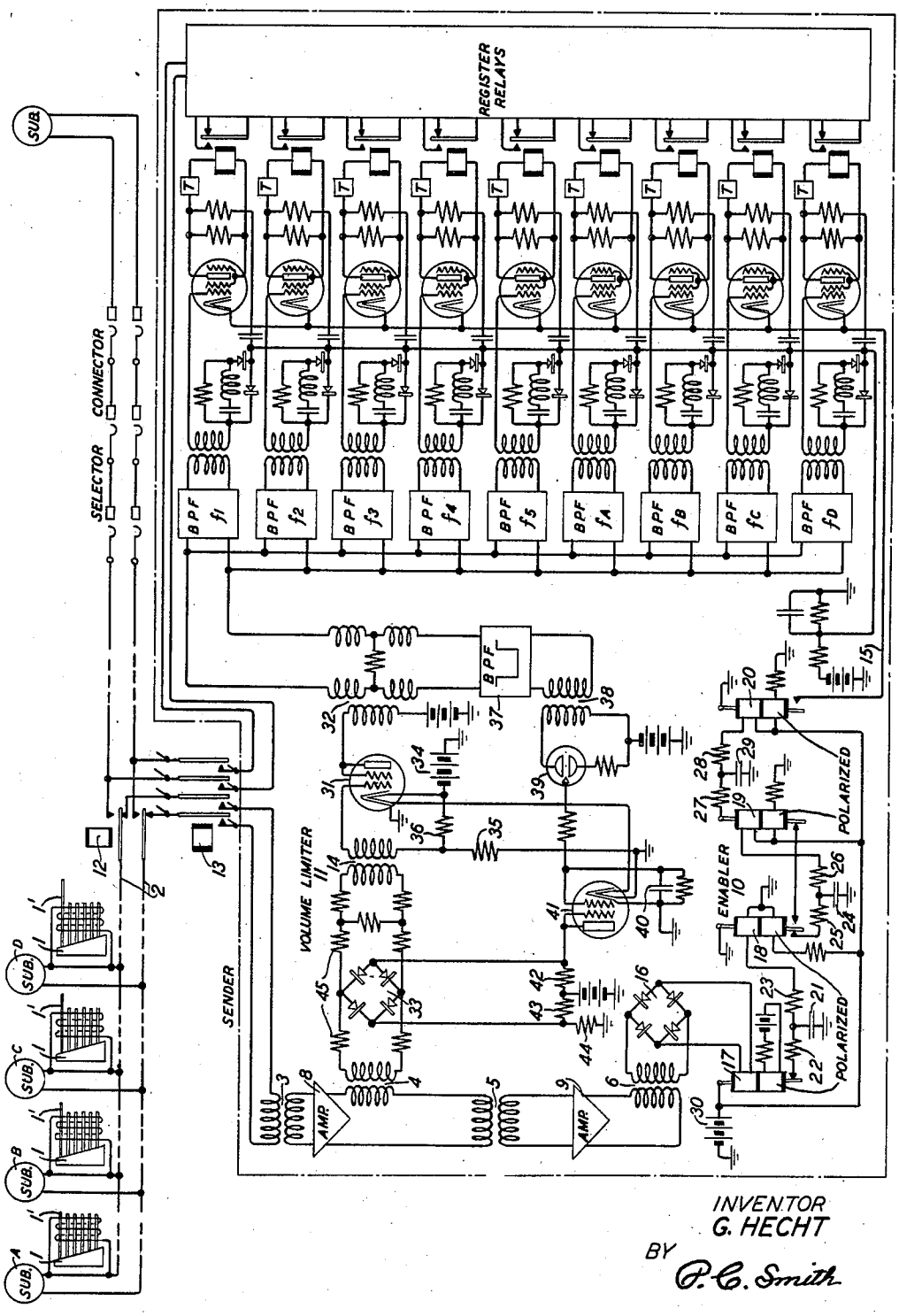

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TELEPHONE SYSTEM

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This invention relates to telephone systems and more particularly to the receiving equipment of a transmission line over which alternating currents, preferably within voice frequency range, are transmitted for effecting the operation of said equipment which, in turn, may be used to control 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 2,237,742 issued to A. A. Lundstrom on 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 terminating in a plurality of channel detectors each selectively tuned to a different one of the signal frequencies and responsive thereto to operate a relay which, in combination with a relay operated over another channel detector responsive to a current of another signal frequency, serves to function a settable register, or sender, in which is locked-in a record of the digit indicated by the two operated relays; that is, by the two frequencies transmitted from the subscriber's station.

In systems of this kind where the signal generating instrument is usually a plurality of keys or the like which are operated to produce a different combination of frequencies to which the channel detectors are respectively tuned to respond, the signal energy available at the channels is a function of the ohmic resistance of the line, and since for the best operating efficiency of the channels the quantity of energy applied thereto must be kept within definitely controlled limits, it becomes necessary to control the energy input to the channels by means of a volume limiting device whose gain or loss is controlled by an instrumentality responsive to the electrical characteristics of the line.

Accordingly, one feature of the present invention relates to a volume limiter whose gain is controlled by a special frequency generated at the calling station and transmitted to the volume limiter over the line loop established between the station and the central office. In its specific application to the present embodiment of the invention, the transmitting device which generates the signal frequencies includes a special reed which is operated in combination with other reeds of the device reserved for digit or character signal purposes, and whenever one of the keys designating a digit or character is operated, the special reed is plucked to cause the generation of a current of the frequency indicated by its own natural period, which current is then utilized at the central office to set the gain of the volume limiting device.

In accordance with another feature of this invention as applied to a telephone system in which a plurality of stations are located on the same line, the signal frequency used for the purpose of setting the gain of the volume limiter is also utilized to identify the station from which the signals are transmitted, there being one special frequency for each station, each of which, however, is also capable of setting the gain of the volume limiter. A receiving channel for each of the special frequencies is provided in parallel with the receiving channels for the other signal frequencies so that, by the operation of the channel reserved for the individual stations, a registration of the calling station designation may thus be effected in response thereto.

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 said above-mentioned patent to A. A. Lundstrom and in which certain other elements to which my invention more directly relates, are shown in detail.

Referring now, to the drawing, A, B, C and D represent party line subscriber stations in an automatic telephone system, each of said stations being equipped with a device 1 suitably arranged to produce one or more currents of different frequencies preferably 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. Each of the devices 1 has a special reed 1' which, when deflected and released, generates a frequency that characterizes the particular station of which it forms a part and is plucked in combination with a plurality of other reeds in the device 1 whenever the same is operated to generate signals indicated by the designation of the key used in operating said device. 2 represents a line that extends from the station instruments to the central office whence, through one of a plurality of selectable sender connectors 13, the line is extended to an idle sender which comprises the coupling transformers 3, 4, 5 and 6, amplifiers 8 and 9, the volume limiter 11, the enabler circuit 10 and the channel detectors f1,

f2, f3, f4, f5 and fA, fB, fC, and fD individually so designated in accordance with the frequency to which each of the channels is respectively assumed adapted to respond, which channels include, also, individually responding relays and the settable register relays (not shown) which follow the operation of the channel relays when operated to signalize an incoming impulse.

The amplifiers 8 and 9 are commercially available circuit units, the device 1 is completely described in Patent 2,147,710 granted to R. F. Mallina on February 21, 1939, except as easily modified to include the additional reed 1' while the channels f1—fD are completely disclosed in the above-mentioned patent to A. A. Lundstrom already mentioned and to which reference is made for a more complete understanding thereof. It is to be understood, however, that the invention is not limited to channels of this description or to other apparatus herein used for the purposes of illustrating the operation of the invention.

In the operation of the invention, a call is initiated at any one of the stations, say, station B, 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 the sender connector 13 after which "key tone" is transmitted back to the calling station B by circuits not shown, as a signal that the sending device 1 may be operated to transmit the number of the wanted station and the designation of the calling 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 devices 1 is operated, two of the five defined frequencies f1—f5 are produced in the combination required to designate the digit or character represented by the key depressed and also the special frequency B which is produced by the deflection of reed 1' in combination with the two digit reeds. The resulting current produced, which consists of two signal frequencies and frequency B superimposed upon each other, is transmitted over a circuit which may be traced from one side of the sending device 1 over the lower conductor of the looped pair 2, lower back contact of relay 12, inner contacts of sender connector cut-in relay 13, primary winding of transformer 3, next to the inner contact of relay 13, inner back contact of relay 12, upper conductor of looped pair 2 to the other side of the station sending device 1. The current composed of the three frequencies is induced in the secondary winding of transformer 3 and fed into the input side of amplifier 8, whence, after suitable amplification, it is applied from the output side of said amplifier to the input sides of transformers 4 and 5, respectively, whence it is further applied, through transformer 4, to the input side of transformer 14 and, through transformer 5, to the input side of amplifier 9.

Considering that portion of the signal energy which passes through transformer 4, the energy further passes through the resistance network 45 after which it is applied, through transformer 14, to the grid of vacuum tube 31. Normally there is a plate current flowing through this tube as is obvious from the circuit drawing, the normal bias for the grid thereof being drawn from negative battery 34 and resistances 35 and 36. When the signal impulse is transmitted, the bias on the grid is altered in accordance with the value of the signal which, in turn, causes a variation in the plate current which is applied, through transformer 32, to the channel filters f1—f5 and also to the party line channel filters fA—fB. Part of the energy, however, goes through the band-pass filter 37 and is applied, through transformer 38, to the control electrodes of the cold cathode tube 39. The band-pass filter 37 passes only the station identifying frequencies fA—fD. However, although a station frequency passes through the band-pass filter regardless of its intensity, the tube 39 is not rendered conducting except if the level of the signal energy is above the predetermined volume limiting point. When this point is reached tube 39 is rendered conducting and thereupon applies a potential to condenser 40 which, in turn, applies a negative bias to the grid of vacuum tube 41 which, in turn, reduces the normal anode current flowing through the bridge circuit comprising resistances 42, 43, 44 and the anode to cathode resistance of said tube. This causes a potential difference to develop between resistances 42 and 43 which is applied to the rectifier bridge 33 causing direct current to flow therethrough and establish a shunt loss across the line to reduce the level of the incoming energy to the desired point. The particular channels f1—f5 as well as channel fB operate when the channel tubes are sensitized by the connection of ground to conductor 15 as described below, one or more channels f1—f5 operating to register the called line designation and channel fB operating to identify the calling station B. Inasmuch as the operation of the channels after sensitization is described in the above-mentioned patent to A. A. Lundstrom, the operation of the channels beyond this point is not repeated except that reference is made to said patent for a complete description of the operation of said channels.

Considering, now, that portion of the signal energy which is transmitted via the transformer 6, it will be observed that enabler 10 comprises the rectifier bridge 16 and the four polarized relays 17, 18, 19 and 20, each having a permanently closed polarizing circuit through their respective lower windings which cause the armatures of the relays to assume the positions indicated in the drawing. Furthermore, 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 the positive battery 30, condenser 21 is normally charged 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. 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 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 posi-

tions shown and that condensers 21, 24 and 29 are charged, discharged and charged, respectively, as indicated above, ground is normally disconnected from conductor 15 at the right contact of relay 20 which conductor is, in turn, connected to the cathodes of the channel detector tubes of the several channel detectors *f*1—*f*D and causes them to be normally unresponsive to signal energy incoming through the transformer 32.

Now when a portion of the input energy is applied to the rectifier 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 away from its right contact. Since condenser 21 is normally charged to the potential of battery 30 over 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 winding of this relay. 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 for an interval after which the armature thereof is caused to break away from its left contact at a time subsequent to the operation of relay 17 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 engaged with its left contact, then, as soon as the armature breaks with this contact, condenser 24 immediately begins to charge over a circuit which may be traced through resistance 26 and 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 the lower winding of relay 19 continues to be neutralized for a short time by this charging current. The armature of relay 19 is subsequently caused to break with its left contact at a time subsequent to the operation of relay 18, that is, at the time when the charging current for condenser 24 through the upper winding of relay 19 is no longer powerful enough to overcome that flowing through the lower winding of the relay.

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 may be traced from ground through condenser 29, resistance 27, armature and contact of relay 19, right contact and armature of relay 18 to ground. The charge accumulated on condenser 29 as a result of the charging current in the circuit through the upper winding of relay 20 is quickly drawn off through the low resistance 27, and a current flow is quickly established through the upper winding of relay 20 for its rapid operation whereby ground is connected to conductor 15 to sensitize the detectors *f*1—*f*D so that when the armature of the relay 19 breaks with 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 therethrough for a subsequent period. This charging current overcomes the effect of that normally flowing through the 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*D. The channel detectors are now made responsive and the three which are adapted to respond to the three frequencies in the input current that flows in their respective input side via transformer 32 operate, causing in turn, the operation of their respective anode relays as fully described in the above-mentioned patent to A. A. Lundstrom and which, in their turn, cause the operation of relays in the register to identify the digit or character marked by two of the frequencies and the station designated by the frequency B.

It is to be noted that relay 18 will make its right contact at a time subsequent to the energization of relay 17 by the rectified current flowing through the bridge 16. This time is, of course, determined by the discharge time of condenser 21 through resistance 23 which causes the normal current through relay 18 to endure for a time 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 conductors at some time after the signal is first applied. This delay is for the purpose of allowing the unwanted spectrum energy in adjoining channels to dissipate itself to avoid unwanted channel operation from this source. It is the purpose of condenser 24 to maintain, by its charge current through the upper winding of relay 19, the normal current flowing therethrough 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 contact of relay 19, right contact 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, upper winding of relay 20, resistance 28, condenser 29 to ground. When this discharge current has dissipated itself, relay 20 will operate and break its contacts to remove ground from conductor 15 regardless of how long thereafter the energy is applied to relay 17 by the signal.

The length of time during which the armature of relay 20 engages its front contact to cause the channel detectors to remain activated depends, of course, upon the constants of condensers 24 and 29 and resistances 26 and 28 which may be chosen to provide any suitable interval desired. However, when 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 cathode element of the several detector channels which, in consequence, will no longer respond to any signal energy forthcoming over transformer 32 and thereby cause their associated anode relays to release.

The circuit conditions prevailing in the enabler 10 during the presence of signal energy through bridge 16 and after the armature of re-

lay 20 has disengaged its right contact are that relay 17 will have its armature disengaged from its right contact, relay 18 will have its armature making its left contact, while relay 19 will have its armature making its left contact. This 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 time when the armature of relay 20 breaks 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 terminated, relay 17 will restore to its normal condition, reestablishing quickly the charging circuit of condenser 21 and the circuits of the top winding of relay 18 to cause it to make its left contact. Relay 18 operates and causes the quick establishment of the circuit through the top winding of relay 19 to cause it to quickly make its left contact. In this operation, condenser 29 has not been charged since ground via the contacts of relays 18 and 19 has not been removed. The enabler circuit is now ready for another cycle of identical operations upon the reception of the next impulse.

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

What is claimed is:

1. In a telephone system, a line, a resistance network connected across said line, a plurality of stations for said line adapted to generate alternating impulse signals characteristic of a wanted number and the identity of the station, a plurality of channel detectors connected to said line, each of said channel detectors being adapted for individual response to each of the frequencies, respectively, of which said impulse signals are composed, and means responsive to the frequency in the signal which designates the station for causing signal energy to be drawn through said resistance network whereby the quantity of signal energy admitted into said channel detectors is reduced by the amount drawn through said resistance network.

2. In a telephone system, a line, a plurality of stations thereon each adapted to produce an alternating current signal characteristic of the station, a resistance network connected across said line, means connected to said line responsive to a signal from one of said stations for registering the identity of the station, and means responsive to the intensity of said signal for causing a portion of the signal energy to be drawn through said resistance network whereby the amount of signal energy admitted into said first-mentioned means is reduced by the amount drawn through said resistance network.

3. In a telephone system, a line, a plurality of stations thereon each adapted to produce an alternating signal characteristic of the station, a plurality of channel detectors connected to said line each responsive respectively to a frequency produced at a different one of said stations, and a volume limiting device for controlling the quantity of signal energy admitted into said channel detectors comprising a band-pass filter for the passage therethrough of said different frequency signals, a gas-filled tube adapted to be rendered conducting when the signal level is at a predetermined level, a vacuum tube including a first resistance bridge of which the anode circuit of said tube constitutes one of its arms and having current normally flowing therethrough, a second resistance bridge connected to said first resistance bridge and across said line, and means responsive to the conductivity of said gas-filled tube for altering the current through said first bridge to produce a difference of potential across the terminals of said second bridge whereby current flowing through the bridge in response to said difference of potential operates as a shunt to reduce the signal energy flowing into said channel detectors.

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