

March 28, 1939.

V. D. LANDON

2,151,778

REDUCTION OF NOISE

Filed March 28, 1936

2 Sheets-Sheet 1

Fig. 1.

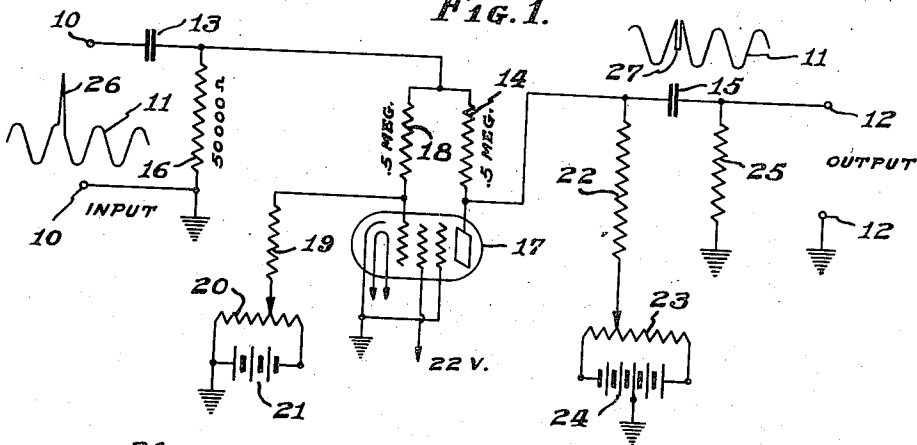


FIG. 2.

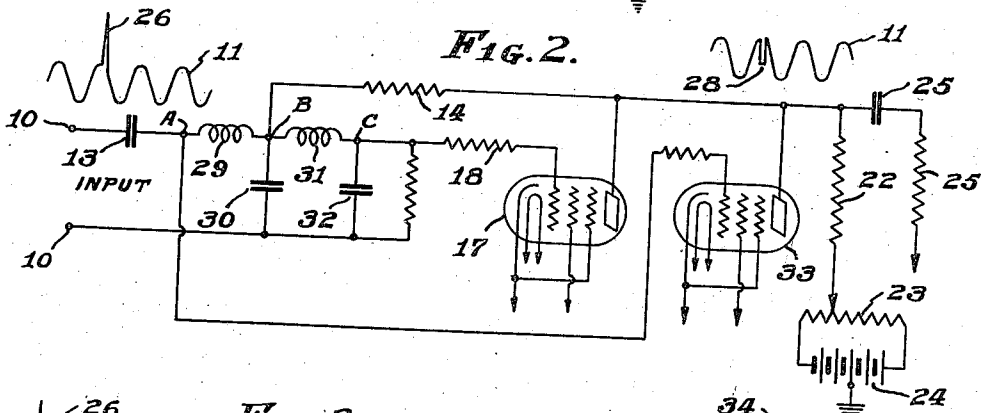
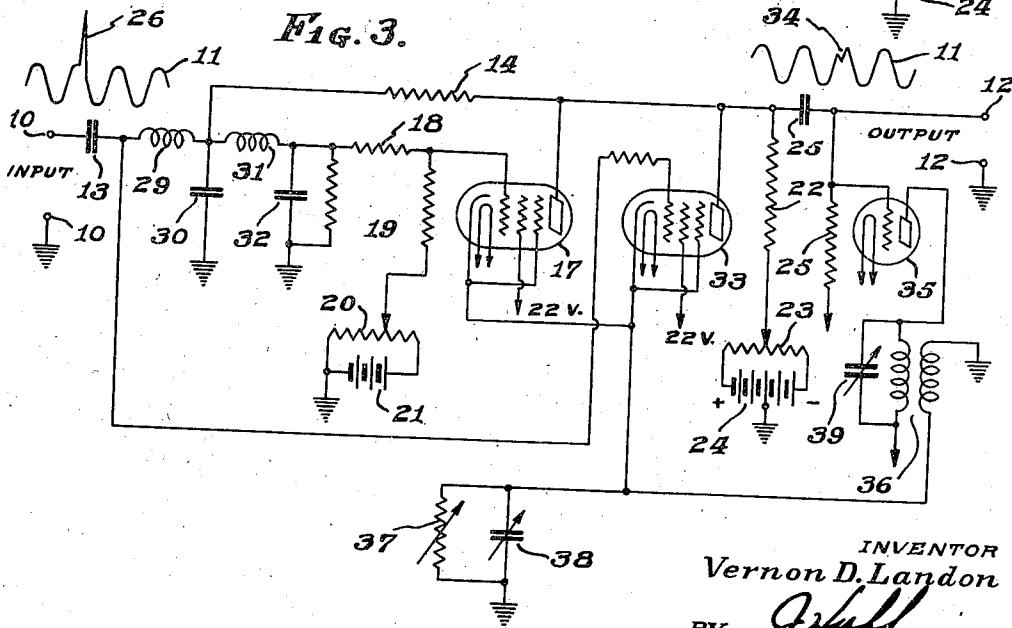


Fig. 3.



INVENTOR
Vernon D. Landon
BY *J. Huff*
ATTORNEY

March 28, 1939.

V. D. LANDON
REDUCTION OF NOISE

2,151,778

Filed March 28, 1936

2 Sheets-Sheet 2

Fig. 4.

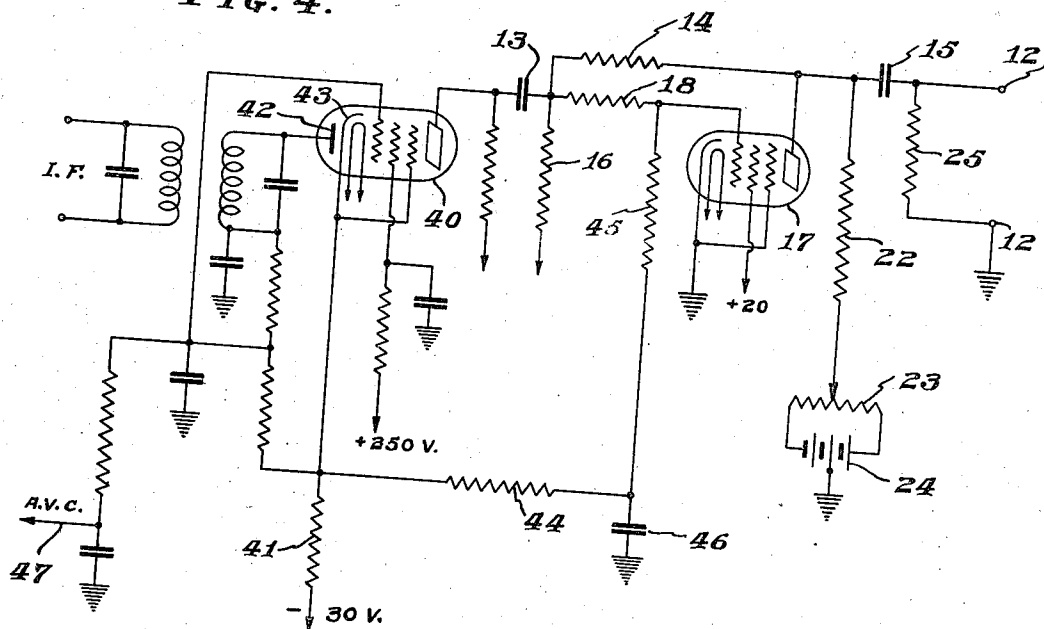
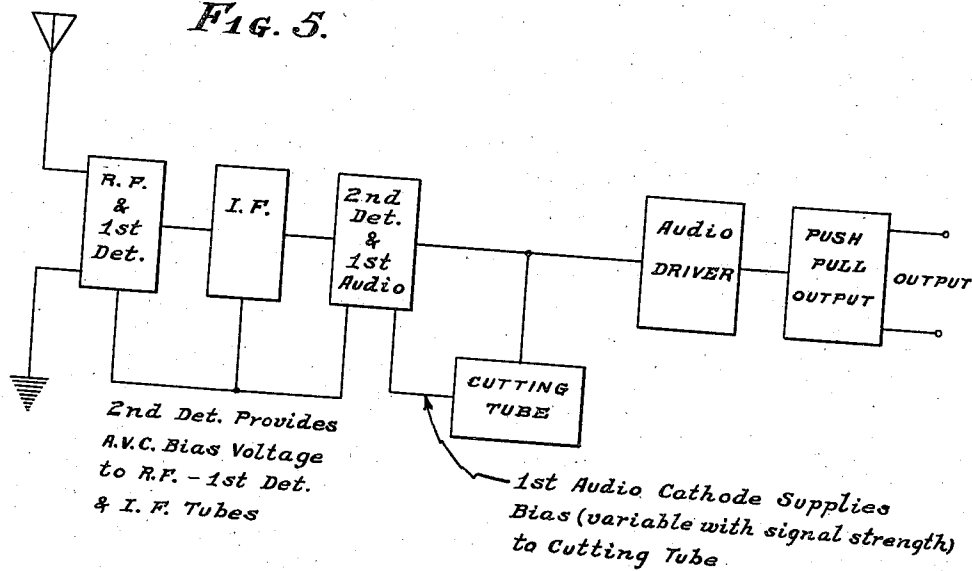


Fig. 5.



INVENTOR
Vernon D. Landon

BY *J. J. Jeff*

ATTORNEY

UNITED STATES PATENT OFFICE

2,151,778

REDUCTION OF NOISE

Vernon D. Landon, Collingswood, N. J., assignor
to Radio Corporation of America, a corporation
of Delaware

Application March 28, 1936, Serial No. 71,380

19 Claims. (Cl. 250—20)

This invention relates to the reduction of the noise produced in radio receivers and similar apparatus as a result of electrical impulses extraneous to the signal or control impulses, and has for its principal object the provision of an improved apparatus and method of operation whereby the noise impulses may be separated from the signal impulses without substantial distortion of the signal impulses.

Noise reduction devices of various types have heretofore been proposed or used. Many of these devices are not altogether satisfactory for the reason that they operate to eliminate the signal impulse during the continuance of the noise impulse thus producing objectionable distortion of the received signal. In accordance with the present invention, this difficulty is avoided by the provision of a limiter or channel short circuiting device controlled both in response to potentials derived from different points of a signal delay circuit and in response to a potential derived from the audio signal already passed.

In the simplest circuit, a vacuum tube is so arranged as effectively to short circuit the amplifier when the input voltage exceeds a predetermined value. Under these conditions, signal impulses of a voltage below this predetermined value are allowed to pass to the output terminals in the absence of relatively high voltage noise impulses but the signal impulse is eliminated during the persistence of a relatively high voltage noise impulse.

In an improved modification employing a plurality of vacuum tubes, signal delay circuits are utilized to eliminate portions of the noise passed by one limiter short circuiting or cutting tube and audio frequency impulses are fed back onto the cathodes of the limiter tubes to prevent cutting holes in the signal, thus rendering the signal substantially free from the distortion otherwise produced by operation of the limiter tubes. In other words, the signal is deleted during the period of the noise impulses and the deleted signal portion is replaced by a portion of the signal immediately preceding the deleted portion.

The present invention is in some respects an improvement on that of Miles A. McLennan, application Serial No. 92,559, filed July 25, 1936 which relates to the use of a telegraphone for producing impulses operable to control the amplifier channel in advance of the signal and on that of Winfield R. Koch application Ser. No. 71,348, filed March 28, 1936 which involves the use of a delay network for deriving control impulses operable in advance of the signal impulses.

The present invention will be better understood from the following description when considered in connection with the appended drawings and its scope will be pointed out in the appended claims.

Referring to the drawings,

Fig. 1 is a wiring diagram of a noise reduction circuit involving the use of a single limiter or control tube,

Fig. 2 illustrates a similar circuit involving the use of a pair of limiter tubes which operate by means of time delay circuits to increase the time during which the signal path is short circuited, thus eliminating the edge portions of the noise impulse passed by the single cutting tube of Fig. 1,

Fig. 3 illustrates a circuit which differs from that of Fig. 2 in that it includes means for feeding back to the limiting tube cathodes audio impulses which function both to prevent elimination of the signal during persistence of the noise impulse and to reduce the effect of the noise impulse in the absence of signal.

Fig. 4 illustrates a modified noise reduction circuit which operates to maintain a substantially constant ratio between the signal strength and the voltage required for operation of the limiter or cutter, and

Fig. 5 is a block diagram which illustrates the application of the noise reduction circuits of Figs. 1 to 4 to a radio receiver.

The circuit of Fig. 1 includes input terminals 10 from which signal impulses similar to those indicated at 11 may be supplied to output terminals 12 through a circuit including coupling capacitor 13, resistor 14 and coupling capacitor 15. Connected between the circuit 13—14—15 and ground are a coupling resistor 16, a limiter tube 17, the grid control circuit 18—19—20—21 of the tube 17, and anode potential adjustment circuit 22—23—24 and a coupling resistor 25.

In the operation of this modification of the invention, the tube 17 is biased beyond cutoff and draws no plate current in the absence of high level signals. The path of the signal under these conditions is through the circuit 13—14—15 and the ground return circuit. When a noise impulse in the positive direction, such as that indicated at 26, exceeds a level predetermined by the grid bias potential applied through the resistor 20, plate current flows and the plate potential is pulled down to approximately no signal value. The exact level to which the plate potential is brought varies from tube to tube because of variation in the emission potential. However, the voltage is always approximately that of the cathode

or ground. Since the plate potential with no signal is adjustable by means of potentiometer 23, this control allows the "short circuit" level and the no signal level to be adjusted to the same level or to different levels as desired.

If the signal consists of a carrier modulated by an unvarying audio sine wave 11, for example, and if the noise impulses 26 are repeated at regular intervals, then the phenomena may be observed on an oscillograph. The composite wave 11—26 is a reproduction of such an observation. The composite wave 11—27 is a similar reproduction illustrating the effect of the limiter tube 17. It will be noted that, during the time of the central part of the noise impulse, the plate potential is brought substantially to zero regardless of the relation between the noise and signal impulses. In the absence of modulation, the noise impulse is seen on the oscillograph as two narrow vertical lines corresponding to the beginning and the end of the impulse. The part of the noise impulse corresponding to these two vertical lines results in an audible distortion which may be reduced and substantially eliminated by the use of means including an additional limiter tube and a low pass filter as indicated in Fig. 2.

The apparatus of Fig. 2 is similar to that of Fig. 1 in several respects, but differs therefrom in that it includes a low pass filter or delay network 29—30—31—32 and an additional limiter tube 33 connected in parallel with the limiter tube 17. It will be noted that the limiter tubes 17 and 33 are subjected to out-of-phase grid control potentials derived from different points A and C of the delay network 29—30—31—32.

Thus the noise impulses arrive at B at a slightly later time than at A and arrive at C at a still later time. As a result, the tube 33 is caused to pass plate current before the noise impulse has established an appreciable voltage at its plate. The tube 17 passes current later and continues effectively to short circuit the signal path while the impulse is dying away at B thus releasing control an instant later when the impulse dies away at C. The net result is an increase in the time during which the signal path is short circuited as indicated at 28, thus reducing or eliminating that portion of the noise impulse which is passed by the single tube 17 of Fig. 1.

The two tube circuit of Fig. 2 leaves something to be desired in that it still cuts a hole in the signal as indicated at 28 and in that the resulting noise is still audible enough to be objectionable.

As indicated by Fig. 3, this difficulty may be avoided by the addition of a circuit including a tube 35 which amplifies the voltage passed by the limiter tubes. This amplified voltage is passed through a step down transformer 36 which gives the same voltage amplitude as that applied to the grid. A variable resistor 37 may be connected across the secondary winding for adjusting the signal to the same level as at the grid. Capacitors 38 and 39 may be connected across the primary or secondary or both to give a slight delay to the secondary voltage. This voltage is applied to the cathodes of the limiter tubes.

Assuming proper adjustment to have been made, a low frequency signal can not cause the limiter tubes to act because their grid and cathode voltages are equal and of near the same phase so that there is no effective input voltage applied between the grid and cathode. However, when high frequency modulation or a steep wave front such as a noise impulse arrives, the sud-

den application of grid voltage to the limiter tubes causes them to act before the voltage has time to reach the cathode. Also, the voltage level to which the limiter tubes pull the circuit is determined by the momentary potential of their cathodes. This potential corresponds to that of the signal at a time immediately preceding the noise impulse. Thus, low frequency modulation is scarcely disturbed at all by the noise pulse and the noise output is almost completely eliminated, as indicated at 34. This slight irregularity of one cycle of the wave indicates the point where the noise impulse occurs.

Unfortunately, the amount of current required to pull the plate potential down to about cathode potential depends on the amplitude of the noise peak appearing at the point B. When more current is required, the potential to which the plates drop is not quite as low as when the required current is lowered. Thus, more complete noise elimination may be accomplished if all noise impulses have the same amplitude. In practice, all such impulses may be made to have about the same amplitude by employing a limiter in a previous portion of the circuit. For example, the plate voltage on the last intermediate frequency tube may be reduced to a value only two or three times that required to pass the signal. If automatic volume control, of the type which allows strong signals to come through slightly stronger than weak signals, is employed, then it is of some advantage to use a series plate resistor in the (by-passed) B supply to this tube so that the automatic volume control will cause limitation to work at a higher level when stronger signals are being received.

If noise impulses are very large, they may cause grid current in the last intermediate frequency amplifier or even in preceding tubes. This makes it undesirable to use automatic volume control on the signal grid of this tube. However, a 6L7 type tube may be used and signals applied to one grid and automatic volume control to the other. Certain advantages may be realized by using 6L7 type tubes throughout the receiver for similar reasons. To reduce strong signals to the same level as weak signals at the limiter tubes, the tube just preceding the limiters may be a 6L7 type with audio applied to one grid and automatic volume control to the other.

As indicated by Fig. 4, the invention may be modified to cause the adjustment of the limiter tube to vary automatically with the signal strength so that the ratio of the signal voltage to the voltage required for limitation is maintained approximately constant. In this construction, the first audio tube 40 is diode-biased by the detector and its cathode returns to a point about 30 volts negative to ground through a resistor 41 of sufficient size to give the cathode approximately ground potential with no signal present. When a signal comes in, the bias developed by the diode 42—43 (shown as enclosed in the same receptacle as the first audio amplifier) reduces the first audio cathode current and runs the cathode negative. This variation in cathode voltage is applied to the grid of the limiter tube 17 through resistors 44 and 45 thus biasing this grid in accordance with the signal level.

In the operation of the apparatus of Fig. 4, the gain of the audio tube 40 is adjusted so that a 100% modulated signal is of barely sufficient amplitude to activate the limiter tube 17. The cathode of the audio tube 40 is not by-passed to

ground because it is impractical to use a large enough by-pass to avoid undesirable distortion of and prolongation of the noise impulse. Instead, the resistor 44 and a capacitor 46 are used to filter out the audio impulses from the bias lead. The resistor 44 may be much larger than the bias resistor 41. Incidentally, this circuit improves the automatic volume control circuit performance limiting strong signals to a lower value at the detector. This results from the fact that the diode anode 42-43 negative swing is increased by the negative swing of the audio tube 40 so that a given radio frequency signal produces a greater automatic volume control voltage. The automatic volume control lead is indicated at 47.

Fig. 5 illustrates diagrammatically the application of the circuits previously described to a complete radio receiver. This figure will be readily understood from the legends applied to it without detailed explanation of its various features.

While various control potentials are shown as derived from batteries, it will be apparent that such potentials may be derived from a source of rectified voltage or the like and that other modifications may be made without departing from the spirit and scope of the invention. For example, the limiter tubes 17 and 33 may be replaced by a single coplanar grid vacuum tube discharge device wherein the coplanar grids are each connected to a different point of the delay network.

I claim as my invention:

1. The combination of a signal channel, a delay network, a pair of limiter devices provided with cathode-anode circuits connected across said channel and with grid control circuits energized from different points of said network, and means for applying signal potential to the cathodes of said limiter devices, said signal potential being obtained from the signal channel at a point beyond said limiter.

2. The combination of a signal channel, an electronic short circuiting device provided with a cathode-anode circuit connected across said channel and with a grid control circuit energized in accordance with a signal supplied to said channel, means for deriving a control potential from the signal in said channel at a point following said device, and means operable to subject another electrode of said device to said control potential.

3. The combination with means providing a signal amplifying channel, of means providing a delay network in said channel, comprising a pair of limiter devices provided with cathode-anode circuits connected across said channel, and with grid control circuits energized from different points of said network, means operable to subject said limiter device cathodes to controlling potentials with respect to ground, and means responsive to changes in the amplitude of a signal supplied to said channel for varying said potentials.

4. The combination of a signal channel, an electronic short circuiting device provided with a cathode-anode circuit connected across said channel and with a grid control circuit energized in accordance with a signal supplied to said channel, means for deriving a control potential from the signal in said channel at a point following said device, means operable to subject the cathode of said device to said control potential, and means for adjusting the level at which short circuiting occurs.

5. The combination of a signal channel, a limiter device provided with a cathode-anode circuit connected across said channel and with a grid control circuit energized in accordance with a signal supplied to said channel, means operable to subject the cathode of said device to a potential dependent on the signal passed by said device, and means for adjusting the phase of the potential applied to said cathode.

6. The combination of a signal channel, a limiter device provided with a cathode-anode circuit connected across said channel and with a grid control circuit, and means including a diode-biased audio amplifier connected across said channel for subjecting said grid control circuit to a potential whereby a substantially constant ratio is maintained between the signal voltage and the voltage required for operation of said device.

7. The combination of a signal channel, a limiter device provided with a cathode-anode circuit connected as a shunt path across said channel and with a grid control circuit, a signal amplifier connected with said channel at a point preceding said limiter device, means in the cathode return circuit of said amplifier for subjecting said grid control circuit to a biasing potential whereby a substantially constant ratio is maintained between the signal voltage and the voltage required for operation of said device.

8. The combination of a signal channel, a limiter device provided with a cathode-anode circuit connected as a shunt path across said channel and with a grid control circuit, means including a signal amplifier connected across said channel at a point preceding said limiter means in the cathode return circuit of said amplifier for subjecting said grid control circuit to a biasing potential whereby substantially constant ratio is maintained between the signal voltage and the voltage required for operation of said device, and means for eliminating the signal current from said biasing potential.

9. The method of operating a noise reduction system including an audio frequency signal channel, which includes deleting from the signals passing through said channel the minute signal portions containing noise impulses and, while the remainder of the signals less the deleted portions are passing through said channel, replacing said deleted portions by an audio frequency signal portion immediately preceding each deleted portion.

10. The combination of a signal channel, a signal delay network, a pair of electronic short circuiting devices provided with cathode-anode circuits connected across said channel, and with grid control circuits energized from different points of said network, and means operable to subject the cathodes of said devices to control potentials, and means for controlling said potentials in accordance with the amplitude of a signal supplied to said channel.

11. In an audio frequency signal channel subject to high amplitude interference impulses, means for deleting from the signals passing through said channel that portion of said signals containing an interfering high amplitude impulse, and means for substituting in said channel for said deleted portion an undeleted portion of the signals in said channel immediately preceding the impulse.

12. In an audio frequency signal channel subject to high amplitude interference pulses, means for amplifying audio frequency signals and received interference voltage pulses, means for re-

ducing to zero that portion of each pulse which exceeds a predetermined value, and means in said channel for substituting therefor in said channel an undeleted portion of the signal wave immediately preceding the interference pulse.

13. In an audio frequency signal channel subject to high amplitude interference pulses, means for amplifying audio frequency signals and received interference voltage pulses, means for reducing to zero that portion of each pulse which exceeds a predetermined value, means for adjusting said last named means to operate at said predetermined value, and means including delay circuits for reducing to zero portions of the pulse immediately preceding and following the portion whose amplitude exceeds said predetermined value.

14. The combination of a signal channel, an electron discharge tube having a control grid and having its anode-cathode circuit connected across the signal channel, means for maintaining the anode at substantially cathode potential at times when the grid is actuated, and means providing an actuating interference voltage impulse on the grid of the tube at a time preceding the arrival of the pulse on the anode, said means including a time delay circuit.

15. The combination of a signal channel, two electron discharge tubes having anode-cathode circuits connected across the signal channel and having control grids, means for maintaining the anodes at substantially cathode potential at times when either grid is actuated, means providing an actuating interference voltage on the grid of one tube at a time preceding the arrival of the impulse on the anode, said means including a time delay circuit, and means for maintaining an actuating voltage on the grid of the other tube following the impulse.

16. The combination of a signal channel, an electron discharge device having an anode connected to one side of the signal channel and a cathode to the other side of said channel, means for applying signals to said channel and across said device, and additional means connected to said device and to another point in the signal channel for deriving signals therefrom for maintaining the anode and the cathode at the same signal potential, the signal potential on the anode being in opposition to that on the cathode, for the duration of voltage impulses exceeding a predetermined amplitude at said other point in the signal channel.

17. The combination of a signal channel, an

electron discharge device having an anode connected to one side of the signal channel and a cathode to the other side of said channel, means for applying signals to said channel and across said device, additional means for maintaining the anode at substantially cathode potential for the duration of voltage pulses exceeding a predetermined amplitude at another point in the signal channel, and means providing a voltage wave on the cathode corresponding to the signal previously passed through said channel.

18. In combination, a signal channel, two multiple electrode tubes having control grids and having anodes connected to a point on one side of the signal channel and cathodes to the other side of the signal channel, means for maintaining the anodes at the potential of the cathodes at all times when actuating voltages are applied to the control grids of said tubes, means including a delay circuit providing an actuating voltage for the grid of one tube beginning at a time immediately preceding the arrival of an interference high amplitude impulse on the anodes, means including a second delay circuit, providing and maintaining an actuating voltage for the grid of the other of said tubes, and means for causing said last named actuating voltage to cease at a time immediately following the termination of an interference impulse at the point from which the anodes receive the signal voltage.

19. In combination, a signal channel, two multiple electrode tubes having control grids and having anodes connected to a point on one side of the signal channel and cathodes to the other side of the signal channel, means for maintaining the anodes at the potential of the cathodes at all times when actuating voltages are applied to the control grids of said tubes, means including a delay circuit providing an actuating voltage for the grid of one tube beginning at a time immediately preceding the arrival of an interference high amplitude impulse on the anodes, means including a second delay circuit providing and maintaining an actuating voltage for the grid of the other of said tubes, means for causing said last named actuating voltage to cease at a time immediately following the termination of an interference impulse at the point from which the anodes receive the signal voltage, means for applying signal potential to the cathodes of said tubes, and means for deriving said last named signal potential from the signal channel at a point beyond the short circuiting connection provided by the tubes.

VERNON D. LANDON.