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REPEATER CIRCUITS

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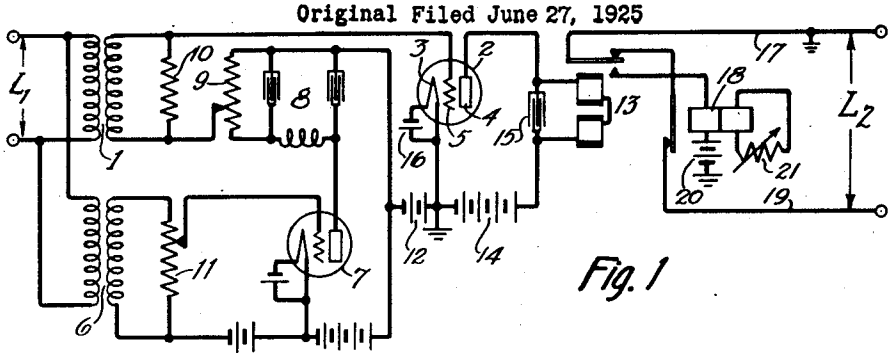


Fig. 1

Fig. 2

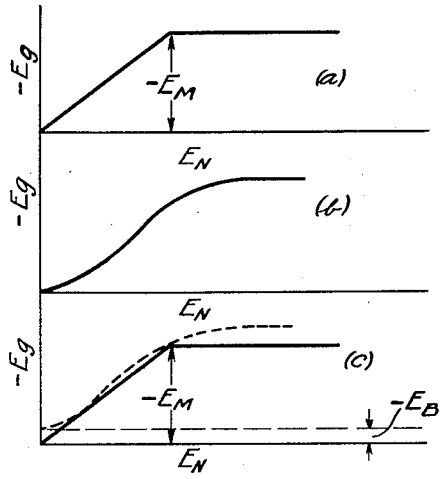
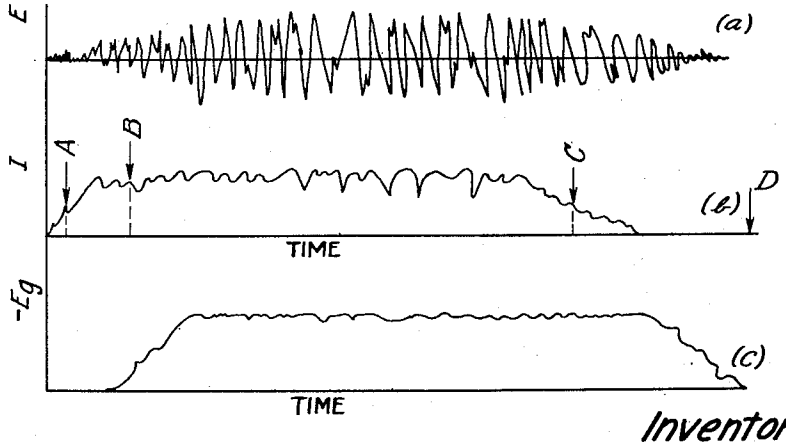


Fig. 3



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REPEATER CIRCUITS.

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This invention relates to transmission systems and particularly to such systems which include repeaters or relaying arrangements for the reenforcement of the transmitted energy.

More specifically, the invention is applicable to electrical circuits of the type containing apparatus, the operation of which is based on the transmission of short electrical impulses, such as voice-operated repeaters and the like.

An object of the invention is to provide a method of and means for reducing the effect of line noise on the operation of repeater circuits or similar apparatus.

One of the greatest sources of trouble encountered in connection with the operation of circuits such as voice-operated repeaters and the like is so-called line noise. Voice-controlled repeater circuits have been devised which operate very satisfactorily on quiet lines, but are either commercially inadequate or afford poor quality on noisy lines. It has heretofore been proposed, in connection with systems using voice-operated relay systems to utilize a fixed negative potential on the grid of a relay-controlling vacuum tube to prevent false operation of the relays due to line noise. A difficulty with such systems, however, is that, as the source of fixed negative potential must be adjusted for the maximum permissible noise on the system, poor articulation will be obtained as the noise decreases from its maximum value.

In accordance with the present invention, false operation of impulse or voice-operated relays is prevented by providing means for producing on the grid of a relay-controlling vacuum tube a negative potential varying in proportion to the amount of noise on the system, thus giving efficient articulation under all conditions. This varying negative potential is obtained by diverting a portion of the noise energy through an auxiliary circuit comprising a rectifier feeding into a delay circuit, the output terminals of which are connected across a resistance in the input circuit of the relay-controlling tube.

The operation of the circuit of the invention is based on the following principles: While voice transmission is intermittent, speech energy being transmitted in pulses of short duration corresponding to words spoken, the noise energy on a line, while varying from time to time, for such short intervals of time may be considered as substantially constant. The noise energy received over the line can be made to produce a negative grid potential on the relay-controlling tube in a voice-operated repeater of such magnitude that the relays will not be kept operated by the noise. Obviously, the speech received over the line will also produce a negative potential on the grid of the relay-controlling tube, but by delaying the building up of this negative potential the switching relays may be operated before it becomes effective. This negative grid potential should be proportional to the noise energy and its maximum value should correspond to the maximum permissible noise, as otherwise it will also finally prevent speech from keeping the relays operated during the whole time of a speech impulse.

The invention may be more fully understood from the following detailed description when read in connection with the accompanying drawing, in which Fig. 1 shows a diagrammatic illustration of a portion of a voice-operated repeater circuit embodying the invention, and Figs. 2 and 3 show curves illustrating the operation of the system of Fig. 1 and the theory on which the invention is based.

In Fig. 1 the noise protective device of the invention is illustrated as applied to an amplifier-rectifier circuit used for operating switching relays in a voice-operated repeater system. The section L_1 of the line leading from the voice-operated repeater (not shown) is associated through an input transformer 1 with the input circuit of the main amplifier-rectifier tube 2, which is of the well known three-electrode type having a cathode or a filament 3, an anode or plate 4 and a grid or control electrode 5. The line L_1 is also associated through an input transformer 6 with the input circuit of an auxiliary amplifier-rectifier tube 7, also of the three-electrode type, the output circuit of which is connected to the input of a delay circuit 8. The delay circuit 8 may be a low-pass filter of the type, for example, illustrated in Fig. 7 of U. S. patent to Campbell 1,227,114, May 22, 1922. The output terminals of the delay circuit 8 are connected across to a resistance 9 in the input circuit of the rectifier tube 2, any portion of which resistance can be placed in series in the in-

put circuit. Resistances 10 and 11 are connected across the input circuits of rectifiers 2 and 7, respectively.

The input circuit of rectifier 2 includes in series the cathode 3, the grid battery 12, the resistance 9, the resistance 10, and the grid 5. The output circuit of rectifier 2 includes in series the anode 4, the winding of switching relay 13, the plate battery 14, and the cathode 3. A condenser having a capacity of the order of 0.1 microfarad is preferably connected in shunt to relay 13. A suitable battery is provided for heating the cathode 3 to incandescence. The usual filament, grid and plate batteries are also provided in the circuit of the rectifier tube 7.

The leads from the delay circuit 8 are so connected across the resistance 9 with respect to the leads across the resistance 10 that energy from the line L_1 passing through the auxiliary circuit comprising the rectifier 7 and the delay circuit 8 will produce a negative potential on the grid of rectifier 2. The low-pass filter comprising the delay circuit 8 in the auxiliary circuit serves two purposes: (1) it produces a smooth rectified current; and (2) it delays the building up of the voltage across the variable resistance 9 when a speech pulse is received over the line L_1.

When no speech impulses are being received from the incoming line L_1, the operating winding of relay 13 is not energized, the outgoing line L_2 leading to the voice-operated repeater (not shown) being short-circuited. In this condition, the terminals of line L_2 are connected together through lead 17, the back contact of relay 13, the normally closed contact of a hangover relay 18, and lead 19. When the operating winding of relay 13 is energized, relay 13 closes its front contact, causing the operating winding of relay 18 to be energized so as to operate that relay, the energizing circuit extending from grounded battery 20, through the operating winding of relay 18, front contact of relay 13, and lead 17 to ground. The right-hand winding of hangover relay 18 is closed through a suitable variable resistance 21.

For an ideal condition from the standpoint of articulation, it is desirable that the magnitude of the negative potential on the grid 5 of the relay-controlling rectifier tube 2 at all times should be such that it is just sufficient to prevent operation of the relay 13 by the noise on the line. That is, the negative potential on the grid of the rectifier 2, and, therefore, the voltage across the resistance 9, required to prevent operation of the relay 13 by the voltage produced by the noise on the grid of the rectifier, which we may call the noise voltage, should be directly proportional to the noise voltage up to a certain point. It is obvious that the constants of the circuit should be adjusted so that the maximum value of this grid potential corresponds with the maximum permissible noise, as otherwise this negative potential would finally prevent speech from keeping the relay 13 operated during the whole time of a speech impulse.

The ideal relation between the noise voltage and the negative grid potential is shown by the curve (*a*) in Fig. 2. The relation between the noise voltage and the negative grid potential which may be obtained by the circuit of Fig. 1, without the use of the grid battery 12 is illustrated in the curve (*b*) of Fig. 2. Curve (*c*) of Fig. 2 illustrates how the addition of the small grid battery 12 to the circuit approximates the ideal condition as shown in curve (*a*), the solid line denoting the ideal curve and the dotted line the close approximation thereto which may be obtained by the circuit of Fig. 1 including the grid battery 12. In the curves (*a*), (*b*), and (*c*) of Fig. 2, the voltage produced by the line noise on the grid 5 of the rectifier 2 is designated E_N, the negative potential on the grid 5 of rectifier 2 required to prevent operation of the switching relay 13 is designated $-E_G$, the maximum value of negative grid potential corresponding to the maximum permissible noise is designated as $-E_M$, and the potential of grid battery 12 is designated as $-E_B$.

The operation of the noise protection circuit of Fig. 1 will now be explained in connection with the curves of Fig. 2 and Fig. 3. It will be assumed, for explanation purposes, that there is some noise on the line when speech is not being received. This noise energy for any small interval of time may be considered as constant. The noise energy received over the line L_1 divides, the part transmitted through the input transformer 1 being impressed on the input circuit of rectifier 2 across resistance 10, and the part transmitted through the input transformer 6 being rectified in the rectifier 7, transmitted through the low-pass filter 8, and impressed on the input circuit of rectifier 2 across the variable resistance 9. As the drop in potential in the variable resistance 9 opposes the drop in potential in the resistance 10, the resistances 9 and 11 may be so adjusted that the maximum voltage across resistance 10 will be less than the rectified voltage across resistance 9. The negative potential on the grid, then, will be that produced by the grid battery 12, or $-E_B$ as shown in curve (*c*) of Fig. 2, which is made of just sufficient magnitude to prevent operation of the relays 13 by the rectified energy in the output circuit of rectifier 2.

Now, if the noise energy on the line received over the line L_1 varies, the drop of potential in the variable resistance 9 will vary accordingly and in combination with the battery 12 produce a negative potential on the grid 5 of the rectifier 2 in accordance

with the dotted curve in Fig. 2 (*c*), this potential being of just sufficient magnitude to prevent the production by the noise of a current in the output circuit of tube 2 of sufficient magnitude to operate the relay 13.

Now, if an inipulse of speech energy is received from the repeater circuit over the line L_1, the portion transmitted, together with part of the noise on the line, through transformer 1 and impressed on the input circuit of rectifier 2 across the resistance 10, causes the production of a voltage of such amplitude as to overcome the negative potential on the grid 5. A rectified current will be thereby produced in the output circuit of tube 2 of sufficient amplitude to operate relay 13, which in turn will cause the operation of the hang-over relay 18. The portion of the speech energy transmitted, together with part of the noise on the line, through the transformer 6, is rectified by the rectifier 7, transmitted through the delay circuit 8, and impressed on the input circuit of tube 2 across variable resistance 9. This energy will, of course, produce a negative potential on the grid 5 of rectifier 2 of sufficient magnitude to prevent operation of the relay 13, but the delay circuit 8 will delay the building up of this negative voltage so that the switching relay 13 will be operated by the speech energy in the main circuit before it becomes effective. The whole output voltage of input transformer, therefore, is available until the auxiliary circuit starts up to build a negative grid potential across the variable resistance 9.

The time of operation of the relay 13 varies from syllable to syllable, and if there is no noise protecting negative grid potential, it might be anywhere from .002 to .02 of a second. As the delay in the circuit may be made greater than .02 of a second, the speed of operation of the circuit will be about the same as if the circuit were adjusted for a quiet line. The building up of the voltage across the resistance 9 should be delayed by the delay circuit 8 for such a length of time that the voltage produced by the voice currents across resistance 10 at that time shall have risen to a higher voltage than the maximum across resistance 9. When the maximum negative grid potential produced by the speech and noise transmitted through the auxiliary circuit becomes effective, the input voltage to the rectifier 2 will be decreased. This decrease in voltage, however, will not be sufficient to cause relay 13 to release, as at that time the voltage produced by speech across resistance 10 will be greater than the saturation voltage across resistance 9 and also only a small current is needed to keep relay 13 operated although a relatively large one is needed to operate it quickly.

The action of the circuit of Fig. 1 for one word or syllable is illustrated in Fig. 3, curve (*a*) of that figure showing the variation with time of the electrical energy representing a word or impulse, curve (*b*) the corresponding variation with time produced thereby in the rectified current in relay 13, and curve (*c*) the corresponding variation with time in the negative potential produced by the speech impulse on the grid of the rectifier tube 2. In these curves, the ordinates represent electrical energy, voltage or current, and the abscissas time.

Referring to the curves, it will be noted that when the speech impulse is received, the current in the relay winding 13 starts to increase at once and will be of sufficient amplitude to operate this relay at some time A before the auxiliary circuit, comprising the rectifier 7 and the delay circuit 8, begins to build up negative potential on the grid of rectifier 2. The operation of the relay 13 causes the operation of the hangover relay 18 at a slightly later time, indicated by B in the curves. At some time C near the end of the speech impulse, the rectified current in the relay winding 13 will decrease sufficiently, due to the building up of the negative potential on the grid 5 of rectifier 2, so that relay 13 releases. The release of relay 13 will also cause the release of hang-over relay 18. Variable resistance 21 is adjusted so that the time of relaxation of this relay is such that its release occurs at but a slightly later time D after the end of the speech impulse, thus preventing part of the word from being cut off.

It is desirable to design the delay circuit 8 so that it will first give an absolute delay and then a quick rise of the negative voltage on the grid 5 of rectifier 2. If the time of rise of this voltage is too long, the circuit may be sluggish in adjusting itself to variations in the noise received over the line L_1. Also, at the end of a word, the time interval that has to be considered is the absolute time delay plus the time of decay of the negative potential on the grid 5 of rectifier 2. This time interval should be shorter than the time of relaxation of the relays 13 and 18, as otherwise a syllable might find the negative potential produced by the preceding syllable still effective on the grid of rectifier 2. This condition may be prevented by making the time of relaxation of the hang-over relay 18 long enough to take care of this delay.

It is, of course, quite obvious that the noise received over the line L_1 may increase very suddenly. The circuit would then be inoperable in one direction for a short interval corresponding to the time delay in the auxiliary circuit comprising the rectifier 7 and the delay circuit 8. If the noise variation happens during conversation over the circuit, it can only do harm if it is on the

listener's side of the repeater, and only then if it happens between syllables when the circuit is in neutral position. The interval of time in which the circuit would be biased by the noise against the talker would in practically every case be smaller than the time delay in the auxiliary circuit. This time delay can be made small enough so that it interferes very slightly and will not even be noticed in an ordinary conversation.

The advantage of the noise protection circuit of Fig. 1 over any circuit utilizing a fixed negative grid potential for noise protection is quite marked. As stated before, if a fixed negative grid battery is used it will have to be adjusted for the maximum permissible noise on a line. Under these conditions the articulation will get worse as the noise decreases from its maximum value due to the longer switching time required, or, in other words, the articulation will be best when the maximum permissible noise is on the line and worse when there is no noise on the line. The noise protection circuit of the invention, however, produces a negative potential at all times, which is just sufficient to neutralize the effect of the line noise.

The circuit of the invention is particularly suitable for protecting voice-operated repeaters of both the neutral and biased types against noise, but it is not limited to voice-operated repeaters, but may be applied for noise protection in any circuits containing apparatus, the operation of which is based on the transmission of short impulses of energy. The system illustrated in the drawing and described above should be construed merely as typical and not as limiting the invention, the scope of which is defined in the appended claims.

What is claimed is:

1. The method of discriminating between momentary impulses of current and relatively steady disturbing currents received over a circuit in their effect on a receiver circuit, comprising utilizing part of the received energy to operate the receiver circuit, separately utilizing part of the received energy to bias said receiver circuit against operation, continuously neutralizing the operating energy due to said steady disturbing currents with the biasing energy due to said disturbing currents, and delaying the effect on said receiver circuit of the biasing energy due to said momentary impulses with respect to the effect on said receiver circuit of the operating energy due to said momentary impulses, thereby insuring operation of said receiver circuit by said momentary impulses.

2. In a transmission system, a path over which momentary impulses of current are transmitted and subject to relatively steady disturbing currents, a receiver circuit, means to utilize part of the energy received over said path to operate said receiver circuit, means to separately utilize part of the received energy to bias said receiver circuit against operation, means to continuously neutralize the effect on said receiver circuit of the operating energy due to said disturbing currents with the biasing energy due to said disturbing currents and means to delay the effect on said receiver circuit of the biasing energy due to said momentary impulses with respect to the effect on said receiver circuit of the operating energy by an interval sufficient to enable operation of said receiver circuit by said momentary impulses.

3. In a signaling system, a space discharge repeater, input and output circuits therefor, a current responsive device in said output circuit, a line connected to said input circuit over which waves of rapidly varying amplitude are transmitted and subject to disturbing waves of slowly varying amplitude, means for neutralizing the effect of said slowly varying waves on said input circuit, and means for causing said rapidly varying waves to control the operation of said current responsive device.

4. In combination, a line over which momentary impulses of current are transmitted, and subject to relatively steady disturbing current, a receiver element responsive to said energy impulses, an electron discharge device fed by said line and feeding said receiver element, said electron discharge device including a control electrode, means to produce on said control electrode a negative potential varying in accordance with said disturbing currents and of sufficient magnitude to prevent disturbing variations from being propagated through said device, the magnitude of said negative potential being insufficient to prevent said momentary impulses from said line from being propagated through said device to said receiver element.

5. In a transmission system, a circuit over which momentary impulses of energy are transmitted and subject to relatively steady disturbing variations, an electron discharge device fed by said circuit, said electron discharge device comprising a control electrode, a receiver element controlled by waves transmitted through said device, means to produce on said control electrode a negative potential varying in accordance with said disturbing variations, such as to prevent the transmission through said device of disturbing variations of sufficient amplitude to effect the operation of said receiver element, and means to delay the building up of a negative potential on said control element by one of said momentary impulses until after said device has been operated to repeat said one impulse.

6. In a signaling system, a line over which

energy comprising momentary impulses of current and relatively steady disturbing variations is transmitted, an electron discharge device fed by said line, said electron discharge device having a control electrode, a receiver element responsive to wave transmitted through said device, means to cause the energy received from said line to produce on said control electrode a negative biasing potential varying in accordance with said disturbing variations and at all times of sufficient magnitude to prevent said disturbing variations from being transmitted through said device, and means to delay the production on said control electrode of a negative potential by one of said momentary impulses until after said one impulse has been propagated through said device.

7. In combination, a line over which momentary impulses of current are transmitted and subject to relatively sustained disturbing currents, an electron discharge device comprising an input and an output circuit, a receiver element in said output circuit responsive to waves transmitted through said device, means to impress part of the energy received over said line on said input circuit in a sense to render said device operative to transmit, separate means to impress part of the energy received over said line on said input circuit in a sense so as to bias said device against operation, said separate means being adjusted with respect to the first mentioned means so that the resultant effect of said sustained disturbing currents is at all times such as to prevent the operation of said discharge device by said sustained currents, and means to delay the transmission to said input circuit of the biasing energy due to one of said momentary impulses with respect to the operating energy due thereto until said one impulse has been transmitted through said device.

8. In combination, a space discharge repeater having input and output circuits, a receiving device in said output circuit, a plurality of resistances in said input circuit, a source of waves having impulse components representing speech and relatively steady components representing noise, separate paths connecting said source to said resistances whereby the drop in potential produced by noise components in one of said resistances neutralizes the drop in potential produced by noise components in the other of said resistances, and means included between said source and said input circuit for causing the potential drop produced by speech components in one of said resistances to be different from the drop in potential produced by speech components in the other of said resistances so that speech components only are transmitted through said repeater to said receiving device.

9. In combination, a space discharge device, an input and an output circuit therefor, two resistances in series in said input circuit, a source of complex waves including impulsive and steady components, a receiving element in said output circuit and responsive to said waves, means comprising a path connecting said source in shunt to one of said resistances to cause the production in said one resistance of a drop in potential corresponding to a portion of said complex wave at a certain instant, a separate path connecting said source in shunt to the other of said resistances, and means in said separate path comprising a delay circuit to cause the production in said other resistance at the same instant of a drop in potential corresponding to a portion of said complex wave at a different instant, the resulting difference in potential on said input circuit causing waves from said source to be transmitted through said device to said receiving element.

10. In combination, a line over which speech impulses are transmitted, and subject to steady disturbing currents, a space discharge device having an anode, a cathode and a control electrode, a receiver element connected between said anode and cathode, and responsive to energy variations transmitted through said device, two resistances and a battery connected in series between said cathode and said control electrode, a path connecting said line in shunt to one of said resistances, a separate path connecting said line in shunt to the other of said resistances, said separate path comprising a space discharge device and a delay circuit.

11. In combination, a line over which momentary impulses of current are transmitted, and subject to steady disturbing currents, a space discharge device comprising an input and an output circuit and having a control electrode, a receiver element in said output circuit responsive to current variations transmitted through said space discharge device, two resistances in series in said input circuit, a path connecting said line in shunt to one of said resistances, whereby a drop in potential proportional to energy received over said line is produced in said resistance, a separate path comprising a second space discharge device connecting said line in shunt to the other of said resistances whereby a drop in potential proportional to energy received over said line is produced in said other resistance opposing that produced in the first mentioned resistance, said resistances being so proportioned with respect to each other that a resultant negative potential varying in accordance with said disturbing current variations is maintained on said control electrode by said steady disturbing currents of such magnitude as to prevent said device from becoming operative to propagate said disturbing

variations therethrough but of insufficient magnitude to prevent operation of said device by said momentary impulses transmitted over the first mentioned path, and means in said separate path to delay the building up of a negative blocking potential on said control electrode by said momentary impulses of current transmitted over said separate path.

12. In a voice-operated relay circuit, a path over which fluctuating voice currents and relatively sustained alternating currents may be transmitted, a space discharge device fed by said path and having a control electrode, means to produce on said control electrode a continuous negative potential varying in accordance with said sustained currents and at all times of sufficient magnitude to prevent operation of said space discharge device by said sustained currents, and means to insure operation of said space discharge device by said voice currents.

In witness whereof, I hereunto subscribe my name this 23 day of June A. D., 1925.

BJÖRN G. BJÖRNSON.