July 23, 1940. E. H. WEBER, JR 2,208,953

NOISE REDUCING RECEIVING SYSTEM

Filed July 12, 1939

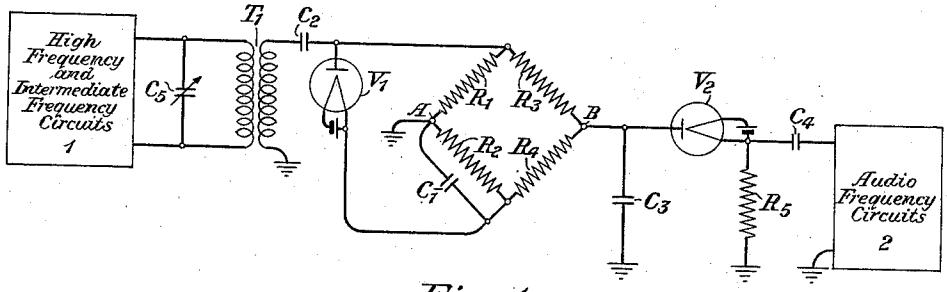


Fig. 1

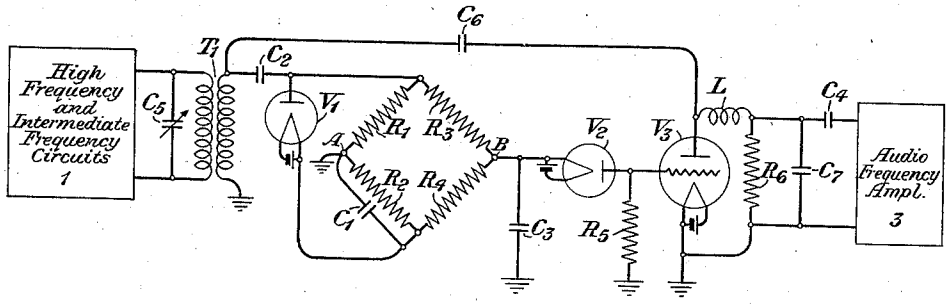


Fig. 2

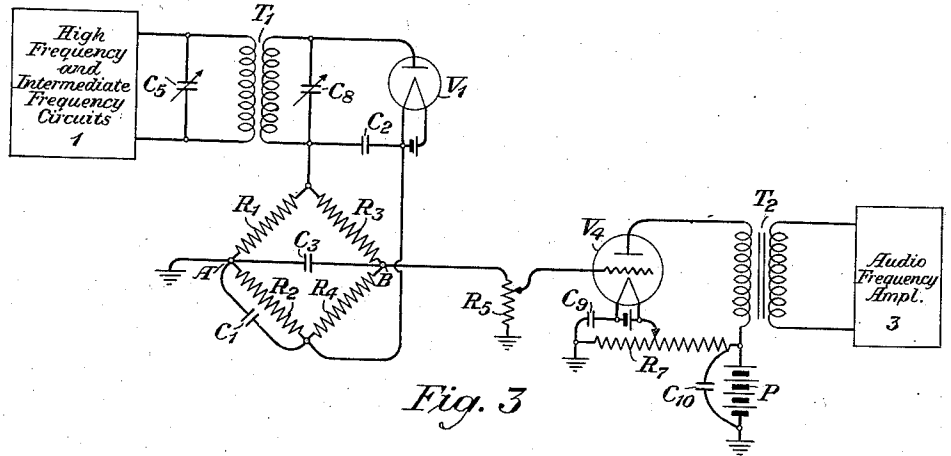


Fig. 3

INVENTOR
E. H. Weber, Jr.
BY William R. Ballard
ATTORNEY

Patented July 23, 1940 2,208,953

UNITED STATES PATENT OFFICE

2,208,953

NOISE REDUCING RECEIVING SYSTEM

Edward Henry Weber, Jr., Toms River, N. J. assignor to American Telephone and Telegraph Company, a corporation of New York

Application July 12, 1939, Serial No. 284,087

9 Claims. (Cl. 250—20)

This invention relates to signal receiving circuits and systems, and more particularly to arrangements for use therein to reduce or eliminate the reception of undesired noise currents and the like.

The invention has for one of its objects to provide an arrangement for reducing or eliminating the effect of noise impulses in dependence on the relation that the noise impulses bear with respect to the strength of the signals which it is desired to receive.

One of the most severe disturbances in signaling systems operating on high and ultra high frequencies is the noise produced by the so-called "man-made static" much of which results from the ignition systems of automobiles and the like. Such noise can sometimes be so pronounced as to practically entirely mask the signals to be received by a receiving circuit or system. Such noise impulses are generally of very short duration, often lasting less than one-thousandth of a second, but the effect of such impulses may last for a longer time. It has been determined that such noise does not seriously interfere with reception unless the peaks of the noise impulses exceed the amplitude of the incoming modulated carrier current.

It is one of the features of this invention to provide an arrangement for overcoming interference of this type. This may be accomplished by connecting certain special circuits to be described hereinafter in the intermediate radio frequency stages of the radio receiving system, and these special circuits will act to reduce or eliminate the noise interference from the audio frequency stages of the radio receiver.

This invention will be better understood from the detailed description hereinafter following when read in connection with the accompanying drawing, in which Figure 1 represents one embodiment of the invention for eliminating the noise in the second detector of a radio receiving system. Fig. 2 is a modification of the arrangement of Fig. 1 employed for suppressing the noise from the second detector of the receiving system, and Fig. 3 is a modification of the circuits of Figs. 1 and 2.

Referring to Fig. 1 of the drawing, the rectangle 1 designates part of the usual radio receiving circuit of the superheterodyne type, which includes an antenna system (not shown) and high frequency and immediate frequency detecting and amplifying apparatus. This apparatus is connected through a transformer T_1 to a rectifier V_1, which may be, for example, of the two-electrode type. This rectifier is connected across one of the diagonals of a bridge circuit having four arms which include two resistors R_1 and R_2, which may be of the same magnitude, and two additional resistors R_3 and R_4, R_3 being of substantially larger resistance than R_4. A condenser C_1 is bridged across the resistor R_2 and is of large capacity.

The other diagonal of the bridge designated by the points A and B is connected to a second rectifier V_2, which may also be, for example, of the two-electrode type as shown. The latter diagonal of the bridge includes, in addition to the rectifier V_2, a resistor R_5, which is preferably of a magnitude larger than any one of the resistors R_1—R_4, inclusive of the bridge. The resistor R_5 is connected to the remainder of the apparatus of the radio receiving set which is schematically represented by the rectangle 2, the latter apparatus including an audio frequency amplifier and a loud speaker (not shown).

A condenser C_2 which is interposed between the secondary winding of the transformer T_1 and the anode of the rectifier V_1 is a radio frequency coupling condenser, which also prevents any flow of direct current through the secondary winding of the transformer T_1. A condenser C_3 is connected across the points A and B of the bridge, and this condenser shunts the series circuit including the rectifier V_2 and the resistor R_5. A condenser C_4 is an audio frequency coupling condenser, which serves also to prevent the flow of direct current from the rectifier V_2 to the audio frequency circuits designated 2. The condenser C_5 which shunts the primary winding of the transmformer T_1, is a tuning condenser for improving the selectivity of the receiving system.

Each of the resistors R_1 and R_2 may be, for example, of 250,000 ohms. The resistor R_3 may be, for example, three times as large as the resistor R_4, the resistor R_3 being, let's say, 600,000 ohms, and the resistor R_4 200,000 ohms. The resistor R_5 may be, for example, as large as a megohm. These values are given, of course, merely for the purpose of illustration, and are not to be construed as limitations upon the invention.

It will be observed that the rectifiers V_1 and V_2 are connected across opposite diagonals of the bridge. The rectifier V_1 will rectify all alternating current transmitted through the transformer T_1, and the rectified current will be impressed across the diagonal of the bridge to which the rectifier V_1 is connected. The rectifier V_2 is poled so as to transmit current through the resistor R_5 only when the point B of the bridge is at a positive potential with respect to the point A. When the potential of point B is either equal to that of point A, or is negative with respect to point A, the rectifier V_2 will block the flow of all current to the resistor R_5 and hence to the audio frequency circuits 2. It will be clear, of course, that when the points A and B are at equal potentials the bridge will then be balanced.

As the resistor R_5 is substantially larger than

all of the other resistors, it will render the efficiency of detection quite high. All of the resistors shown in Fig. 1 have an impedance which is many times the reactance of the condenser C_1 at the lowest modulation frequencies. The theory of operation of the circuit illustrated in Fig. 1 is not believed to be necessary to a complete understanding of the invention, but will be briefly given hereinafter merely to explain the principles involved in the operation of the circuit, it being understood that the theory may not be completely accurate in all respects.

When an unmodulated carrier wave is received by the system and is rectified by the rectifier V_1, the rectified voltages existing across resistors R_1 and R_2 will be substantially equal, while the voltage across the resistor R_3 will be larger than that across resistor R_4, and in the example given hereinabove, three times as large. The potential at point B on the bridge will be positive with respect to point A which is grounded. Current will then flow through the rectifier V_2 and through its associated resistor R_5.

When the incoming carrier wave is modulated by a signal, the modulated wave will have an envelope which will roughly correspond to the wave shape of the signal current. The modulated current will vary from a small or negligible value to a larger value during each cycle of the signal current. The current will be at a minimum value corresponding to a trough in the envelope at one instant, and will reach a peak value corresponding to a crest in the envelope at another instant, as is well known. If the carrier is one hundred per cent. modulated, the amplitude of the modulated current at a crest will be approximately twice the magnitude of the unmodulated carrier current. Such a modulated current may be treated as composed of a direct current component and an alternating current component, both components being equal and of the same polarity at one phase of the modulated wave corresponding to a crest in the envelope, these components being equal and of opposite polarity at another phase of the modulated wave corresponding to a trough in the envelope.

When such a modulated wave is impressed upon the rectifier V_1 and rectified thereby, and the rectified current then transmitted to the bridge, the rectified voltages appearing across resistors R_1, R_3, and R_4 will vary in accordance with the modulation. The alternating current voltage impressed across the resistor R_2, however, will be small due to the fact that the condenser C_1, which is connected thereacross, has a very low reactance at the modulation frequencies. Hence the voltages appearing between points A and B of the bridge network will vary in accordance with the envelope of the modulated carrier current.

During modulation troughs the point B on the bridge will be at a positive potential with respect to the grounded point A, and this positive potential will be approximately twice that impressed upon point B with respect to point A when only the unmodulated carrier is received. During modulation crests, i. e., that part of the modulation cycle in which the apparent direct current and alternating current components are of equal and opposite potentials, there will be no potential between the points A and B on the bridge and the bridge will attain a state of balance. No current will flow either through the rectifier V_2 or through the resistor R_5 during such intervals.

Hence it will be apparent that the modulation cycle will be reproduced across the load resistor R_5. However, the potential across the resistor R_5 may be viewed as 180 degrees out of phase with respect to the incoming modulation cycle.

It will be observed that the bridge is normally unbalanced. That is, as rectified current flows through the bridge a potential appears between points A and B thereof both when the carrier is unmodulated and when the carrier is modulated, except during the brief intervals when the modulated current is at its peak. The bridge becomes balanced only during that part of the cycle when a modulation peak is reached, but this balance is disturbed again immediately after the peak is passed.

When noise impulses which exceed the amplitude of the fully modulated carrier current are impressed upon the receiving system, the instantaneous values of the voltages existing across the various arms of the bridge are such that the bridge is then momentarily unbalanced. When such noise impulses are received, the point B on the bridge becomes negative with respect to the grounded point A as will be explained hereinafter. During such periods the rectifier V_2 will block the flow of current through the resistor R_5, and hence no current will be impressed upon the audio frequency circuits 2. The current due to the noise impulses will not traverse the rectifier V_2 for the reason that a negative potential will then be applied to the anode of the rectifier V_2, and hence the rectifier will be non-conductive. Thus the rectifier V_2 will be conductive during the signal interval provided no large noise impulses are present, but when the large noise impulses arrive, the rectifier V_2 will block all passage of current therethrough.

Thus the bridge described above is balanced for normal modulation crests in the modulated carrier wave and at that time the voltage across resistor R_4 equals that across resistor R_2. It becomes progressively unbalanced with point B positive with respect to point A as the modulation envelope falls to the trough and the voltage on R_4 then decreases, the latter voltage approaching zero. For modulation peaks exceeding the normal crests the voltage across resistor R_4 becomes greater than that across resistor R_2, point B becomes negative with respect to point A and the bridge is again unbalanced but in the opposite direction.

The maximum amplitude of the impulses that may reach the resistor R_5 is thus limited to the amplitude corresponding to normal modulation crests in the modulated carrier wave. It will be observed that the voltage across resistor R_2 and condenser C_1 determines the amplitude at which limiting begins. This voltage is established by the unmodulated carrier amplitude and the bridge thus automatically adjusts itself so that noise impulses in the output are limited to the crest value of normal modulation for the particular carrier amplitude existing. However, the noise impulses above referred to are of very short duration, and as their amplitude may be limited, they will be hardly noticeable in the loud speaker attached to the audio frequency circuits 2.

Fig. 2 of the drawing is in many respects similar to Fig. 1. The rectifier V_2, however, is reversed so that current will flow through the rectifier V_2

only when the point B of the bridge is at a negative potential with respect to the point A. Hence the rectifier V_2 will rectify only the noise voltages of large amplitude which are transmitted thereto from the bridge. These noise impulses will appear across the resistor R_5, and they will be substantially free of the normal modulation frequencies. The voltages appearing across the resistor R_5 will be used to control the output of the vacuum tube detector designated V_3 as will be pointed out hereinafter.

A condenser C_6 is connected between the secondary winding of the transformer T_1 and the anode of the vacuum tube V_3. This condenser will transmit practically all of the radio frequencies to the vacuum tube V_3, the latter tube acting as a detector for these radio frequencies. The tube V_3 may be, for example, the second detector of the radio receiving system. The rectified currents will appear in the output circuit of the tube V_3, which includes the resistor R_6, the condenser C_7 which shunts the resistor R_6, and the radio frequency choke coil L. A source of plate potential (not shown in Fig. 2) may, if desired, be added to the output circuit in any well known manner. The detected current appearing in the output circuit of tube V_3 will be transmitted through the condenser C_4 to the audio frequency amplifier 3, which may include a loud speaker (not shown) attached thereto.

As noise impulses of large amplitude are rectified by the rectifier V_2 and appear across the resistor R_5, they will be applied to the grid of the tube V_3 and render the grid highly negative with respect to the associated cathode of the tube. The negative voltage so applied to the grid will limit or cut off the current flowing through the plate circuit of the tube V_3 for the duration of such noise impulses. The output of the tube V_3 will, therefore, not only greatly limit the amplitude of the noise impulses but may remove them altogether when the ratio of the noise-to-carrier amplitude is sufficiently large. The noise impulses are separated from the signal impulses by an arrangement of Fig. 2 and the noise impulses are employed to control the action of the rectifying tube V_3 and limit or cut off the current flowing in the plate circuit when the grid becomes actuated by these impulses.

Referring to Fig. 3 of the drawing, the instantaneous voltage appearing across points A and B of the bridge network will be applied to the grid of the audio frequency amplifier V_4 through the resistor R_5, the resistor R_5 acting as a volume regulating potentiometer. The grid of the tube V_4 is biased quite accurately to the cut-off point when no signals are being received. This is accomplished by making the cathode of the tube positive both with respect to ground and with respect to the grid of the tube. The voltage divider R_7 is used for this purpose, the element R_7 being connected across the plate voltage supply P. By this arrangement the cathode bias is quite correctly proportioned, even though the plate voltage may fluctuate on account of poor regulation.

The voltage divider R_7 should preferably be of comparatively low resistance so that the flow of cathode current resulting from the amplification of signals will not appreciably change the bias. The impedance in the plate circuit of the tube V_4 should also have a comparatively low direct current resistance in order that the flow of plate current will not appreciably reduce the effective direct current potential applied to the plate electrode of the tube.

When an unmodulated carrier current is being received by the system the direct current potential impressed between points A and B of the bridge network will render the grid of the tube V_4 more positive with respect to the cathode. Hence plate current will flow through the tube V_4.

When the carrier current becomes modulated by signals the bridge circuit will reverse the alternating current component of these signals as already pointed out hereinabove. The grid of the tube V_4 will become more negative when the envelope of the modulated wave reaches a modulation peak and less negative as the envelope passes through a modulation trough. The voltage applied to the grid will thus vary between the cut-off value and some value at which a large current will flow through the plate circuit of tube V_4 and this current will be transmitted through the transformer T_2 to the audio frequency apparatus 3.

As the receiving system receives noise impulses having an amplitude equal to or greater than the amplitude of the modulated carrier current at its peak value, the bridge network will in effect reverse the phase of the alternating current component of these noise impulses. The grid of the tube V_4 will then be made more negative, the negative potential reaching a value beyond the cut-off point of the tube, and hence no plate current will flow through the tube V_4. During such intervals there will be no signal reproduction by the tube V_4.

Thus as the complete modulation cycle is impressed upon the grid of the tube V_4 as a positive voltage, plate current will normally flow through the tube and the modulation cycle will be faithfully amplified and reproduced in the amplifier output. The accuracy of the reproduction will depend somewhat upon the linearity of the grid-voltage plate-current characteristic curve of the tube in the region between the zero grid bias value and the cut-off point. This latter requirement can be easily met in practice. The noise impulses which are of large amplitude merely act to increase the bias of the grid of the tube V_4 momentarily. The noise impulses will then be rejected by the tube V_4, even though no signal is being received by the system. When a signal is being received, however, the amplitude of the noise impulses will not exceed the crest value of the normal modulated current. The circuit just described will substantially reduce, if not entirely eliminate from the output of the system, the impulses generated by ignition systems and the like.

The bias for the cathode of the tube V_4 is quite critical. It has been determined that insufficient bias reduces the noise reduction ability of the system somewhat while an excessive bias introduces distortion. The bias to the cathode should preferably be set at a value where the plate current will cease to flow when no signal is being impressed upon the tube V_4. Once this bias is correctly established it need not be disturbed again.

The condenser C_8 may be added to the circuit in shunt with the secondary winding of the transformer T_1 for the purpose of increasing the selectivity of the receiving system, if this be desired. The condenser C_9, which is connected between the cathode of the tube V_4 and ground, is of such capacity as to act as a by-pass for audio frequency current. The condenser C_{10}

which bridges the source of plate voltage P is similarly employed to act as a by-pass for current of audio frequencies.

While this invention has been shown and described in certain particular arrangements merely for the purpose of illustration, it will be understood that the general principles of this invention may be applied to other and widely varied organizations without departing from the spirit of the invention and the scope of the appended claims.

What is claimed is:

1. Apparatus for receiving modulated signals free from noise impulses, comprising the combination of a bridge circuit, said bridge circuit including four resistors and a condenser in shunt with one of said resistors, two rectifiers connected respectively across the opposite diagonals of the bridge circuit, means for impressing the modulated signals upon one of said rectifiers, and means for translating the signals impressed by the bridge circuit upon the other rectifier into currents which are substantially free from noise impulses.

2. A radio receiving system for translating received radio frequency currents into audible signals substantially free from noise impulses that may be impressed simultaneously with the signals upon the radio receiving system, comprising a first rectifier for rectifying the received currents, a bridge circuit, said first rectifier being connected as a diagonal of said bridge circuit, a second rectifier connected to the other diagonal of the bridge circuit, said second rectifier being biased so as to block the passage of all currents therethrough when noise impulses are impressed upon the bridge circuit, and means for translating the signals traversing said second rectifier when substantially no noise impulses are impressed upon the system.

3. A radio receiving system for translating received radio frequency currents into audible signals substantially free from noise impulses, comprising a detector which prevents the flow of current therethrough when the polarity of said currents is in one direction and rectifies said currents when their polarity is in the opposite direction, a bridge circuit connected to said detector so that the detector is a diagonal thereof, said bridge circuit comprising four resistors which form the arms thereof and a condenser which shunts one of said arms, means including said bridge circuit for applying to said detector currents of one polarity when the signals received by the system are substantially free from noise impulses and for impressing upon said detector currents of the opposite polarity when substantial noise impulses are impressed upon the system.

4. In a radio receiving system for discriminating against noise impulses of large amplitude, means for rectifying all of the currents impressed upon the system, a bridge circuit one of the diagonals of which is supplied with the rectified current, a detector, a resistor connected in series with said detector across the opposite diagonal of the bridge circuit so that all of the impulses detected by said detector will traverse said resistor, and an amplifying device connected across said resistor for amplifying only those voltages appearing across said resistor.

5. In a radio receiving system for discriminating against noise impulses of large magnitude, comprising a bridge circuit, one diagonal of which is supplied with all of the currents impressed upon the receiving system, a three-electrode vacuum tube the grid and filament of which are connected to the other diagonal of the bridge circuit, means responsive to the signal currents for varying the potential impressed by the bridge circuit upon the grid of said tube so that said currents may be translated by the tube, and means responsive to noise impulses of large magnitude transmitted by the bridge circuit to the grid of the tube for so biasing the grid of the tube as to prevent the flow of anode current through said tube while said noise impulses are present.

6. A radio receiving system upon which may be impressed radio frequency signals and noise impulses, a detector tube connected as part of said radio receiving system, said tube having grid, filament and plate electrodes, means for impressing voltages on the grid of said tube corresponding to the signals received by the system so that said tube may detect said signals, means responsive to the noise impulses that may be simultaneously impressed upon the system for rendering said detector tube inoperative during the interval when said noise impulses are present, said latter means comprising a bridge circuit which is connected ahead of said detector tube and as a part of said receiving system, said bridge circuit including four non-inductive resistors as arms thereof and a condenser in shunt with one of said arms.

7. The combination of means for receiving signal currents as well as noise impulses, a Wheatstone bridge circuit to which said receiving means is connected as one diagonal thereof, detecting means connected as the other diagonal of said bridge circuit, means responsive to said signal currents for applying through said bridge circuit voltages of one polarity for detection by said detecting means, and means responsive to said noise impulses for applying voltages of the opposite polarity through said bridge circuit to said detecting means to render said detecting means inoperative.

8. Apparatus for producing a potential of one polarity when a received alternating voltage exceeds a predetermined value and a potential of opposite polarity when the alternating voltage is less than said predetermined value, comprising a rectifier for rectifying said alternating voltage, a Wheatstone bridge circuit to which said rectifier is connected as one diagonal thereof, said bridge circuit comprising four resistive arms and a condenser shunting one of said resistive arms, the potentials of opposite polarities appearing across the other diagonal of the bridge.

9. In a receiving system for receiving carrier current modulated by signals and for discriminating between carrier current which is normally modulated and excessive currents due to abnormal modulation, comprising means for rectifying the received currents, and means for automatically producing a potential of one polarity when normally modulated current is rectified and a potential of opposite polarity when excessive currents due to abnormal modulation are rectified, said latter means comprising four non-adjustable non-inductive resistors arranged in Wheatstone bridge relationship and a condenser bridging one of said resistors, the rectified currents being supplied to said bridge circuit, the potentials of opposite polarity being obtained from said bridge circuit.

EDWARD HENRY WEBER, JR.

DISCLAIMER

2,208,953.—*Edward Henry Weber, Jr.*, Toms River, N. J. NOISE REDUCING RECEIVING SYSTEM. Patent dated July 23, 1940. Disclaimer filed August 7, 1941, by the inventor; the assignee, *American Telephone and Telegraph Company*, consenting.

Hereby enters this disclaimer to claims 2, 4, and 7 of said Letters Patent.

[*Official Gazette September 2, 1941.*]