

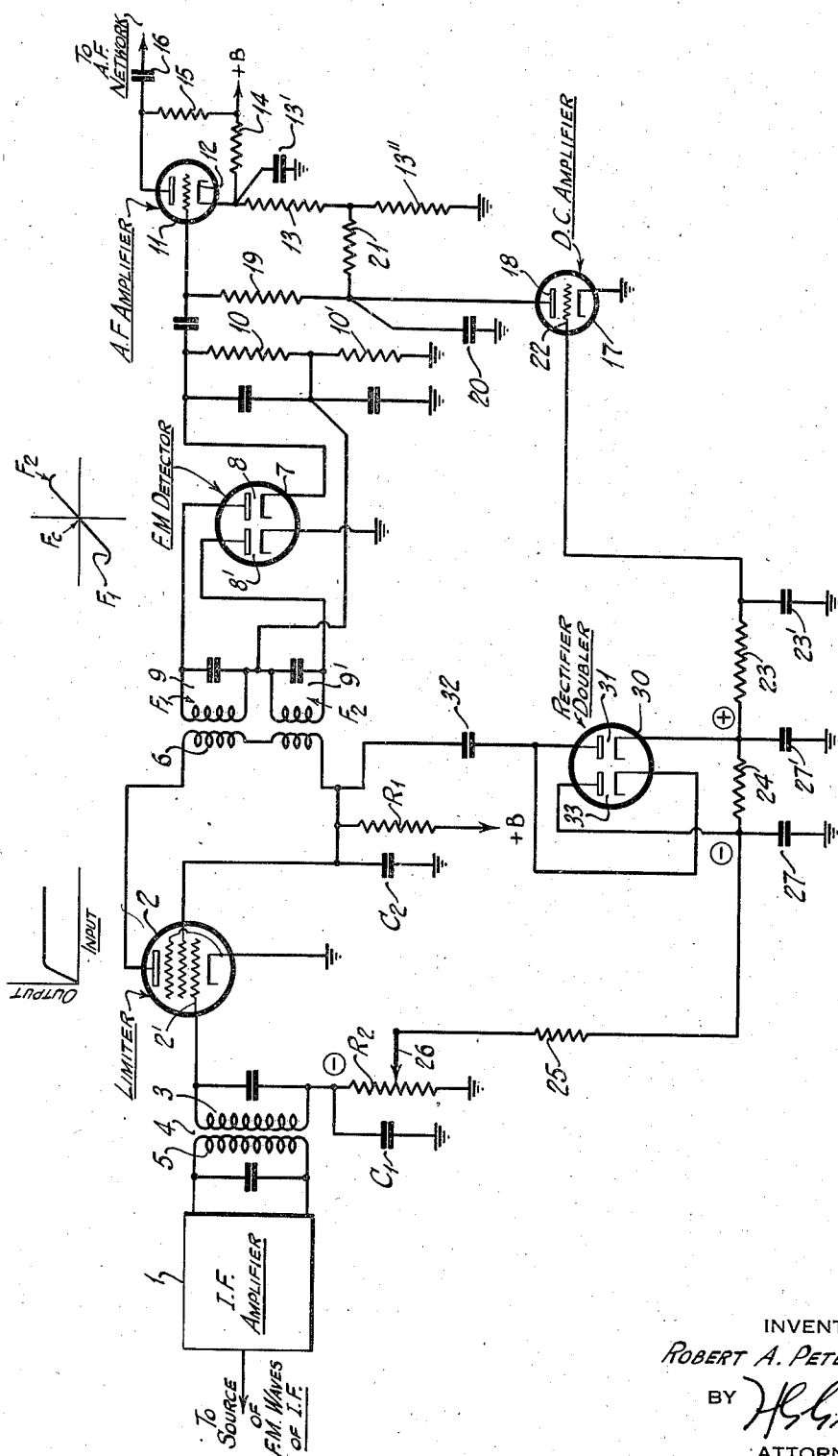
May 28, 1946.

R. A. PETERSON

2,400,948

NOISE SQUELCH SYSTEM

Filed March 19, 1943



INVENTOR
ROBERT A. PETERSON.

BY

ATTORNEY

UNITED STATES PATENT OFFICE

2,400,948

NOISE SQUELCH SYSTEM

Robert A. Peterson, Haddonfield, N. J., assignor
to Radio Corporation of America, a corporation
of Delaware

Application March 19, 1943, Serial No. 479,727

4 Claims. (Cl. 250—20)

My present invention relates to noise squelch systems for radio receivers, and more particularly to a noise-actuated control system for a receiver of angle modulated carrier wave energy.

In the past various schemes have been proposed for impairing the reproduction of a radio receiver in response to a low signal-to-noise ratio at the receiver signal collector. In the case of an angle modulated carrier wave receiver, such as a receiver of frequency modulated carrier energy, it has been proposed to use the discriminator-rectifier network output voltage for noise control. It has, also, been proposed in such receivers to utilize the grid current flowing in the limiter grid circuit. However, these various prior circuits have not been sufficiently sensitive, reliable or efficient to warrant widespread use thereof.

It is one of the main objects of my present invention to provide a method of, and means for, preventing reproduction by a radio receiver during periods of low signal-to-noise ratio, there being utilized the magnitude of noise voltage components as a measure of the control exercised over the receiver reproduction.

Another important object of my invention is to provide a frequency modulated (referred to for brevity as "FM" hereinafter) carrier wave receiver with a noise squelch circuit; the latter including a device for rectifying the noise voltage components at the amplitude limiter output circuit, and the rectified voltage being employed to squelch, or mute, a modulation signal amplifier stage.

Another object of my invention is to provide an improved muting circuit for an FM receiver, or a phase modulated ("PM" hereinafter for brevity) carrier wave receiver, which mutes the audio output of the receiver when no signal is present at the receiver input terminals, and which permits the receiver to reproduce the modulation in efficient manner when a signal of proper strength is received.

Still another object of my invention is to provide a noise squelch circuit for an FM or PM receiver; the squelch circuit comprising a direct current voltage amplifier which acts to apply a cut-off bias to an audio amplifier when the former is conductive, the noise voltage developed in the plate circuit of the limiter tube being rectified to provide a bias control voltage for the direct current voltage amplifier, and the rectified noise voltage being opposed by a negative voltage derived from the limiter grid circuit thereby to provide a residual positive voltage

which is applied as said bias control voltage in the absence of a usable signal.

Still other objects of this invention are to improve the sensitivity and efficiency of noise squelch circuits of receivers of the angle modulated type, and more especially to provide a receiver whose noise output is controlled by an economical circuit which can be readily manufactured and assembled.

The novel features which I believe to be characteristic of my invention are set forth with particularity in the appended claims; the invention itself, however, as to both its organization and method of operation will best be understood by reference to the following description, taken in connection with the drawing, in which I have indicated diagrammatically a system whereby my invention may be carried into effect.

Referring to the accompanying drawing, wherein there is shown a portion of a superheterodyne receiver of the FM type essential to a proper understanding of my invention, it is pointed out that the usual networks prior to the schematically represented intermediate frequency (I. F.)

amplifier are omitted. These networks are well known to those skilled in the art. Usually they comprise a signal collector device, such as a grounded antenna or a dipole, one or more tunable radio frequency amplifiers, and a converter followed by one or more I. F. amplifiers. The receiver frequency may be any frequency that is desirable for an angle modulated carrier wave receiver. The receiver frequency band may be in the 26-50 megacycle (mc.) range, or in the 70-100 mc. range. The operating I. F. value may be in the mc. range, or it may be in the kilocycle (kc.) range. Where the latter is the case, double conversion can be used to reduce the carrier frequency down to an I. F. value of, for example, 455 kc. Let it be assumed, then, that prior to amplifier 1 there has been employed double conversion of the modulated carrier energy, and that the signal fed to stage 1 has an I. F. value of 455 kc. The invention, however, is not limited to any specific frequency values.

The signal energy may be FM or PM. The generic term "angle modulated" has been heretofore employed, and will be used in the following description and claims to indicate either FM, PM or hybrids of the two. By way of specific example, it is assumed that the received signal energy is FM wave energy. It is well known to those skilled in the art of receiving FM waves that the noise output of the receiver rapidly in-

creases when the signal-to-noise ratio at the signal collector device falls below a predetermined value. This ratio will decrease below the noise-free value when tuning between stations, when moving an excessive distance from a desired FM transmitter, or when the receiver is moved into a shielding area such as a bridge and the like. During such periods of noisy reception it is desirable to mute the receiver output. In the case where a transmitter goes on and off intermittently, it is desirable to mute the receiver when the transmitter is off. Also, the receiver comes on automatically when the transmitter is turned on. In the case of police and communication receivers this is a most important use of the squelch circuit, and is most strongly emphasized.

Noise squelch circuits which have been previously used in FM receivers have employed the reduction in noise voltage at the demodulator output circuit in response to signal reception to operate the squelch circuit. However, such an arrangement has not proved to be sufficiently sensitive. It is, also, desirable to provide a muting circuit which will give improved operation in the presence of ignition noise interference.

The present noise muting arrangement satisfies all reasonable requirements in an FM receiver. Generally speaking, my invention is based on the fact that the usual limiter tube circuit provides in its plate circuit noise voltage components in the absence of signal energy of a usable value. I utilize these noise voltage components to provide cut-off bias for a signal transmission stage of the receiving system.

Referring to the specific circuits of the drawing, the numeral 2 designates the limiter tube. While the tube is shown as of the pentode type, it will be understood that any other suitable type of tube may be employed. The limiter tube has its input grid 2' connected to ground through a path which comprises the secondary winding 3 of the I. F. transformer 4 and the resistor R₂. Each of the primary and secondary circuits of I. F. transformer 4 is tuned to the operating I. F. value. The condenser C₁ shunts the resistor R₂. The network R₂-C₁ functions as the usual signal-responsive grid biasing network to provide grid circuit limiting action for input signals whose amplitude exceeds a predetermined amplitude. The network R₂-C₁ has a relatively small time constant value. The cathode of tube 2 is grounded, while the screen grid thereof is connected to a point of positive direct current potential through resistor R₁. The latter is grounded for I. F. currents by condenser C₂.

The plate of the limiter tube is connected to the +B terminal of the direct current source by means of the primary winding 6 of the transformer feeding the discriminator. The limiter operation is well known to those skilled in the art. Its ideal "input vs. output" characteristic is depicted above tube 2. The function of the limiter is substantially to eliminate amplitude variations from the FM signal energy applied to the discriminator circuit.

The FM detector network itself may be of any well known form. The specific detector illustrated is of a well known and simple type. Essentially it comprises a pair of diodes which are connected in opposed relation, and whose tuned input circuits are equally and oppositely mistuned in frequency with respect to the mean frequency of the applied signal energy. The detector tube 7 is shown as of the 6H6 type by way of example.

One diode section 8 has connected between its electrodes the series arrangement of the input circuit 9 and the output load resistor 10. The second diode section 8' has connected between its electrodes the input circuit 9' and the output load resistor 10'. The cathode of diode section 8 is grounded, as is the case with the lower end of load resistor 10'. The resistors 10 and 10' are in series, and each of them is bypassed by appropriate condensers for I. F. currents.

The input circuits 9 and 9' are each reactively coupled to the primary circuit 6, but there is very little coupling between the two input circuits 9 and 9'. The reference characters F₁ and F₂ denote the respective off-tune frequencies of these two circuits. The mean frequency of the applied signal energy is indicated by the symbol F_c, and in the present case the value of F_c is the operating I. F. value. Above the FM detector there is depicted the ideal "frequency deviation vs. rectified output" characteristic of the detector. This is the well known inclined characteristic curve of the FM detector. The peaks of the detector characteristic may be spaced, if desired, by a distance greater than the maximum frequency deviation of the FM signal energy. It is not believed necessary to describe the functioning of the detector circuit, since it is very well known to those skilled in the art. It is sufficient to indicate that there will be taken off from the upper end of resistor 10 the modulation signal, in this case audio frequency, which was originally applied to the carrier at the FM transmitter.

Where the signal energy to be received is a PM carrier wave, it may still be necessary to utilize an amplitude limiter prior to detection. The PM detection network will be of any well known type. It is sufficient for the purposes of this application to point out that the essential difference between a PM carrier wave and an FM carrier wave resides in the fact that in the former case the extent of frequency deviation is greater for the higher audio frequencies.

The modulation signal utilization network is indicated as comprising a tube 11, as for example a triode, whose cathode 12 is connected to ground through a biasing resistor 13 in series with resistor 13''. The condenser 13' bypasses the biasing resistor 13 to ground for audio frequency currents. The cathode end of resistor 13 is connected to a source of positive direct current voltage +B through a resistor 14. The same voltage source supplies positive voltage to the plate of the audio amplifier tube 11 through a load resistor 15. The audio voltage output developed across resistor 15 may be transmitted by audio coupling condenser 16 to a succeeding audio frequency network. The grid of tube 11 receives its bias from the voltage across resistor 13.

The biasing of tube 11 is controlled by the direct current voltage amplifier 17 which is shown, by way of specific illustration, as a triode. The plate 18 of tube 17 is connected to the grid of tube 11 through a resistor 19, the lower end of resistor 19 being bypassed to ground for pulsating current components by condenser 20. The plate 18 is connected through resistor 21 to the upper end of resistor 13'', and the cathode of tube 17 is grounded. A positive voltage exists across 13'', and this is used as plate voltage for tube 17. The control grid 22 of tube 17 is returned back to ground through a path which comprises resistors 23, 24, 25 and the adjustable slider 26 of resistor R₂. The resistor 24 has

the opposite ends thereof bypassed to ground by condensers 27 and 27', while the grid end of resistor 23 is connected to ground by the condenser 23'. The resistor 24 acts as the output load of a voltage doubling rectifier which comprises the 6H6 type tube 30.

The diode section 31 of tube 30 has its anode connected to the upper end of resistor R_1 by the coupling condenser 32, while the cathode of the diode section 31 is connected to the junction of resistors 24 and 23. The diode section 33 of tube 30 has its anode connected to the left end of resistor 24, while its cathode is connected to the output terminal of coupling condenser 32. The noise voltage components developed across the resistor R_1 are transmitted through the coupling condenser 32 to the diode sections 31 and 33 of tube 30. By virtue of the voltage doubling connections of the diode sections 31 and 33 with respect to output resistor 24, there will be developed across the resistor 24 rectified noise voltage whose amplitude is substantially double the amplitude of the noise voltage components at R_1 .

The rectified noise voltage is applied to the grid 22 of tube 17 in a positive polarity sense. The network 23—23' functions as a filter to suppress any pulsating voltage components which may exist in the output voltage across resistor 24. The magnitude of this positive control voltage is reduced by an opposing negative voltage which is derived from across the limiter grid circuit resistor R_2 . The slider 26 is adjusted to a point on R_2 such that negative voltage developed across R_2 will be sufficiently less than the positive voltage developed across resistor 24 to provide a residual positive bias for grid 22. This residual positive bias will exist, of course, only if sufficient noise voltage is transmitted through condenser 32. However, when the residual positive voltage applied to grid 22 has a sufficient and predetermined magnitude tube 17 will be conductive, and will provide space current which flows through resistor 21. This space current flowing through resistor 21 develops sufficient voltage to cut off the space current flow in tube 11 by virtue of the fact that the voltage across resistor 21 is applied in a negative polarity sense to the grid of tube 11. The condenser 20 acts to delay the change in bias across resistor 21.

In the no-signal state it is desirable to adjust the slider 26 on resistor R_2 so that the voltage applied to grid 22 will be slightly positive thereby causing the audio amplifier tube 11 to be cut off. This means that there will be no noise reproduction at the receiver reproducer. It is pointed out that the noise voltage components produced in the plate circuit of the limiter tube may go up to several kilocycles in frequency, depending on the band width of the I. F. amplifier. In other words, the limiter tube acts in the manner of a detector for the radio frequency noise components so far as its plate circuit is concerned, and, hence, develops across its plate resistor R_1 the detected noise voltage components. It is these detected noise components which are transmitted through condenser 32 to the rectifier tube 30 for further rectification to provide the muting voltage produced across resistor 24. Of course, in the grid circuit of the limiter tube rectification of the radio frequency noise components occurs in the network R_2 — C_1 . The resistor 25 acts to isolate network R_2 — C_1 from condenser 21. It is this rectification which provides the opposing negative voltage that re-

duces the positive voltage developed across resistor 24 to the proper value.

When the signal-to-noise ratio at the receiver collector device rises to a usable value, the noise voltage components at R_1 rapidly decrease. This means that the voltage developed across resistor 24 rapidly decreases. However, the voltage across R_2 does not decrease. It either will remain constant, or it will actually increase. This means that the grid 22 of the tube 17 will be biased sufficiently negative to cut off its space current flow, and the cut-off bias across resistor 21 will be removed from the grid of audio frequency amplifier 11. If an additional limiter tube is employed prior to the limiter tube 2, the voltage drop across R_2 will be invariable if the no-signal noise originating in the first circuits of the receiver produce enough voltage to saturate the first limiter, and then the voltage variation across R_1 will be the controlling factor. Such a mode of operation is contemplated by my invention. It is, also, to be understood that the triode sections of tubes 17 and 11 may be embodied in a common tube envelope, as is the case with the twin triode tube. In actual operation, it is desirable to have the tube 11 completely muted in the absence of received signal energy. However, for received signals of 0.1 microvolt, or greater, it is desirable to have the cut-off bias removed from the grid of tube 11. Of course, these constants are purely illustrative, and the set designer can adjust the constants to suit the particular requirements of transmission.

While I have indicated and described a system for carrying my invention into effect, it will be apparent to one skilled in the art that my invention is by no means limited to the particular organization shown and described, but that many modifications may be made without departing from the scope of my invention, as set forth in the appended claims.

What I claim is:

1. In a frequency modulation receiver of the type including an amplitude limiter stage having input and output electrodes, a frequency modulation detector and a modulation signal amplifier; the improvement comprising a pair of diodes, a condenser coupling anode of one diode and cathode of the second diode in common to the limiter output electrodes, a load resistor connected between the cathode of said one diode and anode of the second diode for providing a rectified voltage whose magnitude is proportional to noise voltage appearing in the limiter output circuit in response to a substantial reduction in the signal-to-noise ratio at the receiver input terminals, a resistor-condenser network in circuit with the limiter input electrodes for deriving from the input limiter electrodes a control voltage whose magnitude depends upon the amplitude of received signal energy, means including a connection from a point of predetermined negative potential of said network to said load resistor for combining the voltage output of the rectifier and said control voltage to provide a residual voltage which is positive, an electron discharge device responsive to said positive voltage for producing a space current, and means responsive to the last-named space current for rendering said modulation signal amplifier inoperative.

2. In a frequency modulation receiver of the type including an amplitude limiter stage having input and output electrodes, a frequency modulation detector and a modulation signal amplifier; the improvement comprising a rectifier-doubler

coupled to the limiter output electrodes for providing a rectified voltage whose magnitude is proportional to noise voltage appearing in the limiter output circuit in response to a substantial reduction in the signal-to-noise ratio at the receiver input terminals, a resistor-condenser network for deriving from the input limiter electrodes a control voltage whose magnitude depends upon the amplitude of received signal energy, means combining the voltage output of the rectifier-doubler and said control voltage to provide a residual voltage which is positive, an electron discharge device responsive to said positive voltage for producing a space current, and means responsive to the last-named space current for rendering said modulation signal amplifier inoperative.

3. In a frequency modulation receiver of the type including an amplitude limiter tube having input and output electrodes, a frequency modulation detector and a modulation signal amplifier tube; the improvement comprising a rectifier consisting of opposed diodes having a common coupling to the limiter output electrodes, an output resistor common to said diodes for providing a rectified voltage whose magnitude is proportional to noise voltage appearing in the limiter output circuit in response to a substantial reduction in the signal-to-noise ratio at the receiver input terminals, a resistor-condenser network for deriving from the input limiter electrodes a direct current control voltage whose magnitude depends upon the amplitude of received signal energy, means combining in polarity opposition the voltage output of the rectifier and said control voltage to provide a residual direct current voltage which is positive, an electron discharge device,

means responsive to said positive voltage for producing a space current flow in said device, and resistive means, connected between the amplifier input electrodes and responsive to the last-named space current, for rendering said modulation signal amplifier tube inoperative.

4. In a frequency modulation receiver of the type including a signal transmission tube having input and output electrodes, a frequency modulation detector coupled to the output electrodes and a modulation signal amplifier coupled to the detector; the improvement comprising a pair of opposed diodes, a load resistor common to the space current paths of the opposed diodes, a condenser connecting unlike electrodes of said diodes to said output electrodes for providing a rectified voltage across said load resistor whose magnitude is proportional to noise voltage, a resistor-condenser network connected to said input electrodes for producing a control voltage whose magnitude depends upon the amplitude of received signal energy, means comprising a connection from the negative potential end of said load resistor to a slider adapted to be adjusted along the resistor of said resistor-condenser network for combining the voltage output of the rectifier and said control voltage to provide a residual voltage which is positive, an amplifier tube having an input connection responsive to said positive voltage for producing space current flow, means responsive to the last-named space current for rendering said modulation signal amplifier inoperative, said last means comprising a resistor connected between the modulation amplifier input electrodes and adapted to be traversed by said space current.

ROBERT A. PETERSON.