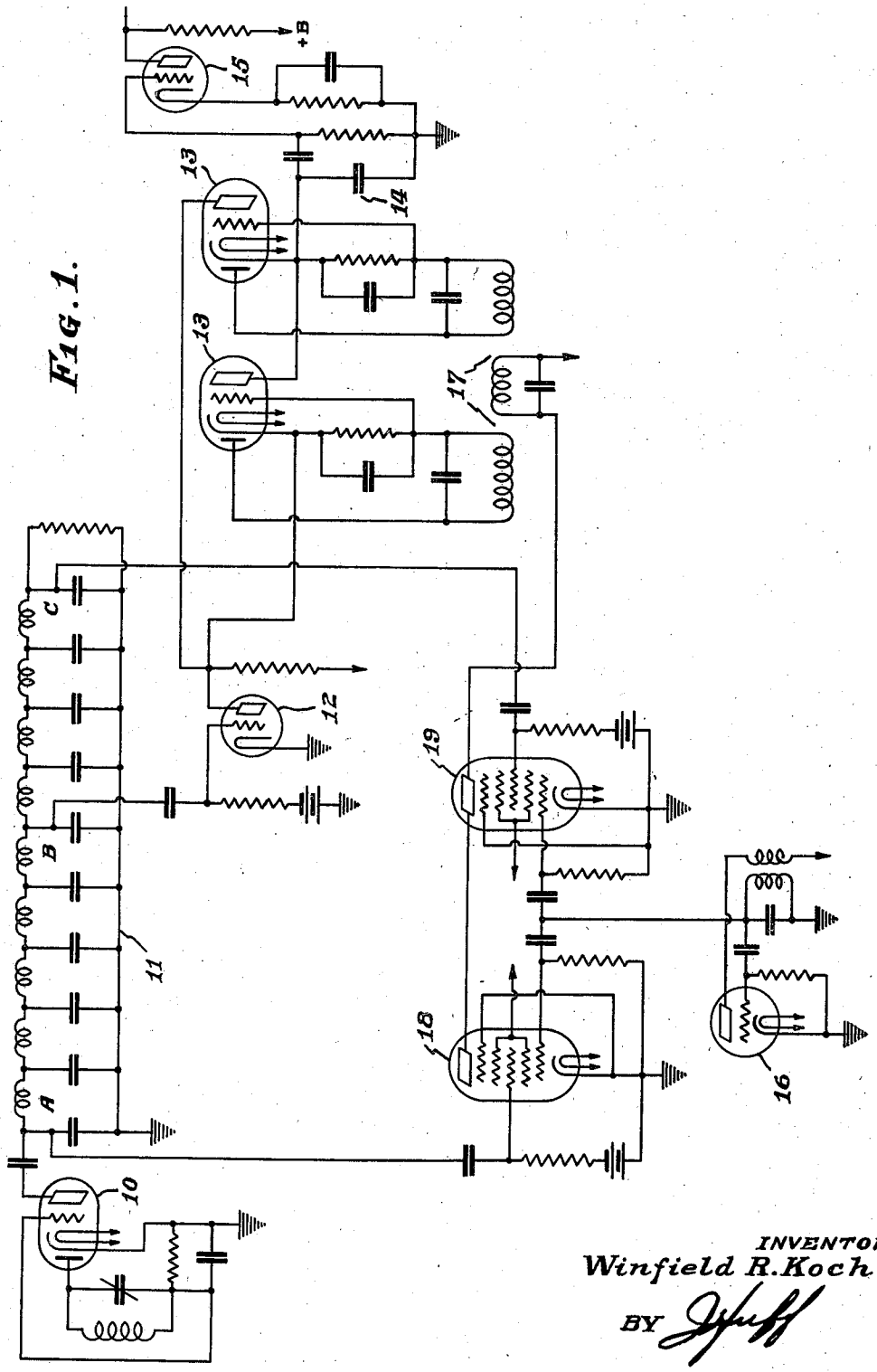
March 28, 1939. W. R. KOCH 2,151,773

REDUCTION OF NOISE

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FIG. 1.



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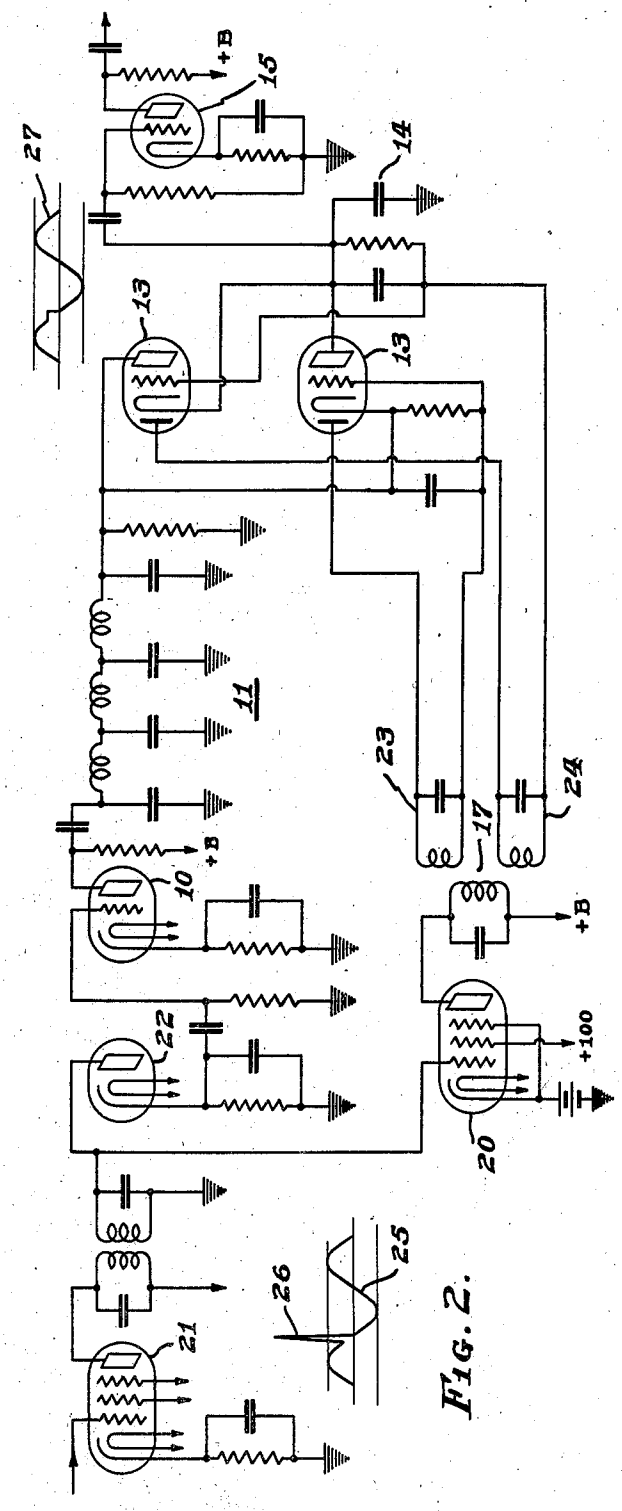


FIG. 2.

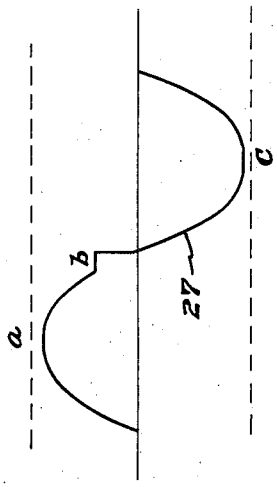


FIG. 4.

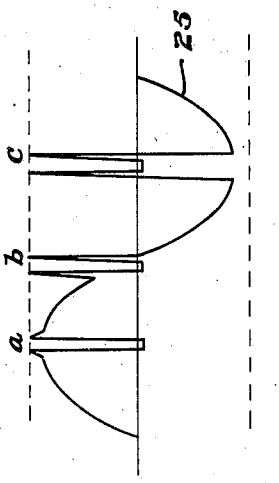


FIG. 3.

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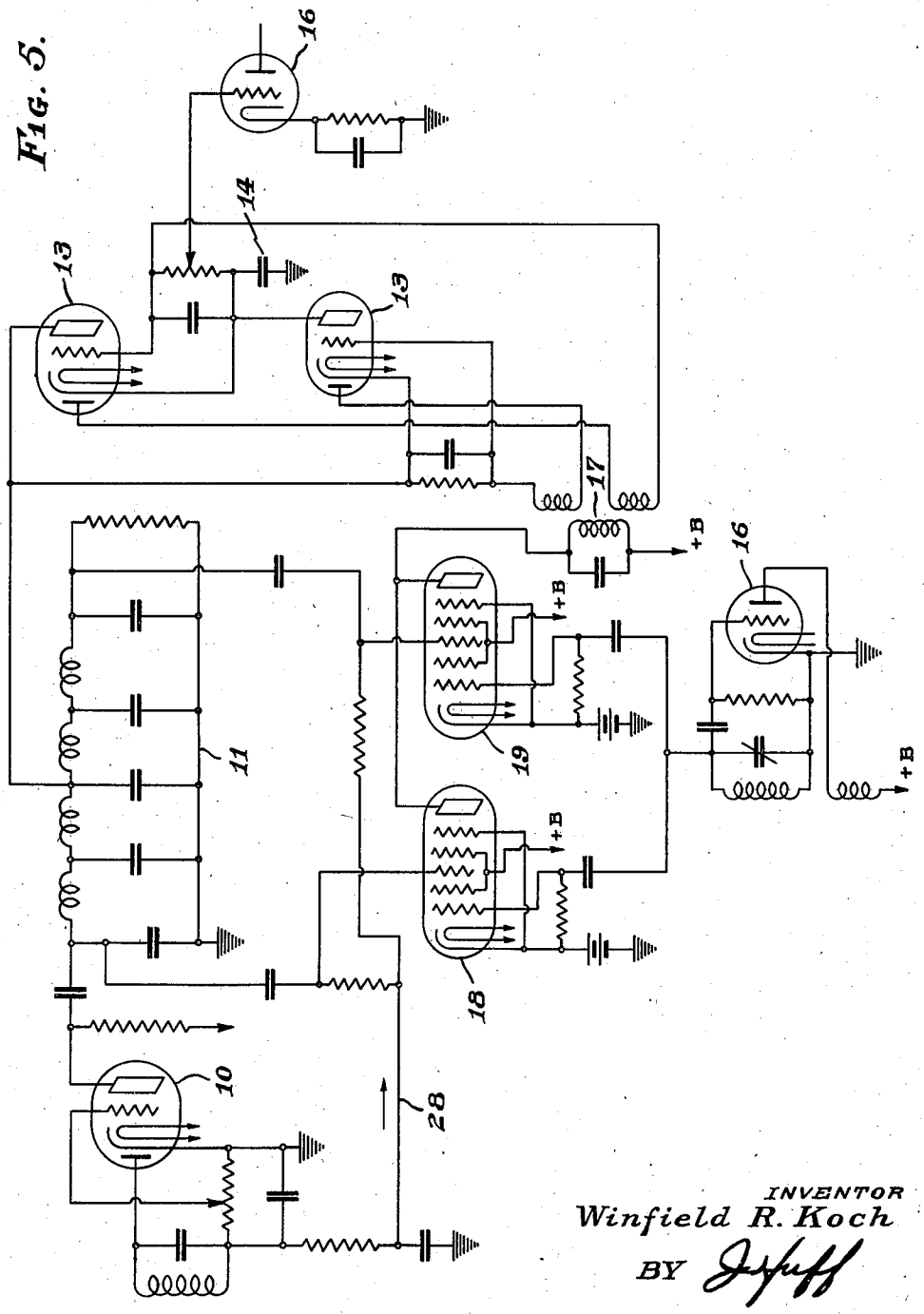
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REDUCTION OF NOISE

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FIG. 5.



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UNITED STATES PATENT OFFICE

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REDUCTION OF NOISE

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Application March 28, 1936, Serial No. 71,348

14 Claims. (Cl. 250—20)

The invention relates to the reduction of the noise which tends to be produced in radio receivers and similar apparatus by electrical impulses extraneous to the desired signal or control impulses. It has for its principal object the provision of an improved apparatus and method of operation whereby the noise and signal impulses may be separated from one another without substantial distortion of the signal impulses.

Many noise reduction methods heretofore proposed have involved reducing the signal output to zero for the duration of the noise impulse or have involved merely limiting the amplitude of the noise impulse. These methods have not been altogether satisfactory for the reason that they eliminate a part of the signal impulse or otherwise distort the signal to such an extent that objectionable noise is produced at the receiver. In accordance with the present invention, this difficulty is largely eliminated by the provision of means which operate for the duration of the noise impulse to (1) open the signal channel, (2) maintain the signal level substantially constant at the receiver or (3) maintain a substantially constant ratio of signal impulse level to noise impulse level.

The invention will be better understood from the following description when considered in connection with the accompanying drawings and its scope is indicated by the appended claims.

Referring to the drawings—

Fig. 1 is a wiring diagram of a noise reduction system including a delay network through which a pair of control vacuum tube devices are operated at successive instants of time to control the grid bias potential applied from an oscillation generator to a pair of channel opening vacuum tube devices, the signal level at points beyond the circuit opening devices being maintained substantially by means of a capacitor connected across the channel at a point following the channel opening devices,

Fig. 2 is a wiring diagram of a noise reduction system which differs from that of Fig. 1 in that an over-biased intermediate frequency amplifier is utilized to perform the function of the control tubes and oscillation generator of Fig. 1,

Figs. 3 and 4 are explanatory diagrams relating to the operation of the apparatus, and

Fig. 5 is a wiring diagram of a noise reduction system which is similar to that of Fig. 1 but differs therefrom in that the grid bias potential of the channel opening devices is made to depend on a resultant potential, the components of which are derived respectively from the delay network and from the intermediate frequency circuit for ensuring operation of the noise reduction apparatus over a somewhat greater range of noise levels.

In the noise reduction circuit of Fig. 1, signal impulses are supplied from a diode biased audio amplifier 10 through a delay network, an audio amplifier 12, and a pair of reversely connected channel opening vacuum tube devices 13 to a capacitor 14 and to the input circuit of an audio amplifier 15. The diode biased amplifier 10 may be the second detector of a superheterodyne radio receiver or the like. The circuit opening tubes 13 are diode-biased. Grid control potential is supplied to these diode-biased tubes 13 from an oscillation generator 16 through a transformer 17, this control potential being controlled by means of a pair of control tubes 18 and 19 which have their input circuits energized from different points A and C of the delay network 11.

For normal operation, without large noise impulses, the capacitor 14 is charged and discharged by the audio amplifier 12 operating through the cathode-anode electron discharge paths of the circuit control or circuit opening tubes 13.

When a noise impulse exceeding a predetermined level occurs, the control tube 18, which is normally biased beyond cutoff by the outer control grid and biasing means indicated in connection therewith, becomes operative, since the presence of a noise impulse causes the outer control grid to become more positive.

The tube 18 then becomes conducting for conveying oscillations from the oscillator 16 through its connection with the inner control grid. The amplified output from tube 16 is thereby applied to the output circuit of tube 18, and the oscillator energy is applied to the control devices 13 through the coupling means 17.

The coupling means 17 permits rapid build-up or decay of the oscillatory currents and the diodes of the tubes 13 rectify the resulting voltage impressed on the diodes through the transformer 17 to produce direct current biasing potential for the control grids of tubes 13. The biasing potential is such that the control grids of the tubes 13 are biased beyond the cutoff value.

With this cut-off arrangement, the charge on the capacitor 14 will be unaffected by the amplifier 12, and the instantaneous input voltage of the audio frequency amplifier 15 will be maintained constant at the value or level attained immediately preceding the operation of the tube 18 or channel cut-off.

When the signal arrives at the end of the

delay network, it serves to operate the tube 19 in a similar manner to maintain the channel open for a short interval after the application of the signal to the amplifier 12. Otherwise, a noise impulse of appreciable magnitude might be applied to the output amplifier 15. Due to the delay effect of the network 11, the channel is opened before the noise impulse reaches the input circuit of the audio amplifier 15.

In like manner, closing of the channel is delayed beyond the point where the noise impulse again reaches the predetermined level, this result being effected by the control tube 19 which is biased beyond cutoff and is maintained open until the noise impulse has passed the point C of the delay network 11.

Various modifications of the noise reduction circuit of Fig. 1 will be apparent to those skilled in the art. Thus, the circuit may be rendered independent of flat automatic volume control action by so adjusting the control tubes 18 and 19 that they operate whenever the instantaneous audio voltage exceeds the direct current voltage resulting from the carrier alone. Under these conditions, operation of these tubes is effected on any impulse of a level exceeding the voltage corresponding to 100% modulation in the positive direction. Instead of the network 11, suitable mechanical, acoustic or like means may be utilized to delay the signal until the channel control tubes 12 and 13 have operated.

The modification of Fig. 2 is similar to that of Fig. 1 but differs therefrom in that the oscillation generator 16 and control tubes 18 and 19 are replaced by an over-biased intermediate frequency amplifier 20, an intermediate amplifier 21 is illustrated and the diode detector 22 is shown as enclosed in a receptacle separate from that of the first audio amplifier 10.

With the overbiased intermediate frequency amplifier 20 connected as shown, intermediate frequency voltages greater than that corresponding to any predetermined percentage modulation cause the amplifier 20 to function. The resulting voltages impressed on the diodes and grids of the channel control tubes 13 cause them to open the channel before the audio noise impulse reaches them. Closing of the channel is delayed for a period of time dependent on the resistance-capacity constants between grids and cathodes of tubes 13.

If the signal impulse has the wave form indicated at 25 and the superposed noise impulse has the wave form indicated at 26, the signal received at the audio amplifier 15 will have a wave form similar to that indicated at 27. The difference between the present and prior methods of noise reduction is more clearly illustrated by Figs. 3 and 4. Thus Fig. 3 illustrates the effect of previous limiter or noise reduction devices on a signal impulse 25 which has noise impulses superimposed on it at points *a*, *b* and *c* and Fig. 4 illustrates the effect on the same composite wave of a noise reduction constructed in accordance with the present invention. The upper dotted line in each case indicates the instantaneous audio level corresponding to 100% modulation and the lower dotted line similarly indicates the instantaneous audio level for zero % modulation.

The noise reduction circuit of Fig. 5 is similar to that of Fig. 1 with the exception that a conductor 28 is connected back to the intermediate frequency circuit for the purpose of injecting into the input circuits of the control tubes 18 and 19 a bias potential which varies in response to the signal carrier level and functions to maintain a relative constant relation between the signal and noise impulse levels insofar as the difference of these levels affects operation of the control tubes 18 and 19. This arrangement has the advantage that it operates over a wider range of noise impulse amplitudes and produces a somewhat more thorough elimination of the noise impulses. The grid of the audio frequency amplifier tube 16 is connected to an adjustable point on the diode resistor connecting to capacitor 14, to permit a balancing action to be obtained, for voltages occurring across this resistor during impulses, which cause currents to flow through the stray capacity to ground of the secondary winding of transformer 17, and back through capacitor 14, thus introducing a small disturbance in the voltage across this capacitor. Otherwise, the system of Fig. 5 operates in a manner similar to that of Fig. 1.

I claim:

1. The combination of a signal channel including a channel open circuiting device and an amplifier in the order named, and means including a capacitor connected in the input circuit of said amplifier for maintaining the signal in said channel following said device and preceding said amplifier at a level attained immediately preceding the opening of the channel by said device.

2. The combination of a signal channel including a delay network through which signals are conveyed, a circuit opening device and an amplifier in the order named, means responsive to the arrival of a relatively high level signal at different points along said network for controlling the operation of said device, and means interposed between said device and said amplifier for maintaining the signal at said amplifier at a level attained immediately preceding the opening of the channel by said device.

3. The combination of a signal channel including a delay network and a channel opening device, means connected to one point of said network for causing said device to open said channel when a relatively high level impulse arrives at said point, and means connected to a subsequent point of said network for maintaining said channel open until said impulse has passed said subsequent point.

4. The combination of a signal channel including a delay network and a channel opening device, means connected to one point of said network for causing said device to open said channel when a relatively high level impulse arrives at said point, and means connected to a subsequent point of said network for maintaining said channel open until said impulse has passed said subsequent point, and means for maintaining in the channel section following said device a predetermined signal level while said channel is open.

5. The combination of a delay network, a leading amplifier coupled to an intermediate point of said network, a following amplifier, a circuit opening device interposed between said amplifiers, and means connected at network points preceding and following said intermediate point for operating said device to maintain said device open while a relatively high level impulse passes between said leading and following points.

6. The combination of a delay network, a leading amplifier coupled to an intermediate point of said network, a following amplifier, a circuit opening device interposed between said amplifiers, means connected at network points preceding and following said intermediate point for

operating said device to maintain said device open while a relatively high level impulse passes between said leading and following points, and means interposed between said device and said following amplifier for maintaining a predetermined impulse level at said following amplifier while said device is open.

7. The combination of a signal channel including a delay network, an amplifier and a pair of reversely connected vacuum tubes interposed between an intermediate point of said network and said amplifier, means including an oscillation generator for applying input control potential to said tubes, and a pair of vacuum tubes energized from the opposite ends of said network for permitting the application of said control potential to said reversely connected tubes only while a relatively high level impulse passes from one end of said network to the other.

8. The combination of a signal channel including a delay network, an amplifier and a pair of reversely connected vacuum tubes interposed between an intermediate point of said network and said amplifier, means including an oscillation generator for applying input control potential to said tubes, and a pair of vacuum tubes energized from the opposite ends of said network for permitting the application of said control potential to said reversely connected tubes only while a relatively high level impulse passes from one end of said network to the other, and means connected between said reversely connected tubes and said amplifier for maintaining a predetermined signal level at said amplifier while said relatively high level impulse is traversing said network.

9. The combination of a signal channel including an intermediate frequency circuit, a leading audio amplifier, a signal conveying delay network in said channel and connected with said amplifier to receive signals therefrom, a circuit opening device and a following audio amplifier, and means including an over biased intermediate frequency amplifier connected between said circuit and said device for operating said device to open said channel while a relatively high level impulse is traversing said delay network.

10. A signal channel including a signal conveying delay network between the input and output terminals of said circuit, a circuit control device connected to an intermediate terminal of said network for receiving signals therefrom, means including control tubes energized at the opposite ends of said network for controlling the operation of said device in response to a relatively high level of the impulses supplied to said channel, and means operable to modify said energization to produce operation of said device over a predetermined range of signal levels.

11. A signal channel including a delay network, a circuit open-circuiting device connected to an intermediate terminal of said network, means energized from different points of said network for controlling the operation of said device in response to a relatively high level of the impulses supplied to said channel, and means operable to modify energy passing through said device in accordance with the carrier level of said impulses.

12. The combination of a signal channel including an intermediate frequency circuit, a leading audio amplifier, a signal conveying delay network in said channel and connected with said amplifier to receive signals therefrom, a circuit opening device and a following audio amplifier, means including an over-biased intermediate frequency amplifier connected between said circuit and said device for operating said device to open said channel, and means connected with the delay network for causing said channel to remain open, while a relatively high level impulse is traversing said delay network.

13. In a signal amplifying channel, the combination of an intermediate frequency circuit, a detector, a time-delay network, a circuit opening device, and a following audio frequency amplifier arranged in the order named in signal-conveying series relation in said channel, and means including an over-biased intermediate frequency amplifier connected between said intermediate frequency circuit and said circuit opening device for operating said device, and means connected with the delay network for effecting operation of said device for a period including a short interval preceding the arrival of a high level impulse at said device, the duration of said high level impulse at said device, and a short interval following the presence of said high level impulse at said device.

14. In a radio receiving system, the combination of means providing an audio frequency detector, an audio frequency amplifier for amplifying signals received from said detector, and a noise impulse-interrupting circuit interposed between said amplifier and detector means, comprising an audio frequency signal delay network connected with said detector means to convey signals therefrom to said amplifier, means for deriving audio frequency signals from said network intermediate its ends, said last-named means including a controllable signal conveying connection with said amplifier having a pair of diode biased amplifier tubes and a coupling capacitor between said tubes and said amplifier, the charge on said capacitor being controlled by said tubes, a pair of control tubes coupled to the delay network one at each end thereof, means for adjusting said tubes whereby they are actuated in response to noise impulses of predetermined high amplitude, and means for applying energy to the diode-biased amplifier tubes through said last-named tubes to actuate said diode-biased amplifier tubes when said control tubes are actuated by said impulses.

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