June 9, 1931. B. G. BJÖRNSON 1,808,915

REPEATER CIRCUITS

Filed Oct. 19, 1926

Fig. 1.

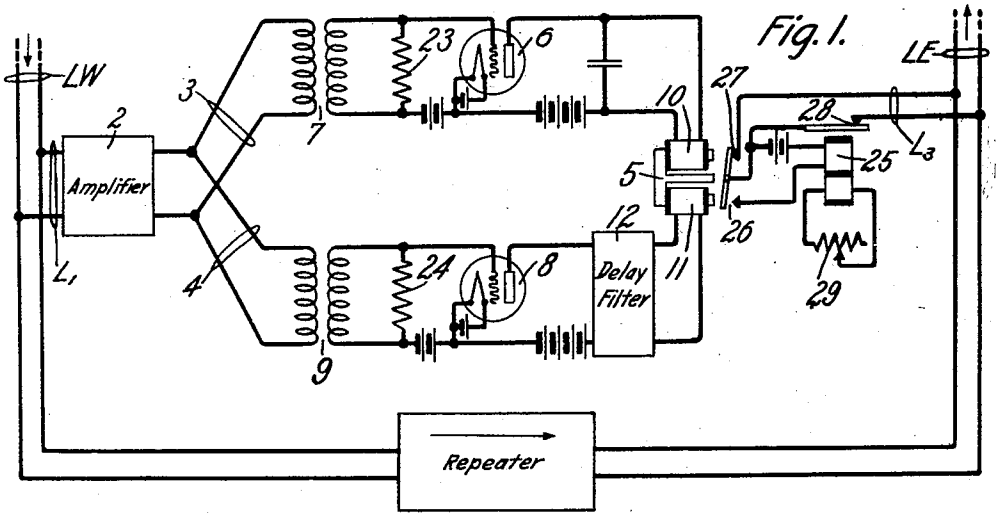


Fig. 3

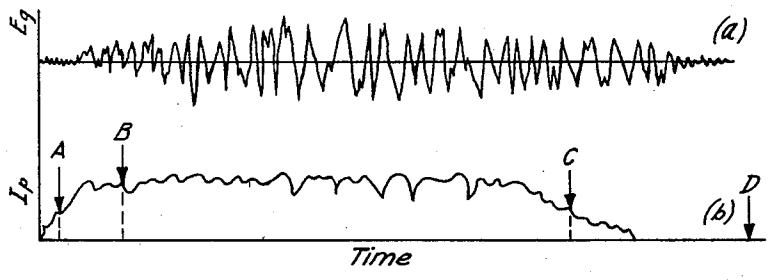


Fig. 2

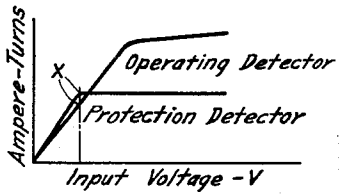
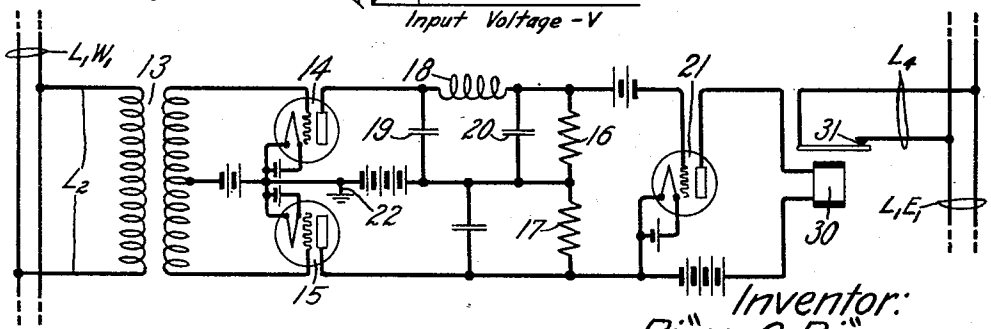


Fig. 4



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UNITED STATES PATENT OFFICE

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REPEATER CIRCUITS

Application filed October 19, 1926. Serial No. 142,566.

This invention relates to transmission systems, and more particularly to telephone repeater systems.

An object of the invention is to reduce the effect of line noise on the operation of repeater circuits or similar equipment.

One of the chief sources of trouble encountered in connection with the operation of circuits, such as are used for voice-operated repeaters, is the 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. This difficulty has been overcome to some extent heretofore by the use of circuit arrangements in which it is feasible to differentiate between a steady current and a sudden impulse. Such arrangements are based on the theory that speech energy is transmitted in impulses corresponding to spoken words, while noise energy, for comparatively long intervals of time, may be considered as substantially constant.

According to one embodiment of the present invention, a line for transmitting voice currents and subject to line noise, is associated with the windings of a polarized relay through two parallel paths, one path including a vacuum tube, which may be termed a relay controlling tube and the other an auxiliary vacuum tube, these paths having such relative characteristics that any steady current through the former tube and below a certain energy level, determined by the saturation of the auxiliary tube, will have its effect on the relay neutralized by the current flowing in a parallel path through the auxiliary tube. The two tubes are so arranged with respect to the relay that the currents passing therethrough flow through the respective windings of the relay in such direction as to produce opposite magnetic effects on the relay armature and the tubes are so adjusted that the magnitude of the current in the output of the auxiliary tube, or protection detector, is slightly greater than the current in the output of the relay-controlling tube, or operating detector, up to a certain point which is determined by the maximum permissible noise, so that the relay will remain inoperative in response to currents produced by noise on the line, but will be quite sensitive to speech impulses.

The invention may be more fully understood from the following detailed description when read in connection with the accompanying drawings, in which Fig. 1 shows a diagrammatic illustration of a portion of a voice-operated repeater circuit, embodying the invention, Figs. 2 and 3 are curves illustrating the operation of the system of Fig. 1 and the theory on which the invention is based, and Fig. 4 shows a modification of Fig. 1.

Referring to Fig. 1, LW and LE designate sections, interconnected through a repeater, of a transmission path, such as one-way paths, of a No. 22 type repeater circuit, or the one-way lines of a four-wire circuit. Such circuits normally have at least one of their respective transmission paths short-circuited so as to prevent singing and echoes on the line, and in order to control the operation of the short-circuit, a voice operated relay is employed whereby voice currents are effective to open the short-circuit thereby permitting transmission over the path. It will be understood, of course, that similar apparatus is associated with the other transmission path (not shown). While voice currents are being transmitted over one of these paths, as for example, the path comprising sections LW and LE, a polarized relay in the protective circuit will hold the short-circuit across section LE open, and since ordinarily, no voice currents will be on the other or second path at this time, the short-circuit associated therewith will be closed.

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 system. The conductors L_1 leading from the path of voice-operated repeater R, are associated through an amplifier 2 with a circuit arranged in two parallel paths 3 and 4. Each path includes a step-up transformer, a vacuum tube detector, and a winding of polarized relay 5 which has differential windings.

The input circuit of detector 6, called herein the operating, or main, detector, is connected with the output circuit of amplifier 2 through transformer 7, and the input circuit of detector 8, called herein the protection, or auxiliary, detector, is connected with the output circuit of amplifier 2 through transformer 9. These detectors are of the amplifier-rectifier, or three electrode, type. The output circuit of detector 6 extends through winding 10 of the polarized relay 5 and the output circuit of detector 8 extends through winding 11 of that relay. It is desired that the opposing currents through the differential windings of the polarized relay shall hold the relay armature against one of its contacts, in order to maintain outgoing conductors L_3 closed, thereby providing a short circuit across path LE under normal conditions. This desired effect is obtained by initially arranging the two paths so that the magnetic effects produced by the current in the output of the protection detector is opposite in direction and slightly greater in magnitude than that of the operating detector up to a certain point which will be determined by the maximum permissible noise on the line, and above that point the magnetic effect produced by the current in the output of the operating detector exceeds that of the current in the output of the protection detector. To obtain these effects the detectors are adjusted for different degrees of saturation, the saturation point of the protection detector being set for the maximum permissible noise and that of the operating detector at some higher point, and the two paths adjusted to give unequal output effects for equal inputs in any one of several ways, as for example by providing transformers of different ratios or a polarized differential relay having unequal windings. By means of the parallel paths the continuous noise energy received over the line will be divided, part being transmitted through one path and part through the other, and each being effective in one of the relay windings. As these noise effects continuously oppose each other, there will be no operation of the relay by the noise. However, when speech energy, such as produced by spoken words, is received over conductors L_1 and passed through amplifier 2 over the parallel paths 3 and 4, the speech wave received over path 3 and transmitting through transformer 7 is rectified by operating detector 6, and the resulting rectified speech current, which is passed through winding 10 of the polarized relay, is of sufficient magnitude to cause the relay to operate. The speech wave received over path 4 and through transformer 9 is rectified by protection detector 8, and the resulting rectified current is impressed on the circuit of filter 12 which delays its transmission until the relay 5 has become fully operated. When the delayed current finally does reach the relay winding 11, it will not be of sufficient magnitude because of the difference in saturation points of the two detectors, to neutralize the magnetic effect of the current in winding 10.

A modification of the circuit described above is illustrated in Fig. 4, in which conductors L_2 branching from the path L_1W_1 of the voice-operated repeater (not shown) is associated through an input transformer 13 with protection detector 14 and operating detector 15. These detectors are arranged as shown, in push-pull relation. In this arrangement the steady noise current received over conductors L_2 causes currents to be produced in the output circuits of the detectors 14 and 15 which are opposite in direction and are thus neutralized as to their effect on the input circuit of amplifier 21 in resistances 16 and 17, respectively. In the output circuit of protection detector 14 is included a delay filter comprising a network composed of inductance 18 and capacity elements 19 and 20. It is obvious then that when the voice impulse is received in transformer 13, and divides over the operating and protection paths, the resulting rectified current in the output of the operating detector is permitted to pass unhindered to the amplifier 21, but the current flowing through the protection detector is delayed by the filter, as was described above in the circuit shown in Fig. 1. The arrangement shown in Fig. 4 has an advantage over that shown in Fig. 1 in systems where high amplification and high speed in the operation of relays is desired, but, on the other hand, the arrangement in Fig. 4 requires the use of some means, such as floating A and B batteries for amplifier 21, to prevent a short-circuit through the filament ground connection 22 of the detector tubes.

The filters used in both figures may be of a low pass type, as is disclosed in Fig. 7 of Patent No. 1,227,113, granted to G. A. Campbel on May 22, 1917.

The operation of the circuit arrangement shown in Fig. 1 may now be described in connection with the curves shown in Fig. 2 and Fig. 3. It will be assumed, for explanatory purposes, that there is some noise on path LW when speech is not being received. This noise energy for each small interval of time may be considered as substantially constant. The noise energy received over the path LW divides, the part transmitted through the transformer 7 being impressed on the input circuit of detector 6 across resistance 23, and the part transmitted through transformer 9 being impressed on the input circuit of detector 8 across resistance 24. The noise wave impressed on the input circuit of detector 6 is rectified and transmitted through winding 10 of polarized relay 5 and that part impressed on detector 8 is rectified and transmitted through delay filter 12 and the wind-

ing 11 of relay 5, but inasmuch as the relay 5 is differentially wound, the resulting currents in the windings continuously oppose each other and the relay will not operate. The filter is designed to delay noise currents as well as the speech impulses, but inasmuch as noise currents are steady for comparatively long intervals, the delay of such currents is effective only to operate relay 5 momentarily at the beginning of each interval. The steady current intervals are of considerable duration, therefore, the momentary operation of relay 5, because of variations in the noise currents, may be regarded as a negligible factor. The protection detector is adjusted to saturate for a certain energy level which is established by the maximum permissible noise and thus the potential of the current which passes through the filter unhindered and is ineffective to operate relay 5, is below this level. The point at which this level is fixed is indicated by "X" on the curves, shown in Fig. 2, which represent the characteristics of detectors 6 and 8.

Now, if an impulse of speech energy is received from the repeater circuit over the conductors L_1, the portion transmitted together with part of the noise on the line, through transformer 7 and impressed on the input circuit of operating detector 6, is rectified by the detector, and inasmuch as this detector is adjusted to have a much higher saturation point than the protection detector 8, the current in the output circuit will be of sufficient magnitude to operate relay 5. The degrees of saturation for the two detectors are represented by the characteristics shown in Fig. 2. The portion of the speech energy transmitted, together with part of the noise on the line, through transformer 9 is rectified by protection detector 9, and transmitted through filter 12, to the winding 11 of relay 5. This current would be of sufficient magnitude to prevent the operation of relay 5, if it reached winding 11 simultaneously with the current in winding 10, but the delay encountered in the filter checks it until the relay is operated by the current in winding 10, and at the time the current does reach winding 11 the opposing current in winding 10 is built to such a magnitude that the protection current is ineffective to return the relay to its normal position.

The time of operation of relay 5 varies from word to word, and if there was no current produced by speech energy in winding 11, it might be anywhere from .002 to .02 of a second. As the delay in the filter 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 was adjusted for a quiet line.

When relay 5 operates, it closes an operating circuit for hang-over relay 25 at contact 26 and opens at contact 27 the short circuit effected by conductors L_3, thereby permitting the voice impulses to be repeated through repeater R and over the path LW to the line west (not shown). Relay 25 operates and opens contact 28, thereby effecting a double opening in the conductors L_3. When the current in the protection circuit, which was delayed by filter 12, finally reaches winding 11, it will not be of sufficient amplitude because of the difference in the saturation points of the two detectors, to affect relay 5, and therefore the armature thereof will remain in its operated position with contact 27 open and contact 26 closed until some time near the end of the word which effected the operation of the relay. Near the end of the word the rectified current in relay winding 10 decreases sufficiently so that the armature is attracted to its opposite contact, closing contact 27 and opening contact 26. The opening of contact 26 will open the circuit of hang-over relay 25, but this hang-over relay has one of its windings connected to a variable resistance 29, which may be adjusted to make relay 25 sufficiently slow acting so that it will remain operated until after the end of the word.

The operation 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, and curve (*b*) the corresponding variation with time produced thereby in the rectified current in winding 10 of relay 5. In these curves the ordinates represent the electrical energy, voltage, or current, and the abscissas represent time.

Referring to the curves, particularly curve (*b*), it will be noted that when the speech impulse is received, the current in the relay winding 10 starts to increase at once and will be of sufficient magnitude to operate relay 5 at "A" sometime before the current in the protection circuit begins to build up in winding 11. The operation of relay 5 causes the operation of hang-over relay 25 at a slightly later time, indicated by "B". At "C" sometime near the end of the speech impulse, the current in winding 10 will decrease sufficiently to cause the armature of relay 5 to be attracted to its normal position, thereby releasing in turn relay 25. Relay 25, which is made slow acting does not release immediately but remains operated until a time indicated "D" after the end of the speech impulse, thus preventing part of the word from being cut off.

In Fig. 1, the noise currents are neutralized in the windings of relay 5, and it is at this point that the noise and voice currents are most amplified. If high amplification is required to maintain high speed in the operation of the switching relays, such as 5 and 25, a modified arrangement may be provided in which the noise currents can be neutralized

before the voice currents are amplified, and Fig. 4 represents such a modification.

In Fig. 4, the arrangement shown is somewhat similar to that shown in Fig. 1, except that the protection detector 14 and operating detector 15 are arranged in push-pull relation as is well understood in the art. If noise waves alone are on the path LW_1, they will be received over conductors L_2 and impressed through transformer 13 upon the respective input circuits of detectors 14 and 15. In the output circuit of detector 14 is a delay network composed of inductance 18 and condensers 19 and 20, but inasmuch as noise currents are substantially constant for intervals which are of comparatively long duration the network is effective as a means for causing the delay in such currents only at the beginning of the intervals as was hereinbefore explained in connection with the delay circuit shown in Fig. 1. The noise currents in the output circuits of the detectors will therefore be of equal, but of opposing potentials in the resistances 16 and 17 respectively, and in this manner the currents are neutralized before reaching the amplifier 21. If an impulse of speech energy is received from path L_1W_1 over conductors L_2, the portion impressed, together with part of the noise on the line, on the input circuit of operating detector 15, will be rectified and the rectified wave permitted to flow unhindered to the input circuit of direct current amplifier 21. The amplified current will then operate relay 30 and a short circuit established in path L_1E_1 by contact 31 in conductors L_4, is opened, so that the voice current can traverse path L_1W_1, through the repeater (not shown) and over path L_1E_1 to the line east. The portion of the speech energy impressed together with part of the noise on the line, on the input circuit of protection detector 14 will be rectified, but the resulting current in this case will be delayed in the network until after relay 30 has become operated by the current in the operating circuit and, inasmuch as the grid of amplifier 21 is of the same polarity as the rectified current in the operating circuit, the current in the protection circuit will have no effect on relay 30 and will thus be held in check until the end of the impulse.

The arrangement of the invention is particularly suitable for protecting voice-operated repeaters against line noise, but it is not confined to voice-operated repeaters because it 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 drawings 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. In a signaling system, a path for steady alternating currents and voice currents, branches for said path, a rectifier in each branch, means for causing the effects of the rectified currents to act in opposition to one another, and means causing the effect in one branch to be predominant when said steady alternating currents are alone flowing in said path and the effect in the other branch to predominate when voice currents are flowing in said path.

2. In a transmission system, a path for transmitting alternating currents, branches for said path, detectors in said branches for rectifying said currents, the detector in one branch being arranged to produce a rectified current of greater magnitude than that in the other for received alternating currents of magnitudes up to a certain value, the detector in the other branch being arranged to produce a rectified current of greater magnitude than the detector in said one branch for received alternating currents of magnitudes exceeding said certain value and electromagnetic means for receiving said rectified currents, said means being arranged to be normally biased in one manner by the rectified current in said one branch and to be operable in another manner by the rectified current in the other branch when the magnitudes of the received alternating currents therein exceed said certain value.

3. In a transmission system, a path over which voice currents and continuous alternating currents may be transmitted, a common receiving means for the transmitted currents having branches, means in each branch for translating the received currents into pulsating currents, a relay jointly controlled by the translated currents, and means operating upon the translated currents in one of said branches to delay their effect upon said relay as compared with the corresponding translated current in the other branch.

4. In a transmission system, a path over which voice currents and steady alternating currents may be transmitted, branches for said path, means in each branch for translating alternating voice currents into pulsating currents, a relay having windings differentially associated with said translating means, and means operating upon the translated current in one of said branches to delay its effect upon said relay as compared with the corresponding translated current in the other branch.

5. In a transmission system, a path over which voice currents and steady alternating currents may be transmitted, a common receiving means for the transmitted currents having branches, a detector in each of said branches for rectifying the received currents, a relay controlled by the rectified currents, and a filter in the output circuit of one of said detectors for delaying the rectified voice current in one branch as compared with the cor-

responding current in the other branch to permit said corresponding current to operate said relay.

6. In a transmission system, a path over which voice currents and noise currents may be transmitted, a common means connected to said path for receiving the transmitted currents and having branches for said paths, a detector in each of said branches for rectifying said currents, a relay controlled by the rectified currents, a filter for delaying the rectified voice current in one branch as compared with the corresponding current in the other branch, and means for amplifying said corresponding currents to operate said relay.

7. In a transmission system, a path over which voice currents and noise currents may be transmitted, branches for said paths, a detector in each of said branches for rectifying said currents, output circuits for each of said detectors for receiving said rectified voice and noise currents and for neutralizing the noise currents, a relay, a filter for delaying the rectified voice currents in one branch as compared with the corresponding current in the other branch, and means for amplifying said corresponding current to operate said relay.

8. In a transmission system, a path over which momentary impulses of current and steady alternating currents may be transmitted, branches for said path, means in each of said branches for increasing the energy of said currents, electromagnetic means for receiving said currents and arranged to be normally biased, means in said branches for impressing said currents on said electromagnetic means, said steady currents being of greater magnitude in one of said branches than those in the other up to a certain point to maintain the bias in said electromagnetic means in the absence of said momentary impulses, and means for delaying said momentary impulses in one of said branches to permit the impulses in the other of said branches to overcome the bias in said electromagnetic means.

9. In a transmission system, a path over which momentary impulses of current and steady alternating currents may be transmitted, branches for said path, a transformer in each of said branches for increasing the energy of said currents, a polarized relay having differential windings respectively connected in each of said branches, means in each of said branches for rectifying said currents, the steady currents rectified being greater in magnitude in one branch than those in the other up to a certain energy level to maintain a bias in said relay when said momentary impulses are absent from the path, and means in one of said branches for delaying said momentary impulses therein to permit the momentary impulses in the other of said branches to overcome said bias and operate said relay.

10. In a transmission system, a path over which momentary impulses of current and steady alternating currents may be transmitted, branches for said path, a transformer in each of said branches for increasing the voltage of said currents, a polarized relay having differential windings respectively connected in each of said branches and arranged to be responsive to said momentary impulses and non-responsive to said steady currents, an electron discharge device in each of said branches for rectifying said currents, the steady currents rectified being greater in one branch than those in the other up to a certain energy level to maintain a bias in said relay when said momentary impulses are absent from said path, and a filter in one of said branches for delaying said momentary impulses to permit the momentary impulses in the other of said branches to overcome said bias and operate said relay.

11. In a transmission system, an incoming and an outgoing line, a path over which momentary impulses of current and steady alternating currents may be transmitted, connected with said incoming line, branches for said path, a polarized relay having differential windings respectively connected in each of said branches for controlling the operation of said outgoing line, an electron discharge device in each of said branches for rectifying said currents, the steady currents rectified being greater in magnitude in one branch than those in the other up to a certain energy level to maintain a bias in said relay when said momentary impulses are absent from said path, a filter in one of said branches for delaying said momentary impulses to permit the momentary impulses in the other of said branches to overcome said bias and operate said relay, and a second relay for controlling said outgoing line after said polarized relay releases.

In witness whereof, I hereunto subscribe my name this 18th day of October, A. D. 1926.

BJÖRN G. BJÖRNSON.