

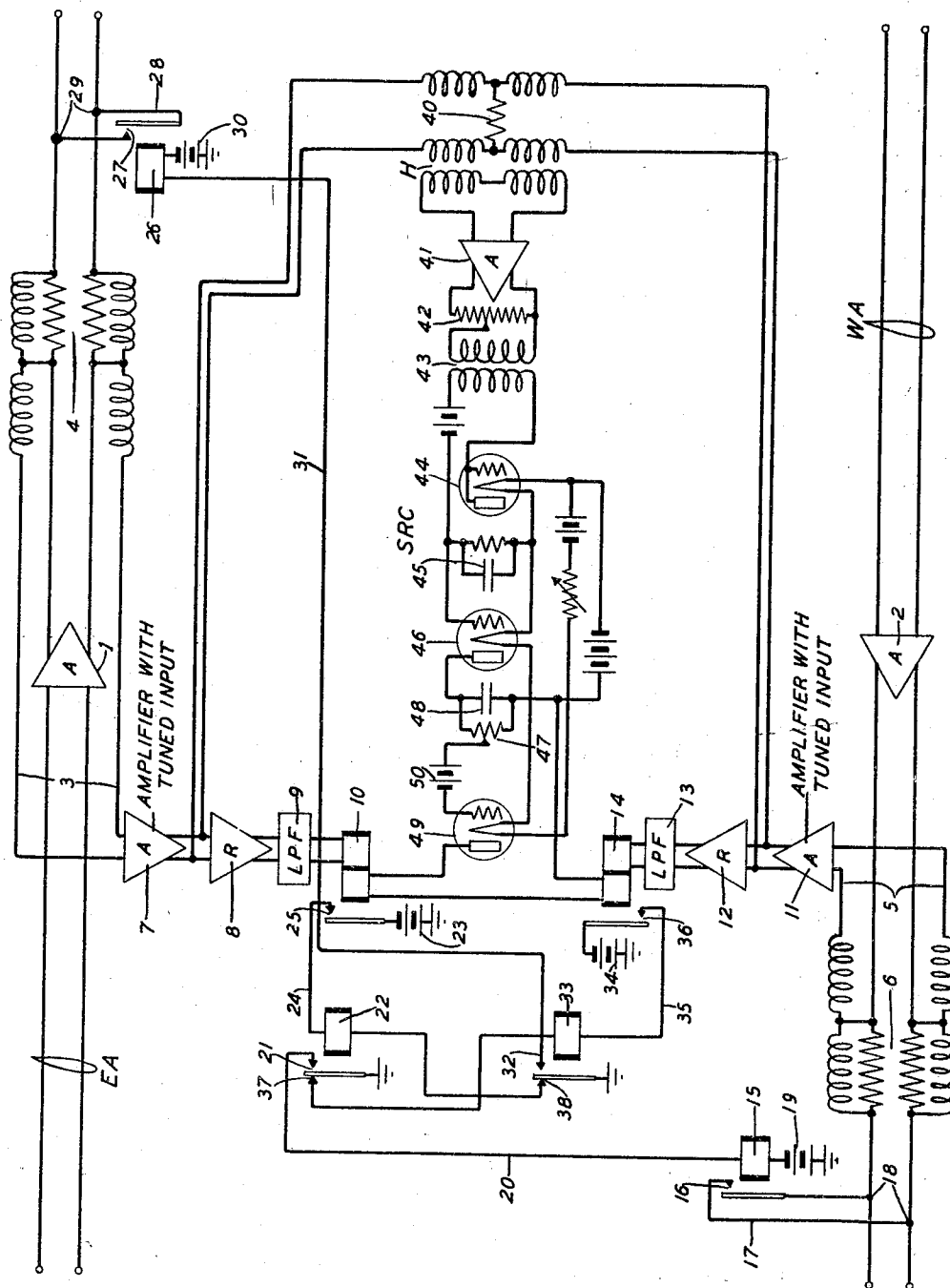
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TRANSMISSION CONTROL CIRCUITS

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TRANSMISSION CONTROL CIRCUITS

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This invention relates to two-way signaling systems and particularly to the signal-controlled means employed in said systems for conditioning the circuits thereof for various purposes, such as to suppress disturbances, i. e., echoes, and to prevent singing.

An object of the invention is to improve the operation characteristics of such signal-controlled means in two-way signaling systems.

Although the invention will be described applied to the signal-controlled means usually located near the middle of long two-way signaling systems for suppressing echoes therein, so-called echo suppressors, it is applicable as well to similar means utilized at the terminals of said systems for suppressing echoes and preventing singing, and to means for controlling voice operated repeaters.

An echo suppressor is that type of signal-controlled device well known in the art utilized in connection with two-way signaling systems for effectively disabling one of the associated one-way transmission circuits thereof while signal transmission is taking place over the other oppositely directed one-way circuit, thereby preventing echo currents or reflected currents from being transmitted back to the transmitting end of the system and causing a disturbance. The disabling apparatus may comprise, for example, a short circuit which may be closed across one of the one-way circuits under the control of a mechanical relay in the output of a vacuum tube amplifier-detector having its input connected across a one-way circuit for transmission in the opposite direction.

This invention is specifically directed to improvements in the type of signal-controlled circuits employed in connection with two-way signaling systems for the above mentioned purposes, in which the sensitivity of the disabling means is controlled in accordance with the amount of line noise in the system so as to prevent false operation by noise while maintaining at all times the circuits in the most sensitive condition as regards operation by signals. These improvements reside mainly in means for automatically producing a smooth, continuous reduction in the sensitivity of the signal-controlled circuits as regards

operation by signals, which is proportional to the increase in the amount of line noise in the system, and in means for preventing interference with the sensitivity controlling means or false operation of the signal-controlled circuits under abnormal noise conditions.

One embodiment of the invention is in connection with a suppressor in a four-wire transmission circuit. The signals transmitted over either one-way transmission path of the signaling circuit control a vacuum tube amplifier-detector circuit having its input bridged across that path, to energize the operating winding of a master relay, the operation of this relay controlling a chain of relays to disable the oppositely directed one-way path and to open the circuit of the corresponding relay chain controlled by the amplifier-detector connected to that path. Bridged across the input of the detectors in both suppressor circuits through a hybrid coil transformer is a "proportional reducer" circuit. This "proportional reducer" circuit comprises a quick operating and fairly slow releasing vacuum tube circuit followed by a slow-operating, quick-releasing vacuum tube circuit, which operates in response to the noise waves impressed upon its input to supply biasing currents varying in proportion to the amplitude of the impressed noise waves to a biasing winding on each of the master relays of each suppressor circuit thus varying the sensitivity of these relays to operation by the signals in direct proportion to the amount of noise in the system, while preventing their operation by the noise waves. The long response time of the "proportional reducer" circuit in comparison with the duration of a single impulse of the signals prevents the signals from applying biasing current to the master relays through the "proportional reducer" circuit.

A feature of the invention is the use in the "proportional reducer" part of the system of a two-element rectifier circuit having a quick build-up time, but a comparatively longer release time. The long release time of the circuit is provided to prevent appreciable variation in the biasing effect on the master relays with regular fluctuation in power of

the noise currents impressed on the rectifier circuit. The release time is fixed so that if the frequency of the power variation in the noise is greater than a certain frequency the relay biasing current will not vary.

Another feature is the use of a low pass filter having a cut-off in the neighborhood of 25 cycles per second in the output of the detector in each suppressor circuit, for preventing false operation of the master relays by induced currents from neighboring circuits, for example, by the beat frequencies produced by harmonics of 60 and 25 cycle waves picked up from adjacent power lines.

Another feature is the provision of means for obtaining over-protection of the signal-controlled circuits against abnormal noise peaks, by the relative design of the reducer detector circuit with respect to the operating detector circuit.

The nature of the invention, its purposes and advantages will be clear from the following detailed description thereof when read in connection with the accompanying drawing, the single figure of which shows diagrammatically a portion of a four-wire telephone repeating system employing echo suppressors embodying the invention.

The four-wire telephone repeating system of the drawing comprises the one-way transmission path EA including the one-way amplifying device 1 for repeating telephonic signals in the direction from west to east and the one-way transmission path WA including the one-way amplifying device 2 for repeating telephonic signals from east to west.

The two one-way amplifying paths EA and WA may be associated at the east and west terminals of the system by means of the usual hybrid coil transformers and associated balancing networks (not shown), in energy transmitting relation with two lines leading to the west and the east subscribers respectively, and in conjugate relation with each other in the manner well known in the art.

The outgoing portion of the transmission path EA and the input of the control circuit 3 are connected by means of the network 4 in substantially conjugate relation with each other and in energy transmitting relation with the output of the amplifying device 1. Similarly, the outgoing portion of the transmission path WA and the input of the control circuit 5 are connected by means of the network 6 in substantially conjugate relation with each other and in energy transmitting relation with the output of the amplifying device 2.

The networks 4 and 6 may be special bridge transformers such as disclosed in Crissom Patent 1,755,243, issued April 22, 1930 for a similar purpose. The networks 4 and 6 are so designed that the voltage input to the control circuits 3 and 5, respectively, will not be affected by the short-circuiting of the out-

going portions of the paths EA and WA, respectively. A hybrid coil transformer and associated balancing network, or an additional one-way amplifying device such as disclosed in the applicant's copending application, Serial No. 471,520, filed July 28, 1930, may be utilized in place of the networks 4 and 6, respectively for the same purpose.

The control circuit 3 comprises the one-way amplifying device 7 having a tuned input circuit connected to the network 4, a one-way rectifying device 8 having its input connected to the output of the device 7, a low-pass filter 9 connected between the output of the rectifying device 8 and the right-hand (operating) winding of the master echo suppressor relay 10. The control circuit 5 comprises a one-way amplifying device 11 having its tuned input circuit connected to the network 6, a one-way rectifying device 12 having its input connected to the output of the device 11, and a low-pass filter 13 connected between the output of the rectifying device 12 and the right-hand (operating) winding of the master echo suppressor relay 14.

The input circuits of amplifying devices 7 and 11 are preferably tuned by well known means to about 1200 cycles, with attenuation increasing rapidly at lower frequencies and increasing but not so rapidly at the higher frequencies.

Adjacent to transmission path WA is a relay 15 which, when energized, is adapted to close the normally open contacts 16 in the connection 17 so as to short-circuit the outgoing portion of the path WA at the points 18. The relay 15 is arranged to be supplied with energizing current from a battery 19 over a conductor 20 when the normally open contacts 21 therein are closed by operation of a relay 22. The relay 22 is arranged to be supplied with energizing current from the battery 23 over the conductor 24 when the normally open contacts 25 therein are closed by operation of the master echo suppressor relay 10.

Adjacent the transmission path EA is a relay 26 which, when energized, is adapted to close the normally open contacts 27 in the connection 28 so as to short-circuit the outgoing portion of the path EA at the points 29. The relay 26 is arranged to be supplied with energizing current from a battery 30 over the conductor 31 when the normally open contacts 32 therein are closed by operation of a relay 33. The relay 33 is arranged to be supplied with energizing current from a battery 34 over the conductor 35 when the normally open contacts 36 therein are closed by operation of the master echo suppressor relay 14.

The normally closed contacts 37 in the energizing circuit for relay 33 are adapted to be opened by operation of the relay 22, thus deenergizing relay 33. Similarly, (the nor-

mally closed contacts 38 in the energizing circuit for relay 22 are adapted to be opened by operation of the relay 33, thus deenergizing relay 22.

5 The relays 10 and 14 each have left-hand windings, which will be referred to hereafter as the biasing windings, so wound that when supplied with energizing current, they will effectively oppose the action of the operating
10 windings of the relays, that is, they will bias the relays against operation.

To control the current to the left-hand biasing windings of the master echo suppressor relays 10 and 14, and consequently the
15 sensitivity of these relays to operation by signals, a proportional sensitivity reducing circuit SRC is employed.

The purpose of the proportional sensitivity reducing circuit is to balance out the contribution of noise from the transmission repeating paths into the input of the echo suppressor control circuit so as to permit the echo suppressors to be actuated only by the speech currents. With the addition of the
20 sensitivity reducing circuit, the sensitivity of the echo suppressors may be set to the value required for satisfactory operation and if noise is present in the system, the sensitivity is automatically reduced to the point
25 where the master echo suppressor relays will just not be operated by the noise, although operative by the voice currents.

The input of the sensitivity reducing circuit SRC is connected in parallel across the control circuit 3 between the output of the amplifier 7 and the input of the rectifier 8
30 therein, and across the control circuit 5 between the output of the amplifier 11 and the input of rectifier 12 therein, by means of the single hybrid coil transformer H. The biasing windings of relays 10 and 14 are connected in series across the output of the sensitivity reducing circuit SRC.

The resistance network 40, bridged between the line windings of the hybrid coil H is given such a value that the waves from path EA passing from the output of amplifier 7 in control circuit 3, or the waves from path WA passing from the output of amplifier 11 in control circuit 5 to the input of the sensitivity reducing circuit SRC, will set up
40 no false action in the echo suppressor connected across the other transmission path of the four-wire circuit. Any other suitable arrangement may be substituted for the hybrid coil transformer H.

In the sensitivity reducing circuit SRC is an amplifying device 41 having its input connected across the terminals of the series winding of hybrid coil transformer H. The output circuit of the amplifying device 41 is coupled through the potentiometer 42 and the interstage transformer 43 to the input of a two-element vacuum tube rectifying device
44.

In the output of the rectifying device 44 is a resistance condenser network 45 so designed that the time of voltage decay across the resistance therein is considerably longer than the time of build-up. The voltage of the rectifier 44 is applied through the network 45 to the three-element vacuum tube amplifier 46, which is essentially a D. C. amplifier, the circuit of which is arranged so that its grid electrode is normally at zero potential. Connected across the output electrodes of the amplifier 46 is a large resistance 47 having a value in the order of about 200,000 ohms. The resistance 47 is shunted by a large condenser 48, having a value in the order of about 6 m. f. The voltage applied by the rectifier 44 through the network 45 drives the grid of the amplifier 46 negative and tends to decrease its plate current. However, as the condenser 48 in the plate circuit of tube 46 will discharge quite slowly through the high resistance 47 the change in the output voltage of the tube 46, which is applied to the input circuit of the three-element vacuum tube rectifier 49, for applied negative voltages will be quite slow. On the other hand when the rectifier 44 no longer biases the grid of the amplifier 46 negatively, the condenser 48 will charge up rapidly through the comparatively low internal impedance of the amplifier tube 46. It is seen, therefore, that there are two vacuum tube circuits in tandem, the first comprising the amplifier 41, the rectifier 44 and the resistance condenser network 45 being quick operating and slow restoring, while the second comprising the amplifier 46, and the resistance 47 and parallel condenser 48 in its output circuit being slow-acting and quick-restoring. This latter circuit is coupled to the three-element vacuum tube rectifier 49 through a C battery 50 of sufficient voltage to hold the plate current of that rectifier to zero for normal conditions of the preceding tube.

The rectifier 49, which controls the application of biasing current to the biasing windings of relays 10 and 14 connected in series in its output circuit, which current will decrease in proportion as the amplitude of the noise wave in the transmission paths EA and WA increase, will be referred to hereafter as the "reducer" rectifier, while the rectifiers 8 and 12 which control the operation of the relays 10 and 14, respectively, will be referred to hereafter as "operating" rectifiers.

The slow release time of the first vacuum tube circuit in the combination is desirable so that the bias produced by the "reducer" rectifier 49 through the biasing windings of the master echo suppressor relays 10 and 14 should not vary with the regular fluctuation in power of a steady noise. The release time of the circuit by suitable selection of the values of the elements therein is preferably made long enough so that if the frequency of

the power variation in the noise is greater than a predetermined small value, for example, 20 cycles per second, the relay biasing currents will not vary.

The slow operating feature in the second vacuum tube circuit is to prevent a quick building up of the back bias by the speech waves impressed on the circuit SRC. With a preferred construction of the sensitivity reducing circuit the back bias does not become operative until after about 0.7 seconds, so that most speech syllables will be too short to build up any back bias.

The sensitivity reducing circuit SRC as a whole, therefore, may be considered as effectively non-responsive to speech waves. It will, however, be responsive to the comparatively steady noise waves impressed on its input through hybrid coil transformer H to produce equal currents in the biasing windings of relays 10 and 14, the amplitude of which currents will be directly proportional to the amplitudes of the impressed noise waves. However, as stated, the biasing currents will not be affected by the usual slow regular fluctuations in the power of the applied noise.

The potentiometer 42 located in the output of the amplifier 41 in the sensitivity reducing circuit SRC is utilized for adjusting the gain of that circuit with respect to the gain of the "operating" rectifier circuits 3 and 5. The large resistance 47 connected between the output of the amplifier 46 and the input of the "reducer" rectifier 49 is made adjustable so that the slope of the "reducer" rectifier, grid voltage-plate current characteristic may be adjusted with respect to that of the "operating" rectifiers 8 and 12. The purpose of these adjustments will be brought out later.

The low pass filter 9 connected in the control circuit 3 between the output of the rectifier 8 and the operating winding of the master echo suppressor relay 10, and the low pass filter 13 connected in the control circuit 5 between the output of the rectifier 12 and the operating winding of the master echo suppressor relay 14, are designed to have a cut-off at a frequency in the neighborhood of 20 to 25, and preferably of 25 cycles per second. Most of the disturbances in noise, such as clicks, have a frequency spectrum such that a good deal of the energy is to be found above 20 cycles. Since the AC components of the rectified voice frequencies contribute little or nothing to the relay operation, the exclusion of the AC components of both noise and speech produces a net gain in protection. In addition, when certain harmonically related frequencies, for example, the beat frequencies produced by harmonics of 60 and 25 cycles picked up from neighboring power lines, are detected they have a tendency to produce high sharp peaks in the output of the detector. It would require large over-protection to cover

these peaks. The low pass filters 9 and 13 are provided to eliminate these peaks, and in this respect the present circuit is different from an automatic sensitivity reducing device which would have to be designed to take care of these peaks. In speech the sharp peaks seldom occur, and contribute little to the operation, so the filters do not affect the operating attributes of speech. As the "operating" rectifier circuit has a cut-off at a frequency of approximately 25 cycles per second, and the "reducer" rectifier circuit does not pass variations of frequencies above about 2 cycles, each circuit furnishes protection for noises when the frequency of their power variation does not fall below 25 cycles.

The operation of the system as a whole will now be described. As the operation of the system when speech waves are being transmitted in the direction from east to west is similar to the operation when speech waves are being transmitted in the direction from west to east, only the former case need be described.

It may be assumed that speech waves are being transmitted from east to west over the transmission path EA and that at that time no speech waves are being transmitted in the direction from west to east over the transmission path WA. It will be also assumed that there is some noise present in one or both of the transmission paths EA and WA at that time.

It will also be assumed that the relative gain of the sensitivity reducing circuit SRC and the "operating" detector circuits 3 and 5 by proper choice and adjustment of the elements therein are adjusted so that with minimum noise present in the system the relays 10 and 14 are at maximum sensitivity as regards operation by speech signal waves.

The speech waves transmitted over the path EA will be amplified by the amplifier 1 therein and transmitted into the network 4. As indicated above, the networks 4 and 6 are designed so that the speech waves will be transmitted therethrough into the echo suppressor control circuits 3 and 5 respectively even when the communication paths are blocked in their outputs and so that this blocking will not react on the inputs to the control circuits.

The main portion of the amplified speech waves will be impressed by the network 4 on the outgoing portion of the transmission path EA, and, the contacts 27 of the connection 28 being in their normally open condition, these waves will be transmitted over the path EA to the line associated with the listening subscriber.

A portion of the speech waves in the output of the amplifier 1, will be impressed by the network 4 upon the control circuit 3 bridged across the path EA and will be amplified by the amplifier 7 therein. The am-

plified speech waves in the output of the amplifier 7 will be divided between the hybrid coil H and the input of the rectifying device 8 in control circuit 3. The portion diverted into the input of the hybrid coil H will be impressed thereby upon the input of the amplifier 41 in the sensitivity reducing circuit SRC and will be amplified thereby. The amplified speech waves will be impressed by the potentiometer 42 and the interstage transformer 43 upon the input of the two-element rectifier 44. Because of the design of the condenser-resistance 45 in its output circuit, the rectifier 44 will operate quickly to apply a negative voltage to the grid of the amplifier 46, which tends to decrease the plate current of that tube. This will cause the large condenser 48 in the output circuit to discharge slowly through the large resistance 45. As the speech syllables are short compared to the discharge time of the condenser the speech waves will not be effective to cause operation of the rectifier 49, and thus will not build up a back bias on the relays 10 and 14.

The portion of the amplified speech waves in the output of the amplifying device 7 impressed on the input of the rectifying device 8 will be rectified and supplied to the low pass filter 9 which will pass those frequencies only in the range below its cut-off frequency which, according to our assumption is 25 cycles per second or less. The portions of the rectified speech currents passed by the low pass filter 9 will energize the operating windings of relay 10.

Meanwhile, a portion of the noise waves which may happen to be present in the input of the transmission path EA at the time the speech waves are being transmitted thereover will also be impressed by the network on the input of the control path 3 and will be amplified by amplifier 7 therein. Also, a portion of any noise waves which may be present in the input of the path WA at this time will be impressed by the network 6 on the input of the control circuit 5 and will be amplified by the amplifier 11 therein. The amplified noise waves in the output of the amplifier 7 will be divided between the hybrid coil H and the input circuit of the rectifying device 8 in control circuit 3, and the amplified noise waves in the output of the amplifier 11 will be divided between the hybrid coil transformer H and the input of the rectifier 12 in control circuit 5. The portion of the noise waves impressed on the input circuit of the rectifying device 8 will cause rectified current varying in accordance with the impressed noise waves to be supplied to the operating winding of the relay 10 through the low pass filter 9, and the portion of the amplified noise waves impressed upon the input circuit of rectifier 12 will similarly cause rectified current varying in accordance

with the impressed noise waves to be supplied to the operating winding of relay 14 through low pass filter 13. The rectified noise currents supplied to the operating windings of relays 10 and 14 will reinforce the rectified speech currents supplied thereto and cause the operation of these relays.

The portion of the amplified noise waves supplied from the output of the amplifier 11 to the hybrid coil transformer H will be superposed upon the portion of the amplified noise waves supplied from the output of the amplifier 7 to the hybrid coil transformer H, and the superposed waves will be impressed by that transformer upon the input of the sensitivity reducing circuit SRC. The superposed, impressed noise waves will be amplified by the amplifier 41 and be impressed thereby through the potentiometer 42 and the interstage transformer 43 on the input circuit of the two-element rectifying device 44. Because of the design of the resistance condenser network 45 in its output circuit, as explained above, the rectifying device 44 will then quickly operate and apply a corresponding negative voltage to the grid of the amplifier tube 46 across the network 45. The plate current of the tube 46 will decrease accordingly and the resulting output voltage will decay slowly across the resistance condenser combination 47-48, in the output circuit. This slowly varying output voltage, which can be made directly proportional to the average amplitude or nearly proportional to the peak amplitude of the superposed noise waves impressed on the input of the circuit SRC, will be applied to the grid of the "reducer" rectifier tube 49 causing a correspondingly slow rise in the plate current of that tube, which is supplied equally to the biasing windings of the echo suppressor relays 10 and 14 in series in the plate circuit of tube 49.

The rectified noise currents in the output circuit of the rectifier 8 have meanwhile been applied to the operating winding of the relay 10 through the low pass filter 9. If the gain of the sensitivity reducing circuit SRC and that of the circuit including the "operating" rectifier 8 were the same, the noise currents supplied to the two windings of the relays would be equal, and, these two windings being wound in opposition, would be effectively neutralized as regards affecting any change in the sensitivity of the relay 10. To prevent this, the gain of the rectifier 8 in control circuit 3 and also that of the rectifier 12 in control circuit 5 is adjusted with respect to the gain of the sensitivity reducing circuit SRC by suitable means, such as, for example, by adjustment of the potentiometer 42 in the output of the amplifier 41, so that the noise current supplied thereby to the biasing windings of relays 10 and 14, respectively, will be greater in magnitude to the desired degree than the rectified noise currents supplied to

the operating windings of these relays from the output of the rectifiers 8 and 12 respectively. In the manner described the sensitivity reducing circuit SRC may be utilized to reduce the sensitivity of the relays 10 and 14 as the amplitude of the noise waves in either or both of the transmission paths EA and WA increase, in direct proportion to these amplitudes.

The current supplied to the operating winding of the relay 10 from the output of the low pass filters 9 comprising as it does the superposed rectified speech and the rectified noise current, will be greater in magnitude than the current supplied to the biasing winding of relay 10 which comprises noise current only, and therefore relay 10 will be operated.

The operation of relay 10 will close the normally open contacts 25 in the conductor 24 causing the winding of relay 22 to be energized over conductor 24 by current from battery 23. Relay 22 will then be operated to open the normally closed contacts 37 in the energizing circuit for relay 33, and to close the normally open contacts 21 in the conductor 20, causing relay 15 to be energized by current from battery 19 over the conductor 20. Relay 15 will then operate to close the normally open contacts 16 in the connection 17 causing the outgoing portion of the amplifying path WA to be short-circuited thereby at the points 18, thus rendering that path inoperative thereafter to transmit echo currents, or reflected current to the transmitting end of the system.

The opening of the normally closed contact 37 in the energizing circuit for relay 33 by operation of the relay 22 will prevent the relay chain comprising relays 33 and 26 from being operated due to false operation of relay 14, to close the short-circuiting connection 28 across the outgoing portion of the transmission path EA, as long as relay 10 is maintained operated by the west to east speech current. The relay 22 and the corresponding relay 33 associated with the other echo suppressor are designed to have the necessary amount of hangover in their operation. This interlocking action is necessary for proper operation of the system, for with the bridging transformer connection the control circuits get their input even though the communication path is blocked and if the circuit had an echo of any considerable magnitude, the echo itself would operate the suppressor in its path, and cause lockout for the period of the hangover. Similar trouble would be encountered if both talkers started speaking about the same time.

When the transmission of the west to east speech currents over the path EA ceases, the operating winding of relay 10 will be deenergized causing contacts 25 to return to their normal open condition, which will cause relays 22 and 15 to be deenergized in

turn, so as to open the short-circuiting connection 17 across the outgoing portion of the path WA at the points 18. The relays 10, 22 and 15, and the corresponding relays associated with the echo suppressor connected across the path WA, may be designed to have the desired amount of hangover in their operating periods, so as to prevent premature opening of the short-circuiting connections across the echo paths which might cause serious interference with the operation of the repeater circuits.

When the supply of noise currents to the sensitivity reducing circuit SRC of the hybrid coil transformer H ceases the negative bias produced by the rectifier 44 on the grid of the amplifier tube 46 through the network 45 is removed. The large condenser 48 in the output circuit of the tube will then charge up rapidly through the comparatively low internal impedance of the tube 46, thus quickly restoring the circuit SRC to its normal condition.

It may be desirable to obtain in the circuit which has just been described certain over-protection of the signal control circuits against abnormal noise peaks. Over protection may be defined as the amount the average "reducer" rectifier current exceeds the operating "rectifier" output current for noise. There are several ways of obtaining this over-protection. One is that of having the absolute gain of the sensitivity reducing circuit SRC greater to a desired degree than that of the "operating" rectifier circuits. This may be readily obtained by the proper adjustment of the potentiometer 42 between the output of the amplifier 41 and the interstage transformer 43 in the sensitivity reducing circuit.

Another method of obtaining this over-protection is by having the slope of the grid voltage-plate current characteristic of the "reducer" rectifier 49 greater to the desired degree than that of the "operating" rectifier 8 or 12. This may be accomplished by varying the adjustment of the variable resistance 47 in the network connected between the output of the amplifier tube 46 and the input of the "reducer" rectifier tube 49 in the sensitivity reducing circuit, altering the proportion of the output voltage of amplifier 46 impressed on the input circuit of rectifier 49.

Another method of obtaining this over-protection is by increasing the build-up time of the "reducer" rectifier voltage and increasing its release time. This will tend to make the rectifier voltage proportional to the noise peaks. This may be readily accomplished by designing the sensitivity reducing circuit SRC to have the required constants, as by altering the relative values of the resistance condenser combination in the network 45, and the values of the resistance 47 and condenser 48 in the sensitivity reducing circuit.

On account of the modulation terms, to obtain proper over-protection against noise peaks it may be necessary to increase the "reducer" rectified amplification and at the same time change the saturation point in order to cover the same range. In general the amplitude of the difference tones produced by modulation is a function of the amplitude of the frequencies producing them, and in a parabolic detector proportional to the product of the amplitudes. Most of the difference tones will not be passed by the low pass filter 9 or 13 in the "operating" rectifier circuits so the amplitude of the difference tones will be small in comparison to the amplitude of the direct current. For any given noise the amplitude of the difference tones and the direct current will be proportional. The sensitivity reducing circuit should be adjusted so that the reducer output current is always just sufficient to cover the noise. The actual slope of the characteristic will have to be determined experimentally.

In the particular modification of the invention which has been illustrated and described, current-controlled mechanical relays are shown as being employed for disabling the transmission paths by connecting short-circuits across these paths. It is apparent that it is within the scope of the invention to utilize other well known means for disabling these paths, for example, current controlled means for connecting loss networks across the path or for open-circuiting these paths. Instead of using mechanical relays and movable contacts to perform the switching operations, stationary means may be used for that purpose, such as vacuum tube relays, disclosed for example, in an article by C. A. Beer and G. T. Evans in the Journal of the Institute of P. O. Electrical Engineers (London), vol. 20, pages 65 to 72 inclusive, published in April, 1927, or in the United States patent to Crisson 1,647,212, issued November 1, 1927.

What is claimed is:

1. A system for suppressing echoes in a two-way signal transmission circuit comprising a detector connected to one side of said circuit and responsive to waves therein, means controlled by operation of said detector for effectively disabling the opposite side of said circuit, and means for preventing operation of said disabling means by the noise waves in said transmission circuit while permitting its operation by the signals therein, including means connected between the output of said detector and said disabling means for preventing the operation of said disabling means by waves of frequencies in the detector output exceeding a certain maximum value.

2. The system of claim 1 and in which the last mentioned means comprises a low-pass filter having a cut-off at a frequency of said maximum value.

3. The system of claim 1 and in which the

last mentioned means comprises a low-pass filter having a cut-off at a frequency of approximately 25 cycles per second.

4. A system for suppressing echoes in a two-way signal transmission circuit comprising a detector connected to one side of said circuit and responsive to waves therein, means controlled by operation of said detector for effectively disabling the opposite side of said circuit, means for preventing operation of said disabling means by noise waves in said transmission circuit while permitting its operation by signals therein and means connected between the output of said detector and said disabling means for preventing operation of said disabling means by interference waves consisting of harmonic frequencies of 25 cycles or over picked up from extraneous energy sources of a fundamental frequency of 25 cycles or over.

5. A system for suppressing echoes in a two-way signal transmission circuit comprising one circuit including a detector connected to one side of said transmission circuit and responsive to waves therein, means controlled by operation of said detector for effectively disabling the opposite side of said transmission circuit, a second circuit also including a detector connected to said one side of said circuit and responsive to noise waves therein to continuously reduce the sensitivity of said disabling means as regards operation by signals in proportion to the amount of noise in said transmission circuit while preventing its operation by said noise, and means in said second circuit for making the slope of the input voltage-output current characteristic of the detector therein greater than that of the detector in said one circuit.

6. A system for suppressing echoes in a two-way signal transmission circuit comprising a detector connected to one side of said circuit and responsive to waves therein, means controlled by operation of said detector for effectively disabling the opposite side of said signal circuit, and means automatically responsive to noise waves in said circuit for maintaining said disabling means at maximum sensitivity at all times as regards operation by signals but inoperative by noise waves, the last mentioned means including a vacuum tube circuit responsive to noise waves in said circuit for continuously biasing said disabling means against operation in proportion to the amplitude of said noise waves and having a responsive time such that it will not respond to the comparatively short impulses of signals from said signal circuit, said vacuum tube circuit including a two-element vacuum tube rectifier circuit designed to prevent variation in the biasing effect on said disabling means for regular fluctuations in the power in said noise waves.

7. The system of claim 6 and in which said rectifier circuit is designed to build up an

output voltage quickly in response to waves impressed on its input, which will decay comparatively slowly on cessation of the supply of waves to its input.

8. The system of claim 6 and in which said two-element rectifier operates from a low impedance into a high resistance shunted by a small capacity.

9. The system of claim 6 and in which said two-element rectifier operates from a low impedance into a high resistance shunted by a small capacity, the values of said resistance and said capacity being chosen so that the release time of the rectifier is long enough to prevent variation of the rectifier output current when the frequency of the power variation in the noise waves impressed on the rectifier input is greater than a given value.

10. A system for suppressing echoes in a two-way signal transmission circuit comprising, connected to each side of said circuit, a detector responsive to waves therein, a relay controlled by operation of the detector for effectively disabling the opposite side of said signal circuit, and means automatically responsive to noise in either or both sides of the signal circuit to maintain both disabling relays at maximum sensitivity at all times as regards operation by signals but inoperative by noise waves, said means including a vacuum tube circuit connected to both sides of said transmission circuit and responsive to the noise therein for continuously biasing both relays against operation in proportion to the total amount of noise in said transmission circuit and having a response time of such duration as compared to a single impulse of said signals as to prevent the signals from biasing said relays against operation, said vacuum tube circuit including a two-element rectifier designed to prevent variation in the biasing effect on said relays for regular fluctuations in the power content of said noise waves.

In witness whereof, I hereunto subscribe my name this 11th day of August, 1930.

BJORN G. BJORNSON.

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