

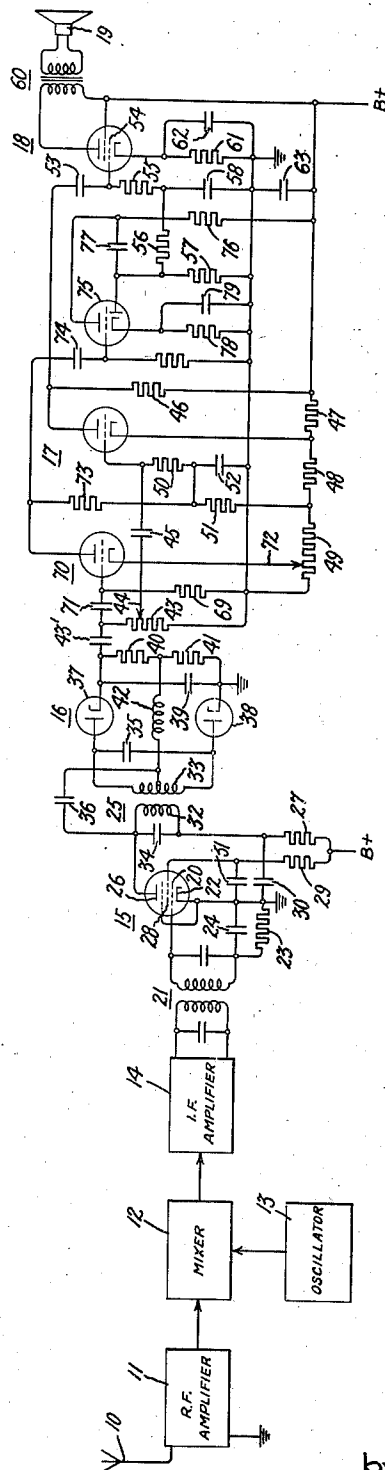
May 13, 1947.

G. M. BROWN

2,420,518

POWER REDUCTION CIRCUIT FOR RADIO RECEIVERS

Filed Jan. 22, 1943



Inventor:
George M. Brown,
by *Harry E. Dunham*
His Attorney.

UNITED STATES PATENT OFFICE

2,420,518

POWER REDUCTION CIRCUIT FOR RADIO RECEIVERS

George M. Brown, Scotia, N. Y., assignor to General Electric Company, a corporation of New York

Application January 22, 1943, Serial No. 473,199

4 Claims. (Cl. 250-29)

1

My invention relates to radio receivers and in particular to receivers of the type which operate under standby or no-signal conditions for a major portion of the time. It is an object of my invention to provide an improved receiver in which the energy consumption is greatly reduced.

Mobile communication receivers of the type employed in police cars, on aircraft, and similar installations usually operate under standby or no-signal conditions for more than ninety per cent of the total time. It is customary in such receivers for most satisfactory operation to use an audio power amplifier as an output tube in which plate current flows at all times. Since such receivers are usually operated from a low voltage storage battery, the large amount of energy consumed in maintaining the plate current of the power amplifier at its average operating value during standby periods accomplishes no useful purposes. It is a further object of my invention, therefore, to provide an improved receiver circuit in which the plate current of the power amplifier is reduced to or near its cut-off value during standby periods.

A further object is to provide the aforesaid result by means which are purely electronic.

Another object of my invention is to reduce the energy consumption of a communication receiver during standby periods by means operative in response to the noise present in the receiver circuits in the absence of a carrier wave in the receiver circuit.

A further object of my invention is to provide a power reduction circuit for a receiver which introduces no distortion in the output of the receiver.

The features of my invention which I believe to be novel are set forth with particularity in the appended claims. My invention itself, however, both as to its organization and method of operation, together with further objects and advantages thereof, may best be understood by reference to the following description taken in connection with the accompanying drawing, in which the single figure represents one embodiment of my invention.

Referring to the drawing, I have shown my invention as applied to a frequency modulation receiver. Many of the elements of this receiver may be conventional and their details of construction are not material to my invention. To simplify the drawing, such elements have merely been indicated in block form. Thus, the receiver illustrated is for the most part a conventional superheterodyne receiver. Signals received at an

2

antenna 10 are amplified in the usual radio frequency amplifier 11 and combined in a mixer 12 with locally generated waves supplied from an oscillator 13. The carrier waves of fixed intermediate frequency are then amplified in intermediate frequency amplifier 14. In frequency modulation receivers of the usual design, it is customary to pass intermediate frequency waves through an amplitude limiter. Hence, the output waves of the intermediate frequency amplifiers are limited in the circuit of the limiter 15 after which they are demodulated in a slope filter or discriminator 16. The output signals are amplified in an audio frequency amplifier 17, the output thereof being supplied to a power amplifier 18. The output of the power amplifier, in turn, is supplied to any suitable signal translating device, such as the loud speaker 19.

The limiter 15 comprises a pentode amplifier having a control electrode 20 to which signals of the intermediate frequency are supplied from the tuned secondary winding of the transformer 21. The intermediate frequency signals appearing on the tuned secondary of the transformer 21 are impressed between the control electrode 20 and the cathode 22 in series with a grid resistor 23 having a by-pass capacitor 24 in parallel therewith. An output circuit, including a tuned circuit 25, is connected to the anode 26 of limiter 15, operating potential being supplied in a conventional manner from a suitable source of power which is not shown, but merely indicated by the connection, designated B+ on the drawing, and connected between the usual voltage dropping and decoupling resistor 27 and ground. Operating potential for the screen grid 28 is similarly supplied from the common power supply source through a voltage dropping resistor 29, by-pass capacitors 30 and 31 being provided between the anode and screen grid circuits, respectively, and cathode.

The limiter circuit thus far described is of well known form. It is self-biased by means of the resistor 23 and the grid capacitor 24 and is adjusted to produce anode current variations in response to variations in grid voltage only between the limit at which the grid becomes positive with respect to the cathode and grid current flows and the limit at which the grid becomes sufficiently negative that anode current cutoff takes place.

The balanced frequency discriminator circuit 16 comprises a transformer having a primary winding 32, which forms part of the tuned output circuit 25 of the limiter 15, and a secondary

3

winding 33, both of these windings being tuned to the intermediate frequency by the capacitors 34 and 35. The primary winding is connected to the mid-point of the secondary winding 33 through a condenser 36. The opposite terminals of the secondary winding 33 are connected to the respective anodes of diodes 37 and 38, the cathodes of these diodes being connected together for alternating currents through capacitor 39 and for direct currents through resistances 40 and 41. The cathode of diode 38 is grounded and the mid-point between the resistances 40 and 41 is connected to the mid-point of the secondary winding 33 through a choke coil 42.

In the operation of the discriminator thus described, assuming that the tuning control of the radio receiver is adjusted for accurate resonance with the received carrier waves, the intermediate frequency has the desired value to which the primary and secondary windings 32 and 33 are each tuned. The voltage across the secondary winding of the discriminator transformer, according to well-known theory, is displaced in phase from the voltage across the primary winding by 90°. Because of this quadrature relation between the primary and secondary voltages, the voltage on one half of the secondary leads the voltage on the primary by 90° whereas that on the other half of the secondary lags that on the primary by 90°. Thus, the voltages applied to the two diodes 37 and 38, when the intermediate frequency is at its desired value, are equal and, accordingly, equal values of unidirectional current flow through each of the diodes and hence through resistances 40 and 41. It is observed that these resistances are poled oppositely, that is, the voltages across the two are opposite in polarity in the circuit between the cathode of diode 37 and ground with the result that the cathode of diode 37 is at ground potential when the intermediate frequency is of the desired value.

The quadrature relation between the primary and secondary voltages exists, however, only when the oscillations supplied thereto have the desired intermediate frequency. If this frequency changes in either direction, the phase of the secondary voltage varies from its 90° relation with the primary voltage in one direction or the other depending upon whether the frequency increases or decreases. For example, if the frequency increases, the phase shift may be in such a direction that the voltage on the upper half of the secondary approaches the aiding relation with the primary voltage, whereas that on the lower half of the secondary winding approaches the opposing relation with the primary voltage. Thus, the voltage applied to diode 37 increases and that applied to diode 38 decreases with the result that the unidirectional potential on resistance 40 increases whereas that on resistance 41 decreases.

In this manner discriminator 16 functions to demodulate frequency modulation waves which are coupled thereto from the output circuit of limiter 15. The demodulated signals are impressed through capacitor 43' across resistance 43, which has an adjustable tap 44, by means of which they are supplied to the control electrode of the audio frequency amplifier 17 through coupling capacitor 45. Operating potential for the anode of signal amplifier 17 is supplied from a suitable source of power, which again is not shown but merely indicated by the connection illustrated as B+ on the drawing, and which is connected between the usual plate load resistor 46 and

4

ground. Connected across the source of potential is a potentiometer comprising the series connected resistors 47-49 connected between the point B+ and ground. The cathode of amplifier 17 is maintained at a positive potential determined by the potential drop across resistors 48 and 49, while the grid resistance between the control electrode and cathode of amplifier 17 comprises the resistors 50 and 51 connected in series with resistor 48, the capacitor 52 being connected between the lower terminal of resistor 50 and ground to serve as a by-pass for alternating currents.

The amplified signals appearing in the output of amplifier 17 are coupled, by means of capacitor 53, to the control electrode 54 of the audio power amplifier 18, the series connected resistors 55, 56, and 57 forming resistance between the control electrode 54 and ground and capacitor 58 forming a by-pass across resistors 56 and 57 for alternating currents. The power amplifier 18 has been shown as a tetrode having its anode connected to the source of potential indicated at B+ through the primary winding of an audio transformer 60, its screen grid connected directly to the source of operating potential B+, and its cathode connected to ground through a cathode resistor 61 by-passed for alternating currents by capacitor 62, the capacitor 63 acting as a by-pass for alternating currents in the screen grid and anode circuits. The secondary winding of audio transformer 60 is shown as directly connected to the loud speaker 19.

In the operation of the receiver circuit thus far described, it has been found that there are always noise voltages present at the limiter even when no voltages are impressed upon the receiver input. It has been demonstrated that the nature of these voltages is that of a spectrum containing an almost infinite number of component frequencies, some of which always coincide with the frequencies of the desired signal. Since it is preferable to provide a very high gain through the radio frequency and intermediate frequency amplifiers, these noise voltages, which may be disturbances received by the antenna 10 or disturbances arising because of irregularities in the preceding receiver circuits, have a very large value when impressed upon the input of the limiter 15. When a signal is received by the antenna 10 and amplified, and after amplification in the preceding portions of the receiver is impressed upon the input of the limiter 15, the noise voltages appear as outward peaks of modulation on the envelope of the signal modulated carrier wave. In the limiter circuit, this wave undergoes amplitude limitation so that the noise voltages do not appear in the output circuits of the limiter. Hence, after the signal modulated waves which do appear in the tuned output 25 of the limiter have been demodulated in the slope filter or discriminator 16, in the manner previously outlined, demodulation or signal voltages appear across the volume control resistor 43 and are impressed upon the input of the amplifier 17.

During periods when no carrier wave is being received, the noise voltages alone are impressed across the input of limiter 15 and, consequently, these voltages are not removed by the limiter, but appear in the output circuits thereof. Under such conditions, it is undesirable that the noise voltages which appear in the output of the discriminator 16 be amplified and appear in the loud speaker.

In order to silence the audio circuits of the re-

ceiver during periods when no carrier waves are being received, the squelch tube 70 is provided having its input circuit coupled to potentiometer 43 in the output of the discriminator 16 through the filter circuit comprising capacitor 71 and resistor 69. The cathode of squelch tube 70 is connected to tap 72 on resistor 49 in order to maintain the cathode at a positive potential with respect to the control electrode of the tube. The position of tap 72 is adjusted so that the squelch tube 70 is biased to cutoff, but it passes a small amount of plate current when no signals are being received by the receiver, due to alternating noise voltages present in the receiver which appear across potentiometer 43 and are impressed upon the control electrode of tube 70 through condenser 71. The anode of tube 70 is supplied with operating potential from the tap between resistors 48 and 49 on the potentiometer 47, 48, 49 through the resistors 51 and 73 connected in series, capacitor 52 serving as a by-pass capacitor for alternating currents, resistor 73 acting as a plate load resistor for noise voltages and resistor 51 serving as a plate load resistor for slow changes in current values in the anode circuit. The potential drop across resistor 51, due to current flowing in the anode circuit of squelch tube 70, acts as an additional bias in the grid circuit of amplifier 17 and the value of resistor 51 is selected so that this additional bias is sufficient to bias the amplifier 17 to cutoff during standby or no-signal conditions of the receiver, thus interrupting the output circuit of the receiver under such conditions.

In order to provide means to reduce the current flow in the power amplifier 13 and thus reduce the energy consumption of the receiver during such periods, the noise voltages appearing in the output circuit of squelch tube 70 are coupled, by means of capacitor 74, to the control electrode of a noise amplifier which comprises the triode portion of the electron discharge device 75. While the usual type of triode may be used as such a noise amplifier, I have shown device 75 as a diode-triode tube having a diode within the same envelope with the above-mentioned triode. The anode of the triode portion of device 75 is likewise supplied with operating potential from the common potential source B+ through a load resistor 76 and is coupled by means of capacitor 77 to the anode of the diode portion of the device 75 to impress the amplified noise signals across this said diode. The noise signals thus impressed across the diode are rectified and appear as rectification voltages across the diode load resistor 57. The unidirectional voltages thus developed across resistor 57 by the rectified noise voltages serve as additional bias for the control electrode 54 of power amplifier 13 and, by proper selection of the value of resistor 57, may be utilized to reduce the current flow in power amplifier 13 to either a very low value or to complete cutoff.

When a signal is again received by the antenna 10 and, after amplification, appears across the limiter 15, noise voltages are removed by the action of the limiter so that no noise currents appear in the output of the discriminator. Since the squelch tube 70 is biased to the cutoff point, its current output reduces to zero. Hence, the current output of the triode portion of device 75 and the auxiliary current-reducing bias on device 18 are also reduced to zero. The filter circuit comprising capacitor 71 and resistance 69 is arranged to block the flow of currents of signal frequency but permit the flow of currents out-

side of the range of frequencies involved in the desired signal, which may be voice or music. Signal voltages in the output of the discriminator 16, which appear across potentiometer 43, therefore, are not passed by the capacitor 71 to drive the grid of tube 70 sufficiently positive to initiate current flow in the tube. Therefore, since current flow in tube 70 is stopped, the additional bias across resistor 51 is removed from the input circuit of amplifier 17 simultaneously with the reduction of noise voltages in the input of tube 70 and translation of the audio modulating signals through the circuits of the receiver to the loud speaker 19 is resumed.

It is, therefore, apparent that my invention as described above combines a highly sensitive background noise suppression circuit with a circuit to reduce energy consumption in the receiver during standby or no-signal conditions. Since in mobile receivers the power supply is usually a 6-volt storage battery and the large amount of energy consumed in maintaining the plate current of the power amplifier 13 at its average value accomplishes no useful purpose, it is desirable that this current be reduced during such periods. In the usual type of emergency communication receivers, standby or no-signal periods may comprise 90 to 98 per cent of the total time of operation. By reducing the current flow in the amplifier 13 during such periods to its cutoff point, the current drain on the power source may be decreased by approximately one-third during such standby operation. Furthermore, by using purely electronic means to effect such a reduction in current during these periods, successful operation of the circuits under all conditions is assured, since the audio circuits are silenced by noise which is present in the receiver during such periods and are made operative again upon the appearance of a carrier wave. Also, by using the carrier wave to open up the circuits at the beginning of a period of operation, all clipping of the audio signals is avoided and, hence, distortion in the output circuit caused by operation of the squelch and power economizer circuits is avoided.

While I have shown my power economizer circuit as applied to a frequency modulation type of receiver, it will be apparent to those skilled in the art that it may likewise be adapted to an amplitude modulation type of receiver. In such a circuit, the discriminator 16 and limiter 15 are replaced by the usual type of detector used for amplitude modulation receivers, which is used to provide audio voltages for the control electrode of amplifier 17. An auxiliary limiter and demodulator, energized by the same intermediate frequency signal, may be used to supply the necessary noise signal for the control electrode of tube 70 during standby periods.

While I have shown a particular embodiment of my invention, it will be understood that I do not wish to be limited thereto since various modifications may be made, and I contemplate by the appended claims to cover any such modifications so fall within the true spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. The combination with a receiver for signal modulated high frequency waves subject to undesired noise voltages, of an output power amplifier in which current normally flows during the operation of said receiver, and means for interrupting the normal current flow in said amplifier

7

in the absence of received carrier waves, said means comprising means limiting the amplitude of said waves thereby to remove said noise voltages therefrom in the presence of received carrier waves, said limiting means serving to translate said noise voltages in the absence of a received carrier wave, means for demodulating said received carrier wave and for reproducing said signals from said waves, an electron discharge device coupled to said demodulating means, said device being biased to cutoff in the presence of a received carrier wave and being arranged to amplify said noise voltages in the absence of said wave, and means coupled to the output of said device for applying a negative bias to said power amplifier in the absence of said wave..

2. In a receiver for signal modulated waves subject to noise voltages, the combination of an output power amplifier, means for reducing the gain of said amplifier in the absence of a received carrier wave, said means comprising, electron discharge means for amplifying said noise voltages in the absence of a wave, means responsive to said amplified voltages for reducing the gain of said power amplifier, and means operative when a signal modulated wave is being received to bias said electron discharge means to cut-off.

3. In a receiver for signal modulated oscillations subject to undesired noise voltages, the combination of a signal translating channel, an output power amplifier, means operative in the absence of received oscillations for simultaneously disabling said channel and for reducing the current flow in said amplifier, said means comprising means for rectifying said noise voltages and deriving a control potential therefrom, means responsive to said potential for interrupting translation by said channel, means for amplifying said potential, means applying said potential to said power amplifier in a gain reducing sense,

8

and means responsive to said received oscillations for disabling said potential deriving means.

4. In a receiver for frequency modulated carrier waves, the combination of, an audio signal translation channel, an audio power amplifier, and means responsive to the noise voltages present in said receiver and operative in the absence of a received carrier wave for disabling said channel and reducing the current flow in said amplifier comprising, means for limiting the amplitude of said waves to a predetermined value, thereby to remove said noise voltages from the output of said receiver when a wave is present therein, a balanced frequency discriminator, an electron discharge device coupled to said discriminator, said device being rendered non-conductive when a carrier wave is received in said receiver and being operative to amplify said noise voltages in the absence of a received carrier wave, means responsive to said amplified noise voltages for interrupting translation in said channel, means for rectifying said amplified noise voltages, and means responsive to said rectified voltages for reducing the gain of said audio amplifier.

GEORGE M. BROWN.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,096,625	Brown	Oct. 19, 1937
1,919,160	Faraham	July 18, 1933
1,925,825	Starrett	Sept. 5, 1933
2,028,859	Barton	Jan. 28, 1936
2,078,055	Carlson et al.	Apr. 20, 1937
2,152,515	Wheeler	Mar. 28, 1939
2,263,633	Koch	Nov. 25, 1941
Re. 22,302	Case	Apr. 20, 1943