

July 22, 1941.

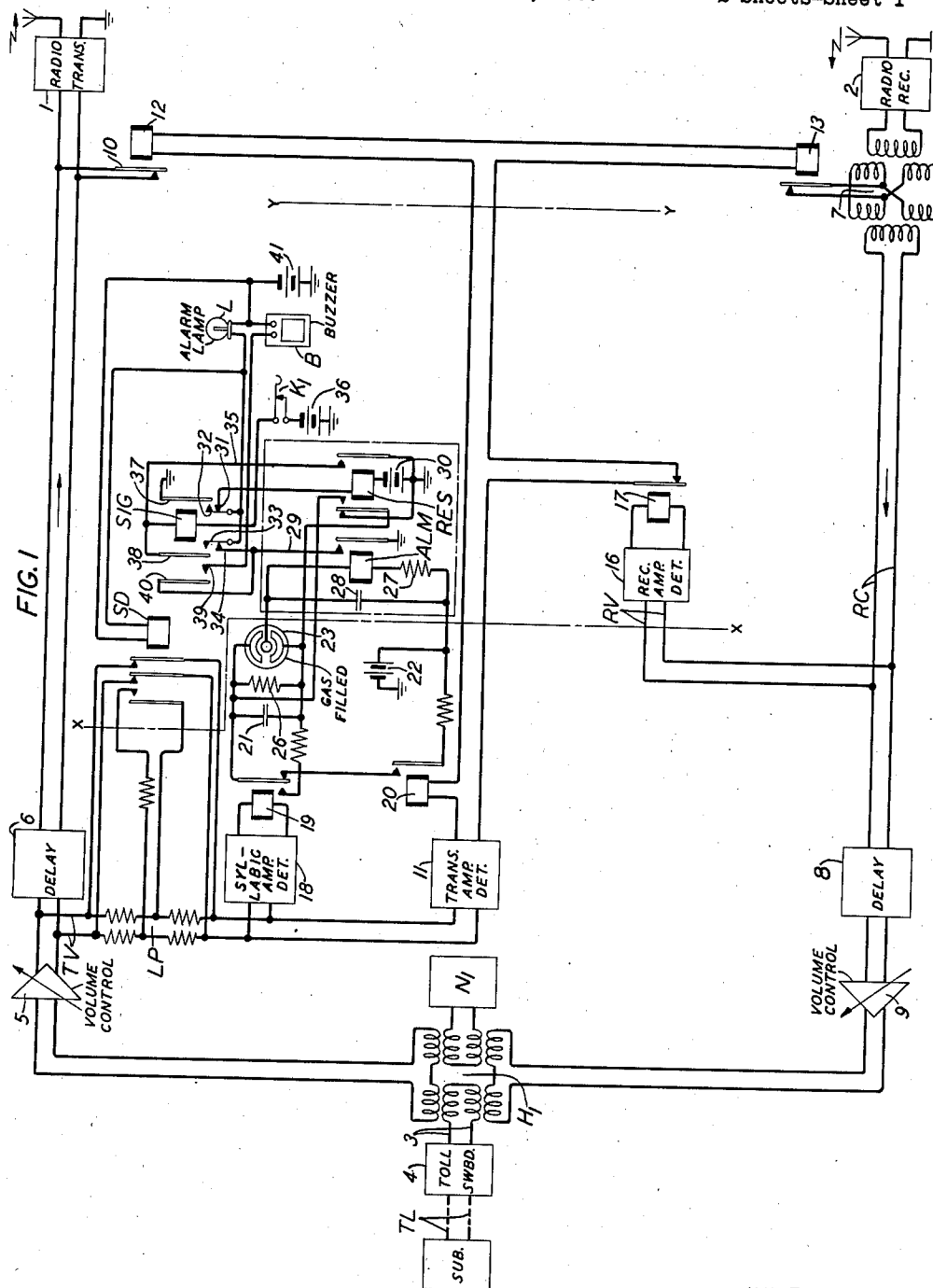
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2,249,931

INDICATING AND CONTROL CIRCUITS

Filed Nov. 28, 1939

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

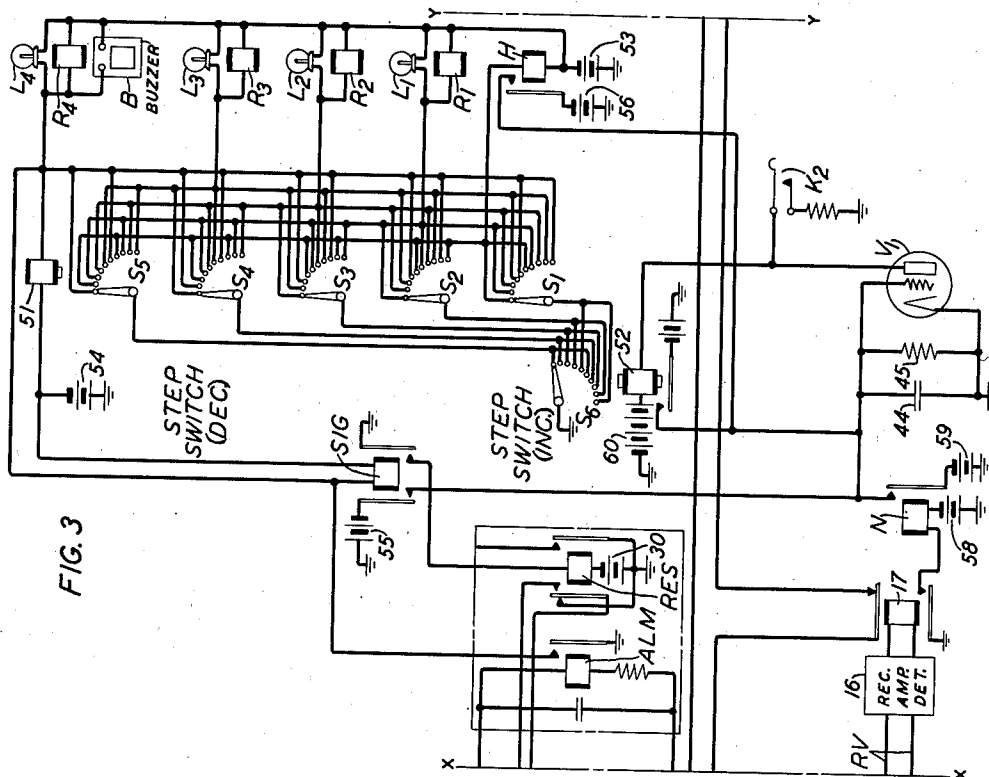


FIG. 3

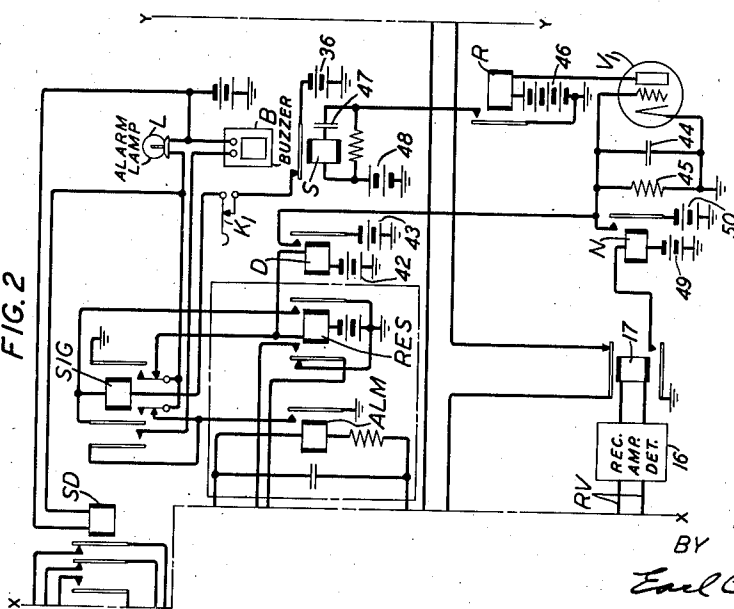


FIG. 2

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INDICATING AND CONTROL CIRCUITS

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10 Claims. (Cl. 177—311)

The invention relates to indicating and control circuits, and particularly to circuits for indicating the occurrence and extent of false (undesired) operation of signal-controlled switching devices in telephone systems and for correcting for such a condition.

The invention will be specifically described as applied to voice-operated echo suppressors and anti-singing (Vodas) devices in two-way telephone systems, such as a two-way radio telephone system, but is adapted as well for use in connection with other types of voice-operated switching devices. As is well known, such systems are subject to variable noise, such as room or line noise, or static, having a frequency spectrum similar to that of speech signals but which is of a steady nature compared to speech signals. This noise is often of such amplitude as to tend to produce false operation of the voice-operated switching device when adjusted to the sensitivity required for its proper operation on some speech signals.

In the case of a radio telephone system, for example, under some conditions of operation, the noise received by the transmitting circuit of a terminal from the associated two-way telephone line may be sufficient to cause false operation of the transmitting vodas, and such operation, when severe, may actually lock up the transmitting vodas for an extended period of time, thus blocking the receiving circuit of the terminal and preventing the signals received from the distant terminal from reaching the telephone subscriber associated with the local terminal during that time interval. Also, the receiving vodas of a radio telephone terminal may be falsely operated and in some cases actually locked up by static received from the radio link, thus mutilating or preventing the transmission of signals from the terminal.

There are a number of known circuits available for indicating the occurrence of false operation of the vodas devices in such systems by noise. One such circuit is disclosed in the co-pending application of B. G. Bjornson, Serial No. 250,940, filed January 14, 1939, which issued as Patent No. 2,183,339 on December 12, 1939. That circuit operates by effectively balancing, on the basis of operated times, the operation of the vodas charging a condenser at a given rate, against that of a syllabic device responsive to voice signals but substantially unresponsive to noise, discharging the condenser at a more rapid rate. If there is infrequent or no operation of the syllabic device indicating the absence of

speech signals, while there is operation of the vodas, indicating the presence of speech or noise energy, the charge on the condenser will reach a predetermined value which will cause the operation of an alarm while this condition continues.

An object of the invention is to improve the operation of such circuits.

Another object is to indicate the occurrence and extent of false operation of a signal-controlled switching device.

A related object is to indicate the occurrence and extent of false operation of a signal-controlled switching device by noise, and to correct for that condition.

A more specific object is to indicate by means of distinctive alarms the extent of abnormal false operation of a voice-operated switching device by noise, and to automatically vary the sensitivity of the switching device in accordance with the amount of applied noise so as to reduce such false operation.

These objects are attained in accordance with the invention by a circuit arrangement operating in two or more steps to give an alarm for excessive false operation of the signal-controlled switching device by noise, each step indicating a particular degree of noise trouble, and associated circuits causing automatic adjustment of the sensitivity of the switching device for each step sufficient to cause its release, thus making the alarm more reliable in operation and reducing the amount of attention required from a technical operator.

A feature of the invention is an arrangement for automatically increasing the sensitivity of the switching device if alarm operations are not repeated within a predetermined time interval.

Other objects and features of the invention will be brought out in the following detailed description when read in connection with the accompanying drawings in which:

Fig. 1 shows schematically one terminal of a radio telephone system including an alarm circuit embodying one form of the invention; and

Figs. 2 and 3 show alternative forms for the alarm circuit of the invention, which may be used in the system of Fig. 1.

Fig. 1 shows schematically one terminal of a two-way radio telephone system comprising a four-wire circuit connecting a telephone line to a radio transmitter and a radio receiver which may be of any well-known type or construction. The four-wire circuit comprises a transmitting circuit TC, including a volume control device

which may be a vogad (volume-operated gain-adjusting device), and a delay circuit 6, leading to the radio transmitter 1; and a receiving circuit RC, including the suppressor switching pad 7, the delay circuit 8 and the receiving volume control device 9, leading from the radio receiver 2; the circuits TC and RC being coupled by the hybrid coil H and associated balancing network N to a two-wire line section 3 which is connected by the toll switchboard 4 with a two-way telephone line TL.

The suppressor switching pad 7 may be of any type providing a low loss to transmitted waves normally, and adapted to be switched to a high loss condition by operation of a relay. The particular pad illustrated is disclosed and claimed in Silent Patent 1,749,851 issued March 11, 1930.

The transmitting circuit TC is normally blocked at a point between the radio transmitter 1 and the delay circuit 6 by a short-circuiting connection 10, and the receiving circuit RC is normally operative due to a normal low loss condition of the suppressor switching pad 7. Connected across the circuit TC between the volume control device or vogad 5 and the delay circuit 6 is the input of the transmitting vodas TV comprising a voltage-operated amplifier-detector 11, and a plurality of electro-magnetic switching relays including relays 12 and 13, connected to the output of the control device 11. Outgoing speech signals in the transmitting circuit TC diverted into the transmitting vodas TV and amplified and detected by the device 11, will operate relay 12 to respectively open the short-circuiting connection 10 to unblock the transmitting circuits TC for the outgoing signals; and simultaneously operate relay 13 to open a normal cross-connection in the variable loss pad 7, changing it from its normal low loss condition to a high loss condition, to effectively block the receiving circuit RC, thereby suppressing echoes and preventing singing.

Connected across the receiving circuit RC between the suppressor switching pad 7 and the delay circuit 8 is the input of the receiving vodas RV including the voltage-operated amplifier-detector 16 and the relay 17 connected to the output of the device 16. When the variable loss pad 7 is in its normal low loss condition, the voice signals received in the receiving circuit RC control the receiving amplifier-detector 16 to cause operation of relay 17 to break the connection between the transmitting vodas relays 12 and 13 and the transmitting amplifier-detector 11, thereby preventing subsequent false operation of the transmitting vodas TV.

Associated with the transmitting vodas TV is a circuit for indicating abnormal noise operation of the transmitting vodas. For purposes of illustration this circuit is shown as including an alarm circuit of the type disclosed in the aforementioned Bjornson patent application. As shown in Fig. 1, this alarm circuit includes a syllabic amplifier-detector 18 responsive to applied waves having the syllabic characteristics of speech signals but substantially unresponsive to the comparatively steady applied noise waves, having its input connected across the transmitting circuit TC in front of the delay circuit 6, and relay 19 operating in response to operation of the syllabic device 18. It includes also the relay 20 connected in series with the transmitting vodas relays 12 and 13 so as to be operated simultaneously with the latter two relays in response to operation of amplifier-detector 11; a

condenser 21 arranged to be charged from the battery 22 during operation of the relay 20 and to be discharged at a more rapid rate during the operation of the syllabic relay 19; and an alarm circuit including the gas-filled tube 23 having its control discharge gap between the two cathodes connected across the condenser 21 in parallel with the discharge resistance 26, and an alarm relay ALM is connected in series with battery 22 across the main discharge gap of tube 23, adapted to be operated to actuate an alarm in response to the building up of a charge on condenser 21 of a predetermined high value indicating undue false operation of the vodas relays by noise. The detailed operation of this circuit for the conditions when noise alone, speech alone or both speech and noise are applied to the transmitting vodas, is described in the aforementioned Bjornson patent.

As a result of tests of a radio control terminal equipped with an alarm circuit such as described above, it was concluded that its value would be considerably enhanced provided it could be made to operate in two or more steps, the first of which would give only a visual alarm. There are several reasons why a two-step or multistep alarm operation would be better suited to operation of a semiautomatic terminal. First, it may be unnecessary and even undesirable to give the technical operator an audible alarm on a call when the trouble is only of a few seconds duration, or when the only evidence of the trouble is an occasional small amount of clipping. This would be confusing in the case where one technical operator is attending to a number of radio channels. Also, a large proportion of alarm conditions on a transmitting vodas arises from the fact that the transmitting vogad may occasionally increase its gain above normal during a long pause to the point where intermittent noise operation would bring in an alarm on a device such as described above. Such a condition would usually cause no trouble noticeable to the subscriber since the vogad gain is quickly reduced when the near-end talker speaks, and ordinarily the transmitting vodas is not operated by noise so continuously that the far-end talker cannot get through with little difficulty.

Also, in an alarm circuit such as described above, it would appear that if there is sufficient noise to operate the vodas enough to cause noticeable clipping, an alarm would be registered in practically every case. But there ordinarily would be a relatively wide margin with such a circuit between sufficient noise to register an alarm and the amount which would cause the circuit to become inoperable by locking up the vodas.

A simple circuit arrangement in accordance with the present invention for providing improved operation of the alarm circuit such as has been described under the varying conditions of use referred to, which is illustrated in Fig. 1, will now be described.

As shown in Fig. 1, the alarm relay ALM in series with the resistance 27, shunted by the condenser 28, is connected in series with the battery 22 across the plate and one cathode of the gas-filled tube 23. In addition to the apparatus in the vodas alarm circuit described above, the modified alarm circuit of Fig. 1 includes signaling relay SIG, the reset relay RES, a visual alarm L, which may be an incandescent lamp, an audible alarm B, such as a buzzer, the "vodas sensitivity decrease" relay SD and the sensitivity adjusting

loss pad LP in the input of the transmitting vodas TV. This apparatus operates in the following manner:

Let it be assumed that the alarm relay ALM is operatively energized by current from the battery 22 flowing through its winding and the discharge path of the gas-filled tube 23 in response to the charge on condenser 21 being brought up to the predetermined value indicating abnormal noise operation of the vodas relay 20. Relay ALM operated puts ground on lead 29 which operates the relay RES from battery 30 through the normally closed contacts 31, 32 and 33, 34 of the relay SIG. The relay RES operated opens its left-hand contacts to break the anode circuit for the gas-filled tube 23 causing that tube to be restored to the deionized condition and condenser 21 to be discharged through resistance 26. This returns the vodas alarm circuit to normal so that the relay ALM releases after a short hang-over interval provided by the hang-over circuit consisting of condenser 28 and resistance 27.

The relay RES operated also closes its right-hand contacts to put ground on a lead 35 operating the relay SIG from battery 36. When the relay SIG operates, it locks itself up by getting ground through its contacts 37, 32 and 38, 33. In the operated condition of relay SIG its contacts 33, 34 are opened and its contacts 39, 40 are closed so that the lead 29 is transferred to the buzzer B preparatory to giving an audible signal on the following operation of the alarm relay ALM, the alarm lamp L is lighted and the relay SD in parallel therewith is operated from battery 41 through closed contacts 32, 37 of relay SIG. The relay SD operated will make the resistance loss pad LP of selected fixed value effective in the input of the transmitting vodas TV to reduce the sensitivity of the latter sufficiently to cause the release of the transmitting vodas relays 20, 12 and 13. If the technical operator notices the lighting of the alarm lamp L, he may restore the circuit to its previous condition by opening the switch K₁. If the operator does not restore the circuit, and if another operation of the relay ALM occurs, the buzzer B will be operated to give an audible alarm by current from battery 41 over a circuit extending from ground through battery 41, buzzer B, closed contacts 39, 40 of the relay SIG and closed contacts of the alarm relay ALM to ground, until the switch K₁ is opened by the operator.

With this arrangement a serious trouble condition would not result in a buzzer signal until the alarm had operated twice. However, the small probability of trouble due to noise which would require a buzzer alarm immediately in this arrangement, would be more than compensated for by the decrease in attention to the terminal required by the operator.

Since many alarms which would be brought in by the circuit arrangement as described above are isolated cases and do not indicate more than a transient trouble such as the infrequent large increase of gain of the automatic volume control (vogad) 5 on operator's room noise or on a call with some line noise, it might be desirable to operate the alarm in such a way that if a first operation of a two-step alarm were not followed within some given time interval by a second alarm, the switch K₁ would be opened automatically and the entire alarm system returned to normal. The modification of the alarm circuit in this manner is shown in Fig. 2, the circuit ar-

angement of Fig. 2 being substituted for the portion of the circuit of Fig. 1 included between the dot-dash lines X—X and Y—Y.

The alarm circuit of Fig. 2 requires in addition to the circuit elements in the alarm circuit of Fig. 1, a three-electrode vacuum tube V₁ and four additional relays D, N, R and S. The operation of the relay SIG is the same as in Fig. 1. The relay D is connected in parallel with the relay RES and is arranged to operate from battery 42 at least as fast as the latter relay in response to operation of the alarm relay ALM. The relay D when operated connects the negative terminal of the grounded battery 43 to the ungrounded terminal of the condenser 44 which is connected in parallel with the resistance 45 across the grid and cathode of the vacuum tube V₁, so that a negative charge is placed on that condenser. The relay R is connected in the plate-cathode circuit of the vacuum tube V₁ in series with the plate battery 46. The negative bias produced on the control grid of the vacuum tube V₁ due to the negative charge applied to condenser 44 from battery 43 prevents flow of plate current in the tube V₁ and the relay R, therefore, will be held in the released condition. After the charge on condenser 44 has been sufficiently dissipated through the shunt resistance 45, plate current will start to flow in the plate circuit of tube V₁ causing the operation of the relay R. The resultant closure of the make contacts of the relay R will cause operation of the relay S for a short time interval while the condenser 47 in series with relay S is charged up to the potential of battery 48 through the winding of the latter relay. Operation of the relay S opens the operating circuit for the relay SIG from battery 33 through the switch K₁, causing the relay SIG to release and thus resetting the alarm circuit. The relay N which is operated from battery 49 through the lower contacts of the receiving vodas relay 17 when that relay is operated in response to incoming voice signals in the receiving circuit RC applied to the receiving amplifier-detector 16, is provided to hold a high negative charge from battery 50 on the control grid of tube V₁ to hold that tube, and thus relay R, unoperated when the receiving vodas RV is operated.

If, by proper selection of the values of the circuit elements, the delay time before automatically resetting the alarm is made to be about a half of a minute, with the circuit of Fig. 2, the radio channel will require less attention from the technical operator than the circuit of Fig. 1.

Fig. 3 shows a modified alarm circuit in accordance with the invention providing a larger number of steps of alarm operation with suitable automatic adjustment of vodas sensitivity, as well as an arrangement for automatically returning the vodas to maximum sensitivity if no alarm operation occurs within a predetermined time interval. The particular circuit arrangement illustrated provides four different visual alarms indicating successive operations of the alarm relay, with successive reduction of vodas sensitivity from a maximum for each step of alarm operation, and an audible alarm and lock-up of the circuit on the last step; this arrangement also provides successive increases of sensitivity back to the maximum value if operations of the alarm relay ALM do not occur within a predetermined period of time.

The circuit arrangement of Fig. 3 differs essentially from that of Fig. 2 in employing in

place of the three relays R, S and D of the latter circuit, two step switches designated DEC and INC controlled respectively from the alarm relay ALM and the output of the vacuum tube V₁; in the use of four visual alarms, lamps L₁ to L₄, and four vodas sensitivity decrease relays R₁ to R₄ each controlling the insertion of a separate resistance loss pad (not shown) in the vodas input, instead of one such relay and loss pad as in the circuit of Fig. 2; and in the use of an additional relay H for biasing the step switch INC against operation when the vodas sensitivity is at a maximum.

The step switch DEC comprises a stepping magnet 51 and five switch segments S₁ to S₅ each consisting of an arcuate row of terminals and a brush or armature rotatable over the terminals, one terminal at a time, in response to each energization of the stepping magnet 51. The step switch INC comprises a stepping magnet 52 and one switch segment S₆ consisting of an arcuate row of terminals and a brush or armature rotatable over the terminals, one terminal at a time in response to each energization of the stepping magnet 52. Both step switches DEC and INC are preferably of the type operating to continuously step their armatures always in the same direction (clockwise), and are not reset to the zero position. The armature of switch segment S₆ of step switch INC is grounded, and the five armatures of switch segments S₁ to S₅ of step switch DEC are connected to the terminals on switch segment S₆ of switch INC in such manner that only one armature of the switch DEC at a time gets ground from the armature of switch INC. The relay H, lamp L, and relay R₁; lamp L₂ and relay R₂; lamp L₃ and relay R₃; and lamp L₄, relay R₄ and buzzer B, are respectively connected in series with grounded battery 53 to successive sets of terminals on the switch segments S₁ to S₅ of switch DEC.

Each operation of the alarm relay ALM will cause the signaling relay SIG and the stepping magnet 51 of step switch DEC to be operatively energized from battery 54. The operation of relay SIG will in turn through its closed right-hand contacts cause the reset relay RES to be operated from battery 30 to break the anode circuit of the gas-filled tube 23 to return the main vodas alarm circuit to normal in a manner similar to that illustrated in Fig. 1, and through its closed left-hand contacts will connect grounded battery 55 to the ungrounded terminal of condenser 44 to apply a high negative bias to the grid of tube V₁.

The operation of stepping magnet 51 of step switch DEC will cause the five armatures on the switch to be simultaneously rotated one step over the respective arcuate terminals of the switch segments S₁ to S₅, but only that armature of one segment, which is connected to the grounded armature of the step switch INC for that particular step will get ground. In the particular positions of the armatures of step switches DEC and INC shown in Fig. 3, an operating ground is supplied to the lamp L₄, sensitivity adjusting relay R₄ and buzzer B, indicating the vodas circuit is at minimum sensitivity. If before the operation of the relay ALM the vodas sensitivity were at a maximum, the grounded armature of switch DEC would step from the connection to relay H and grounded battery 53 in series, to the connection to the parallel signal lamp L₄ and sensitivity reducing relay R₁, and grounded battery 53 in series. Lamp L₄ will then light up to indi-

cate one operation of alarm relay ALM, and relay R₁ will operate to connect a resistance loss pad (not shown) in the input of the vodas, and of a value sufficient to reduce the sensitivity a predetermined amount. The relay ALM is always automatically released when relay RES is operated.

Further operations of relay ALM following in close succession will cause the armatures of switch DEC to advance over the terminals in the respective switch sections so that a grounded armature of the switch will cause successively operation of alarm lamp L₂ and relay R₂, of alarm lamp L₃ and relay R₃, and finally of alarm lamp L₄, relay R₄ and buzzer B. The operation of each relay R₁ to R₄ will cut in an additional resistance loss pad (not shown) of fixed value in the input of the vodas TV, in the manner indicated for relay SD in Fig. 1, so that the sensitivity of the vodas relay will be reduced to the point where noise will not cause excessive operation. If this sequence of operation continues to the position at which R₄, L₄ and buzzer B are operated, the DEC step switch will be locked in this position by application of ground through INC and DEC armatures and contacts, to the actuating winding 51.

If, however, there are no further operations of alarm relay ALM within, say, twenty or thirty seconds, depending on the selected constants of the circuit associated with tube V₁, the plate current of tube V₁ which has been returned to the operative condition following the release of the relay SIG, will cause the operation of stepping magnet 52 of switch INC to step in a direction to transfer the ground connected to its brush or armature to an armature of the switch DEC, operating an alarm lamp and a sensitivity adjusting relay which provides one step towards higher vodas sensitivity adjustment. After another twenty or thirty seconds, if the relay ALM has not operated, the switch INC operates to transfer the ground connected to its armature to another armature of switch DEC, causing the operation of the corresponding alarm lamp and sensitivity reducing relay. This cycle of operations is repeated until ground is connected to the relay H, indicating that the vodas sensitivity has reached the maximum. The consequent operation of relay H from battery 53 will connect battery 56 to the control grid of tube V₁ so as to apply a high negative bias to the tube disabling it and preventing further operation of the sensitivity increasing step switch INC, the operation of the switch INC in this respect being similar to that of the relay D in the circuit of Fig. 2. The length of time from the operation of relay ALM to operation of the step switch INC may be varied by changing the time constant of condenser 44 and resistance 45 by suitably selecting their values. As indicated, the connection of the armature to a contact terminal of INC which is connected through an armature and contact of DEC to the H relay, causes a high negative disabling bias to be applied to the grid of tube V₁, which will prevent further operation of stepping magnet 52, causing the return of the armature to the first contact terminal which starts the cycle for another operation of the switch INC. The relay N is operated from battery 58 when the relay 17 of the receiving vodas RV is operated by received voice currents at the terminal. This causes a high negative disabling bias from battery 59 to be applied to the grid of tube V₁ preventing operation of switch INC.

When the sensitivity of the vodas is a minimum so that the buzzer B is operated from battery 53, an energizing connection to the operating winding of the stepping magnet 51 of step switch DEC and of relay SIG holds both operated, so that no sensitivity decrease or sensitivity increase action can take place until the technical operator resets the alarm system. This may be done by closing switch K₂ to operatively energize the stepping magnet 52 of switch INC from battery 60 to start operation of that switch.

When a noise condition exists which requires a sensitivity adjustment of the vodas between the maximum and minimum value provided by the automatic device of Fig. 3, there may be "hunting" of the sensitivity adjustment, since the sensitivity cannot remain indefinitely at an intermediate step but must be either decreased or increased from that step within the time interval of say, twenty or thirty seconds, required to operate the switch INC after any previous adjustments. This hunting would rarely cause any difficulty, except, perhaps, in the case of strong steady noise which would hold the vodas locked up on one step, and which did not cause appreciable false operation on the next less sensitive step. Such noise conditions, of course, are infrequent.

The number of steps of alarm operation and sensitivity adjustment may be increased in the circuit arrangement of Fig. 3 by using a greater number of switch sections of switch DEC and adding other alarm lamps and vodas sensitivity adjusting relays. Also, the circuit arrangement of Fig. 2 may be modified to provide more steps of alarm circuit and vodas sensitivity adjustment by providing additional relays operating in the manner of those shown.

Each of these alarm and sensitivity adjusting circuits as described above may be used with the receiving vodas RV in a manner similar to that described for the transmitting vodas TV. Likewise, application of the principles of this invention may be made to other marginal signal operated devices in which the presence of interfering and unwanted signals may be detected by similar or other types of alarm or indicating circuits.

With any of the above-described arrangements of using the vodas shown, the seriousness of a false alarm would be diminished since an audible signal would not command the attention of a technical operator until two or more operations of the alarm circuit had occurred. Therefore, the time interval required to bring in a change of sensitivity could be shortened and the alarm circuit made more susceptible to noise trouble conditions for the purpose of making the proper adjustment of vodas sensitivity without at the same time requiring more attention from the technical operator.

Various modifications of the circuits illustrated and described which are within the spirit and scope of the invention will occur to persons skilled in the art.

What is claimed is:

1. In combination with a wave-operated switching device responsive to applied signal waves and subject to false operation by applied noise waves, alarm means operating in a number of steps each corresponding to a different degree of excessive false operation of said device by the noise waves and means for automatically reducing the sensitivity of said device in accordance with the amount of noise causing each stage of alarm operation.

2. In combination with a wave-operated switching device responsive to applied signal waves and subject to false operation by applied noise waves, alarm means operating to give different alarms for excessive false operation of said device by said noise waves, of respectively different degrees of seriousness, means to reduce the sensitivity of said device for at least the first noise-operating condition sufficiently to prevent its further false operation by noise of the degree causing such operation, and means to return said alarm means to the unoperated condition after operation.

3. In combination with a voice-operated switching device supplied from a circuit transmitting voice signal waves and subject to interfering noise waves, a control circuit comprising means responsive to a given extent of false operation of said device by applied noise waves to give an alarm indicating that condition, to automatically reduce the sensitivity of said device sufficiently to relieve that condition, and then to return said control circuit to the unoperated condition, other means responsive to false operation of said device with the reduced sensitivity, by applied noise waves to give a different type of alarm indicating the latter condition, and other means for returning the control circuit to its unoperated condition.

4. In combination with a voice-operated switching device supplied from a circuit transmitting voice signals and subject to varying noise waves, a control circuit comprising a plurality of means respectively responsive to excessive false operation of said device by noise waves, of different degrees of seriousness to give a distinctive alarm for each condition, to reduce the sensitivity of said device sufficiently to relieve that condition and then to return the control circuit to normal, and means responsive to a predetermined higher degree of false operation of said device to operate a different type of alarm and lock said control circuit up in its last operated condition.

5. The combination of claim 2, in which said circuit comprises a visible alarm device, an audible alarm device, relay means adapted to operate once for each case of excessive false operation of said switching device by noise, a relay circuit operating to return said relay means to the unoperated condition a given time after each operation thereof, and a second relay circuit operating in response to operation of the first relay circuit to lock itself up, to operate said visual alarm device, to reduce the sensitivity of said switching device just sufficiently to cause its release, and to condition an energizing circuit for said audible alarm device so that operation of the latter will occur on the next operation of said relay means.

6. In combination with a switching device responsive to applied signals and subject to false operation by applied noise, a circuit comprising means operating to give distinctive alarms for excessive false operation of said switching device by noise, of respectively different degrees of seriousness, means to automatically vary the sensitivity of said switching device for each step of alarm operation, in proportion to the amount of noise causing the excessive false operation of said device for that step, so as to prevent further false operation for that amount of noise.

7. In combination with a switch device responsive to applied signals and subject to false operation by applied noise, a circuit comprising means operating to give different distinctive

alarms for excessive false operation of said switching device by noise, of respectively different degrees of seriousness, means operating automatically to vary the sensitivity of said device for each alarm condition in proportion to the amount of noise causing that condition, to prevent further operation on that amount of noise, and means operating automatically to increase the sensitivity of said switching device a given amount if operations of said alarm means do not follow each other within a predetermined time interval.

8. In combination with a voice-operated switching device supplied from a circuit transmitting voice signal waves and subject to interfering noise waves, a control circuit comprising a plurality of means respectively responsive to excessive false operation of said device by applied noise waves, of different degrees of seriousness, to give a distinctive alarm for each condition, to automatically vary the sensitivity of said device in proportion to the amount of noise causing the false operation, to prevent further false operation by that amount of noise, and then to return the control circuit to the unoperated condition, and means operating automatically to progressively increase the sensitivity of said device as the time between operations of said alarm means increases over a predetermined time interval until the sensitivity of said device reaches a given maximum value.

9. The combination of claim 2 in which said circuit comprises a visual alarm device, an audible alarm device, relay means adapted to operate once for each case of excessive false operation of said switching device by noise, a relay circuit responsive to operation of said relay means to return said relay means to the unoperated condition a predetermined time after its operation, a second relay circuit, a third relay circuit, said second relay circuit operating in response to operation of the first relay circuit to lock itself up, to operate said visual alarm device, to reduce the sensitivity of said switching device to cause its release, and to condition an energizing circuit for said audible alarm device so that the latter will be operated in response to the next operation of said relay means, a vacuum tube device,

a fourth relay circuit operatively responsive to the output current of said vacuum tube device to cause the release of said second relay circuit to reset the alarm circuit, said third relay circuit operating in response to operation of said relay means, at least as fast as said first relay circuit, to cause said vacuum tube device to produce an output current for operating said fourth relay circuit for a limited interval of time, a predetermined time interval after said third relay circuit operates, so that if the first operation of said relay means is not followed by a second operation within said predetermined time interval the alarm circuit will be returned to normal.

10. The combination of claim 2 in which said circuit comprises a plurality of visual alarm devices, each with an associated control relay, an audible alarm device, relay means adapted to operate once for each case of false operation of said switching device, a plurality of selector switches adjustably connected with said visual alarm devices and associated relays, means automatically responsive to each operation of said relay means to advance said selector switches one step so as to cause operation of a different one of said visual alarm devices and its associated relay for each step, and to operate said audible alarm means on the last step, the operation of each control relay causing the sensitivity of said switching device to be reduced by a fixed amount causing the release of said relay means, and other means automatically responsive to the failure of the operation of said relay means to follow another within a predetermined time interval to adjust said selector switches step by step in the opposite direction from that caused by operation of said relay means, to operate said visual alarms and associated control relays in reverse order until said switching device is returned to its maximum sensitivity, and means responsive to any operation of said relay means during this process to prevent further operation of said other automatic means and to return it to its normal unoperated condition, and another relay operating when said switching device is at maximum sensitivity, to prevent operation of said other automatic means.

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