Oct. 5, 1948. R. K. VERMILLION 2,450,818

ELECTRONIC NOISE ELIMINATOR

Filed Aug. 26, 1944 3 Sheets-Sheet 1

Fig 1.

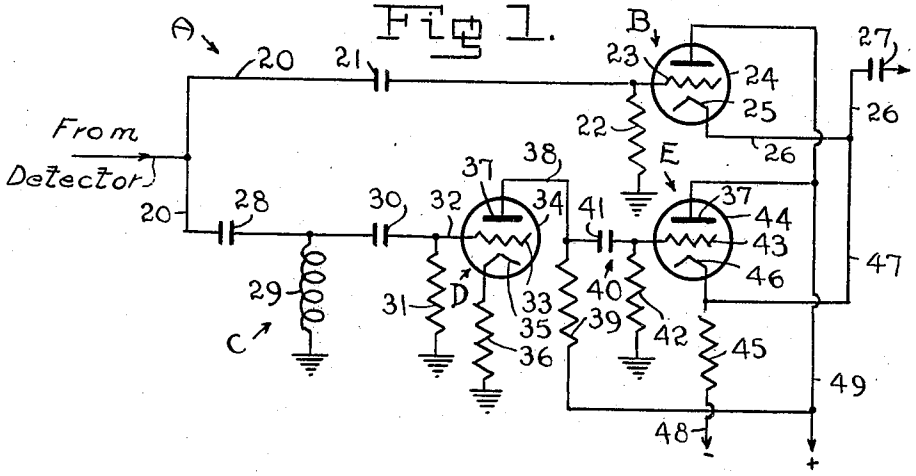


Fig 2.

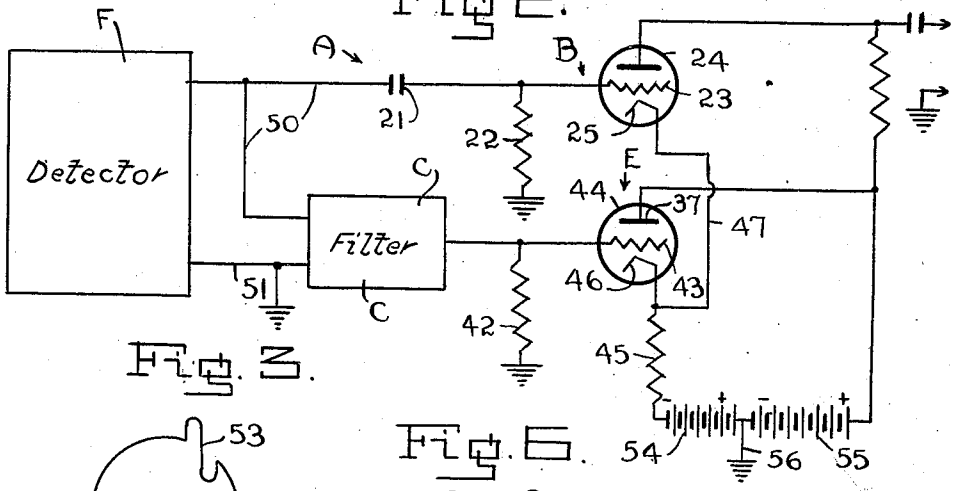


Fig. 3.

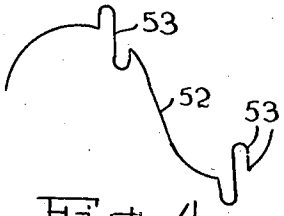


Fig. 6.

Fig. 8.

Fig. 4.

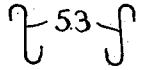
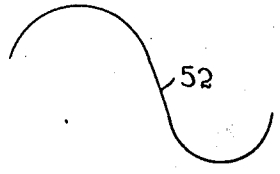


Fig. 7.



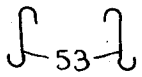


Fig. 5.

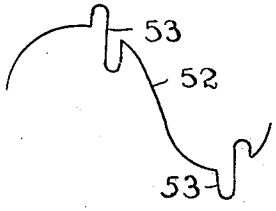


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Fig. 9.

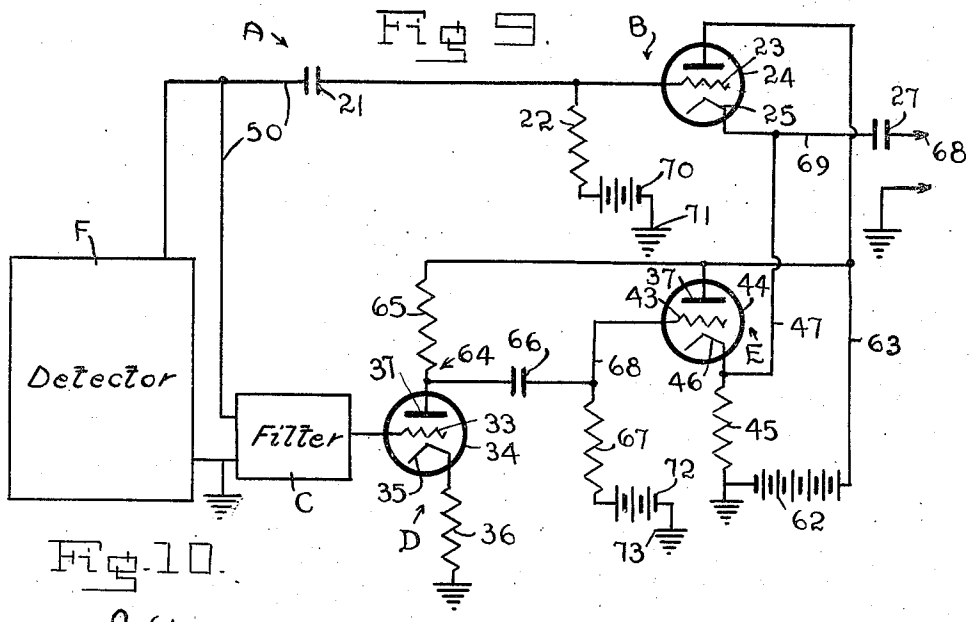

Fig. 10.

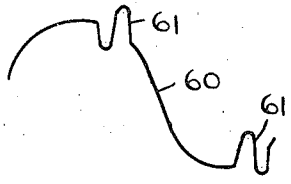

Fig. 11.

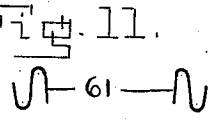

Fig. 12.

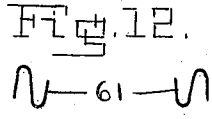

Fig. 13.

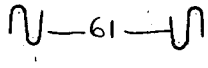

Fig. 14.

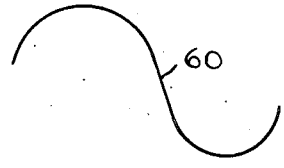

Fig. 15.

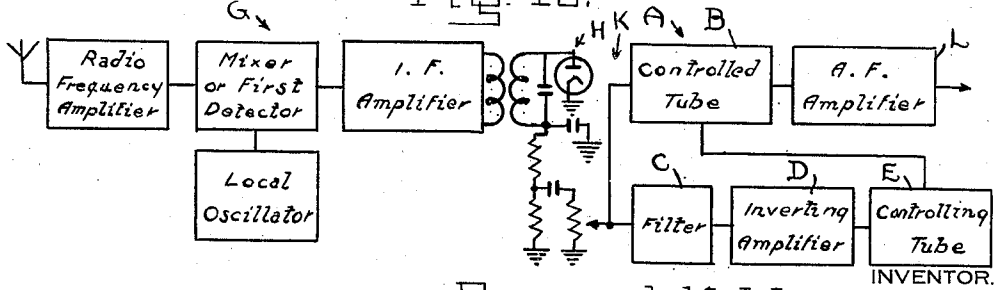

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Fig. 16.

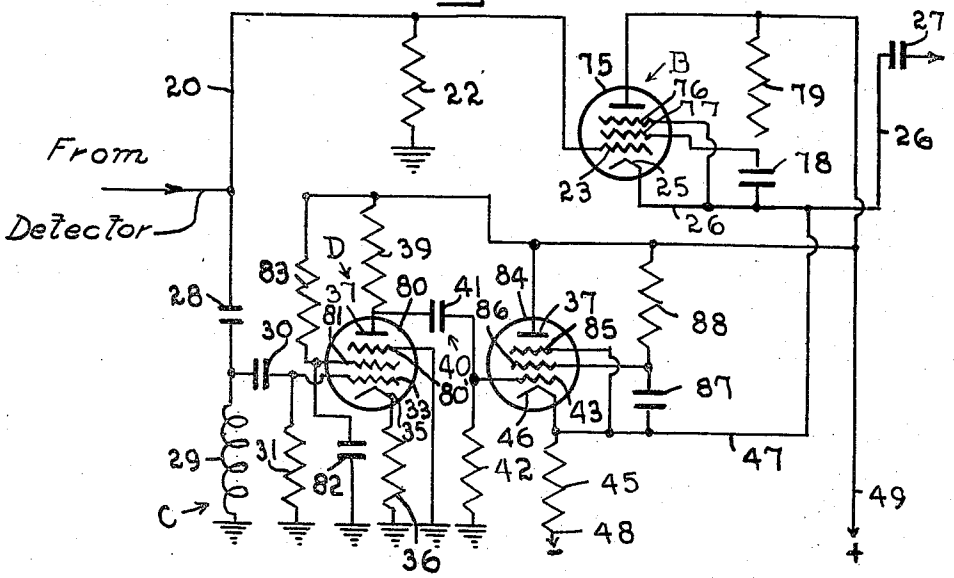
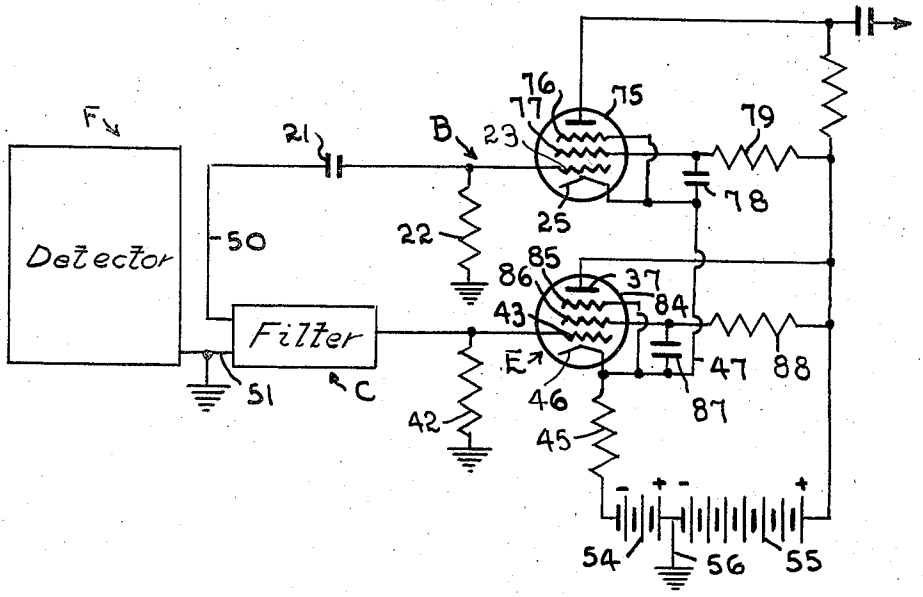


Fig. 17.



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Patented Oct. 5, 1948

2,450,818

UNITED STATES PATENT OFFICE

2,450,818

ELECTRONIC NOISE ELIMINATOR

Raymond K. Vermillion, St. Petersburg, Fla.

Application August 26, 1944, Serial No. 551,377

12 Claims. (Cl. 250—20)

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This invention relates to electronic noise eliminating systems and more specifically to an automatic system which may be employed to cancel a single frequency or a wide band of frequencies, and may be connected to amplifiers to cancel noises, such as record scratches as well as line disturbances.

The novel system cancels undesired frequencies and does not simply limit their amplitudes.

An important object of the invention is to provide such a system which may be inserted in existing circuits without any major alteration to such circuits.

Another important object is to provide a system having a wide application, since it is adapted to eliminate undesired noises due to natural static disturbances, transients set up as by arcing contacts in electrical equipment, disturbances due to heterodyning of two radio carriers, those disturbances due to key clicks of radio telegraph transmitters, and any and all known interferences offering a vertical wave front.

Other objects and advantages of the invention will be apparent during the course of the following detailed description of the invention, taken in connection with the accompanying drawings, forming a part of this specification, and in which drawings:

Fig. 1 is a diagrammatic showing of the general aspect of the system per se, separated from the structures of conventional receiver and conventional amplifier.

Fig. 2 is a diagrammatic showing of the invention, disclosing control of a plate load amplifier, and employing triodes.

Figs. 3 to 8 illustrate steps in the elimination of noise signal impulses by the system of Fig. 2.

Fig. 9 is a diagrammatic showing of the invention, illustrating control of a cathode-coupled amplifier, employing triodes.

Figs. 10 to 14 illustrate steps in the elimination of noise signal impulses by the system of Fig. 9.

Fig. 15 is a diagrammatic showing of the system interposed in a conventional radio apparatus, so that its position, with respect to the conventional apparatus, will be clear.

Fig. 16 is a digrammatic showing of the general aspects of the system per se, employing pentodes.

Fig. 17 is a diagrammatic showing, illustrating control of a plate load amplifier, employing pentodes.

In the drawings, wherein for the purpose of illustration is shown a preferred embodiment and

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modifications of the invention, similar reference characters are employed to designate corresponding parts throughout the several views, and the letter A may designate the system as a whole; B, controlled amplifier; C, filter assembly; D, inverter amplifier; E, controlling tube; F, conventional radio receiver-detector; G, a superheterodyne receiver including a conventional diode detector H, while the letter K illustrates position of the novel noise eliminator A, interposed between the receiver G and a conventional audio frequency amplifier L.

In Fig. 1, where the system A is illustrated generally, the output of the receiver detector (not shown in Fig. 1) is carried by one branch of conductor 20 in turn to condenser 21, grounded resistor 22, and grid 23 of tube 24, while from the cathode 25 of tube 24, a conductor 26 extends to condenser 27. This assembly provided the audio frequency amplifier B which may be termed the controlled stage.

The other branch of conductor 20 extends, in turn, to a condenser 28, grounded inductance 29, condenser 30 and grounded resistor 31, which form a filter C of the high-pass type adapted to pass frequencies above a given frequency, and the output of the filter C is connected to the inverter amplifier D, as at 32, to grid 33 of a triode 34, being a regenerative tube, for the purpose of phase inversion. The cathode 35 of the tube 34 is connected to a grounded biasing resistor 36.

From the anode 37 of triode 34 extends conductor 38 to plate load resistor 39, across which the inverted signal is developed, and to a coupling combination 40, comprising a condenser 41 and grounded resistor 42, adapted to feed the grid 43 of controlling triode 44. A resistor 45 is connected with the cathode 46 of triode 44, as a cathode load resistor. Between the cathode 46 and resistor 45, a lead 47 extends to conductor 26 which is, as stated, connected with the cathode 25 of triode 24 and condenser 27. Resistor 45 is connected, at 48 to a voltage, negative with respect to the voltage drop across the resistor 45 minus the bias required for tube 24.

Briefly, at this point, it should be stated that the output of a conventional radio receiver detector (not shown in Fig. 1) is connected to conductor 20. As stated, one branch of this conductor 20 extends to tube 24. It is this branch that is followed by the signal and noise impulses. On the positive swing of the signal and/or noise impulses, tube 24 conducts more, the voltage across resistor 45 increases and, since this resistor is connected by lead 26 to the cathode 25 of tube

24, the cathode voltage of tube 24 becomes more positive, thus making the grid 23 negative with respect to the cathode 25, but not proportionately equally negative with respect thereto. Therefore, there will be an increase in plate current and an increase in voltage drop across resistor 45, which follows the grid signal wave form. In other words, the stage is degenerative.

The same signal is conducted to the grid 33 of tube 34 along the other branch of conductor 20 and by way of the high-pass filter assembly C of Fig. 1, this latter passing frequencies above the wanted signal.

Triode 34, resistors 31, 36 and 39 and condenser 41 make up a phase inverting stage. On the positive swing of the grid 33 of tube 34, there occurs, more heavily, a voltage drop across resistor 39, in the negative direction, thus inverting the wave form. Of course, this signal is conducted to the grid 43 of triode 44 by way of condenser 41 and resistor 42. At this time, tube 44 is functioning as a cathode follower, its cathode 46 being connected with the cathode 25 of tube 24 by leads 26 and 47.

At a given instant, the grid 23 of triode 24 and grid 33 of triode 34 are swinging positive, but the grid 43 of triode 44 is swinging negative, due to the phase-inverting stage of tube 34.

As may be seen from Fig. 1, resistor 45 is common to the cathode circuits of tubes 24 and 44, so that, when tube 24 conducts more, tube 44 conducts less, due to its negative grid swing. As a result, the drop across resistor 45 is constant and cancellation of the noise signal takes place, whereby tube 24 is free to follow the wanted signal.

The anodes 37 of triodes 24 and 44 are substantially alike and are connected together, all by leads 38, and 49 and their branches.

The system may be inserted between the output of a radio receiver detector and an amplifier and, in Fig. 2, is shown a circuit, including the system, applied to a plate-coupled amplifying stage.

A radio receiver detector is shown diagrammatically at F with outlet leads 50 and 51. The wanted signal 52 and noise signal 53 are conducted to the grid 23 of tube 24 in the usual manner, with a change in the plate and cathode currents of triode 24.

The same signals 52—53 of Fig. 3 are also conducted, by lead to filter assembly C, which may be the high-pass type of Fig. 1. Assembly C passes only the noise signal 53 (Fig. 4) in the same phase as the wanted and noise signals 52—53 reached grid 23 of tube 24. On positive swing of the noise signal 53 voltage, controlling tube 44 conducts more current and its cathode 46 becomes more positive. Cathodes 25 and 46 are connected, as heretofore, by lead 47, so that, as the noise signal 53 voltage swings positive in both tubes 24 and 44 (as it must, because of the phase conditions) both tubes will conduct more current, and tube 44, adding its conduction, through the common cathode resistor 45, will maintain a constant plate current in tube 24, since the increased bias equals the amplitude of the noise and tube 24 is free to amplify the wanted signal 52, because this signal cannot pass the filter C.

It is apparent that, on the negative swing of the noise signal 53, both tubes 24 and 44 will conduct less current. The signal through the filter C causes tube 44 to conduct less and the resulting bias on the grid 23 of tube 24 decreases in value so that the plate current does not change. It should be noted that the electric current-producing means 54—55 is bias and plate batteries, grounded as at 56, with battery 54 so adjusted as to permit tubes 24 and 44 to operate on the linear portion of their Eg—Ip curve (class A) in order to reproduce the wanted signal 52, and to cancel both positive and negative going noise signals 53.

In Fig. 3 is diagrammatically shown the input wanted and noise signals, in Fig. 4 the input (noise signals) to tube 44, in Fig. 5 the resultant cathode wave form, in Fig. 6 the noise signal voltage present on the grid 23 of tube 24, in Fig. 7 the resultant bias on the grid 23, caused by the controlling tube 44 and in Fig. 8 the resultant plate wave form of the controlled tube.

Filter C may control only a very narrow band (heterodyne interference), it may cancel frequencies lower in frequency than the wanted signal, or it may be a combination filter (band stop), cancelling frequencies both above and below the wanted signal.

In Fig. 9 are diagrammatically shown cathode-coupled amplifiers, together with an inverter amplifier, with a signal control therefor. Here the wanted signal 60 and noise signals 61 of Fig. 10 are led from the receiver F by conductor 50 to the grid 23 of controlled tube 24. This tube, having no plate load, is connected to the plate battery 62 by lead 63. In the circuit of cathode 25 of tube 24 is resistor 45. This resistor 45 forms the cathode load resistor across which the signals are developed in the following manner: As the grid 23 of tube 24 swings positive with the wanted signal and noise signals 60 and 61, the tube conducts more and the cathode 25 becomes more positive, following the grid voltage wave form.

The noise signal 61 voltage is conducted to the grid 33 of inverter tube 34 in the same phase as the voltage applied to grid 23 of tube 24. This voltage, on the positive swing, causes tube 34 to conduct more, the voltage dropping at 64 because of the resistor 65, which is in series with the plate 37 of tube 34. This change in voltage is conducted, by condenser 66, resistor 67 and lead 68 to the grid 43 of tube 44. This tube 44 has no plate load resistor, its cathode 46 being connected to resistor 45, and to the cathode 25 of tube 24.

In action, while the cathode 25 is becoming positive, the cathode 46 of tube 44 is becoming negative, thereby cancelling the noise signal 61 voltage at 68, while signal voltage is conducted by way of condenser 27 and lead 69.

It will be noted that there is provided a bias battery 70, grounded at 71, and furnishing current bias for tube 24, so that the latter will operate on the linear portion of the Eg—Ip curve (class A). Of course, the battery 72, grounded at 73, serves the same purpose for tube 44.

Fig. 11 shows the noise signal input to inverter tube 34, Fig. 12, the same on the plate of inverter tube, Fig. 13 the same on the grid 43 of controlling tube 44 and Fig. 14 the wanted signal 60 on the cathode 23 of the controller tube 24.

The system may employ any suitable vacuum tube and, by way of example, Figs. 16 and 17 illustrate the system, employing pentodes, in place of the triodes of the corresponding Figs. 1 and 2.

Similar reference characters are employed, of course, to designate corresponding parts in Figs. 1, 2, 16 and 17. The pentode 75 of Figs. 16 and and 17 contains a grid 23 and cathode 25 as well as grids 76 and 77 and a condenser 78 and resistor 79 are provided. The pentode 80 of Fig. 16 contains the grid 33, cathode 35 and anode 37 as well as grids 80' and 81 with the necessary

grounded condenser 82 and resistor 83, while the pentode 84 of Figs. 16 and 17, contains grid 43, cathode 46 and anode 37 with grids 85 and 86 there being also provided the condenser 87 and resistor 88.

In Fig. 15 is illustrated a typical hookup, shown diagrammatically, where a conventional superheterodyne receiver indicated generally at G is provided with a conventional diode detector H, with the output of the detector connected with the novel electronic noise eliminator A, as at K, interposed between it and a conventional audio frequency amplifier L.

Various changes may be made to the forms of the invention herein shown and described without departing from the spirit of the invention and scope of the claims.

What is claimed is:

1. In an electronic noise interference eliminator, adapted to be disposed in a radio receiving circuit to follow a detector in said circuit, means for receiving wanted signal impulses and noise interference from a detector, said means including a vacuum tube, having a cathode; high pass filter means for receiving and separating wanted signal impulses and noise signal impulses, having frequencies higher than the highest desired signal frequency, from the detector and passing frequencies above the wanted signal impulses; phase inverting stage means for receiving said frequencies and inverting the wave form, including a second vacuum tube; a biasing resistor for said last named tube and plate load resistor means across which said inverted wave form is developed, means for receiving said inverted wave form, including a third vacuum tube, having a cathode, means electrically connecting together the cathodes of said first and third named tubes so that they are at substantially the same operating potentials at all times, and an electrical resistor, common to the cathode circuits of said first and third tubes.

2. In an electronic noise interference eliminator, adapted to be disposed in a radio receiving circuit to follow a detector in said circuit, means for receiving wanted signal impulses and noise interference from a detector, said means including a first vacuum tube having a cathode and an anode; high pass filter means for receiving and separating wanted signal impulses and noise signal impulses, having frequencies higher than the highest desired signal frequency, from the detector and passing frequencies above the wanted signal impulses; phase inverting stage means for receiving said frequencies and inverting the wave form, including a second vacuum tube, having an anode; means for receiving said inverted wave form, including a third vacuum tube having a cathode and an anode, means electrically connecting together the cathodes of said first and third named tubes so that they are at substantially the same operating potentials at all times, an electrical resistor common to the cathode circuits of said first and third tubes; and electric current generating means in circuit with said resistor and electrically connected with the anode circuits of said tubes, said resistor being connected with said last-named means at a point where the voltage of said last-named means is negative, with respect to the ground and of a value equal to the voltage drop across said resistor minus the bias required for said first-named vacuum tube.

3. In a noise-cancellation apparatus for a radio receiver, a controlled amplifier including a vacuum tube, having a cathode, a grid and an anode; filter means for separating the wanted signal impulses and the noise impulses, having frequencies higher than the highest desired signal frequency, and passing only said noise impulses, in the same phase as the impulses reaching the grid of said tube; means for electrically connecting said controlled amplifier to said receiver; means for electrically connecting said filter means to said receiver; means for receiving said noise impulses from said first-named means and inverting the wave form thereof, including a vacuum tube, having an anode, a biasing resistor therefor, and plate load resistor means for developing said inverted wave form across said plate load resistor; means for receiving said inverted wave form, including a vacuum tube, having a cathode and an anode; means electrically connecting together the cathodes of said first and third tubes so that they are at substantially the same operating potentials at all times; a common electrical resistor for the cathode circuits of said first and third tubes; and electric current generating means in circuit with said common electrical resistor and electrically connected with the anode circuits of said tubes, said common electrical resistor being connected with said last-named means at a point where the voltage of said last-named means is negative, with respect to the ground, and of a value equal to the voltage drop across said common electrical resistor minus the bias required for said first-named vacuum tube.

4. In an electronic noise eliminator, means for receiving wanted and noise signal impulses, including a vacuum tube, having a grid and a cathode; means including a high pass filter, for separating said wanted signal impulses and noise signal impulses, having frequencies higher than the highest desired frequency, and passing only said noise signal impulses, in the same phase as the impulses reaching the grid of said tube; means for receiving said noise signal impulses from said second-named means, including a second vacuum tube, having a cathode; means electrically connecting together the cathodes of said tubes so that they are at substantially the same operating potentials at all times; and an electrical resistor, common to the cathode circuits of said tubes.

5. In an electronic noise interference eliminator, adapted to be disposed in a radio receiving circuit to follow a detector in said circuit, means for receiving wanted signal impulses and noise interference from a detector, said means including a vacuum tube, having a cathode; low pass filter means for receiving and separating wanted signal impulses and noise impulses, having frequencies lower than the lowest desired signal frequency, from the detector and passing frequencies below the wanted signal impulses; phase inverting stage means for receiving said frequencies and inverting the wave form, including a second vacuum tube; a biasing resistor for said last named tube and plate load resistor means across which said inverted wave form is developed; means for receiving said inverted wave form, including a third vacuum tube, having a cathode; means electrically connecting together the cathodes of said first and third named tubes so that they are at substantially the same operating potentials at all times; and an electrical resistor, common to the cathode circuits of said first and third tubes.

6. In an electronic noise interference eliminator, adapted to be disposed in a radio receiving circuit to follow a detector in said circuit, means

for receiving wanted signal impulses and interference signals from a detector, said means including a first vacuum tube having a cathode and an anode; band-pass filter means for receiving and separating wanted signal impulses and interference signal impulses, having frequencies within the pass-band of the filter from the detector and passing frequencies within the pass-band; phase inverting stage means for receiving said frequencies and inverting the wave form, including a second vacuum tube, having an anode; means for receiving said inverted wave form, including a third vacuum tube having a cathode and an anode; means electrically connecting together the cathodes of said first and third named tubes so that they are at substantially the same operating potentials at all times; an electrical resistor common to the cathode circuits of said first and third tubes; and electric current generating means in circuit with said resistor and electrically connected with the anode circuits of said tubes, said resistor being connected with said last-named means at a point where the voltage of said last-named means is negative, with respect to the ground and of a value equal to the voltage drop across said resistor minus the bias required for said first-named vacuum tube.

7. In a noise-cancellation apparatus for a radio receiver, a controlled amplifier including a vacuum tube, having a cathode, a grid and an anode; filter means for separating the wanted signal impulses and the noise impulses, having frequencies lower than the lowest desired signal frequency, and passing only said noise impulses, in the same phase as the impulses reaching the grid of said tube; means for electrically connecting said controlled amplifier to said receiver; means for electrically connecting said filter means to said receiver; means for receiving said noise impulses from said first-named means and inverting the wave form thereof, including a vacuum tube, having an anode, a biasing resistor therefor, and plate load resistor means for developing said inverted wave form across said plate load resistor; means for receiving said inverted wave form, including a vacuum tube, having a cathode and an anode; means electrically connecting together the cathodes of said first and third tubes so that they are at substantially the same operating potentials at all times; a common electrical resistor for the cathode circuits of said first and third tubes; and electric current generating means in circuit with said common electrical resistor and electrically connected with the anode circuits of said tubes, said common electrical resistor being connected with said last-named means at a point where the voltage of said last-named means is negative, with respect to the ground, and of a value equal to the voltage drop across said common electrical resistor minus the bias required for said first-named vacuum tube.

8. In an electronic noise eliminator, means for receiving wanted and noise signal impulses, including a vacuum tube, having a grid and a cathode; means, including low-pass filter, for operating said wanted signal impulses and noise signal impulses, having frequencies higher than the highest desired signal frequency, and passing only said noise signal impulses, in the same phase as the impulses reaching the grid of said tube; means for receiving said noise signal impulses from said second-named means, including a second vacuum tube, having a cathode; and means electrically connecting together the cathodes of said tubes so that they are at substantially the same operating potentials at all times; and an electrical resistor, common to the cathode circuits of said tubes.

9. In an electronic noise interference eliminator, adapted to be disposed in a radio receiving circuit to follow a detector in said circuit, means for receiving wanted signal impulses and noise interference from a detector, said means including a first vacuum tube, having a cathode; band-pass filter means for receiving and separating wanted signal impulses and noise signal impulses, having frequencies within the filter pass band, from the detector and passing frequencies differing from the wanted signal impulses; phase inverting stage means for receiving said frequencies and inverting the wave form, including a second vacuum tube; a biasing resistor for said last named tube and plate load resistor means across which said inverted wave form is developed, means for receiving inverted wave form, including a third vacuum tube, having a cathode, means electrically connecting together the cathodes of said first and third named tubes so that they are at substantially the same operating potentials at all times, and an electrical resistor, common to the cathode circuits of said first and third tubes.

10. In an electronic noise interference eliminator, adapted to be disposed in a radio receiving circuit to follow a detector in said circuit, means for receiving wanted signal impulses and noise interference signals from a detector, said means including a first vacuum tube having a cathode and an anode; band-pass filter means for receiving and separating wanted signal impulses and interfering signal impulses, having frequencies within the filter pass band and differing from the desired signal frequency; phase inverting stage means for receiving said frequenices and inverting the wave form, including a second vacuum tube, having an anode; means for receiving said inverted wave form, including a third vacuum tube having a cathode and an anode, means electrically connecting together the cathodes of said first and third named tubes so that they are at substantially the same operating potentials, an electrical resistor common to the cathode circuits of said first and third tubes; and electric current generating means in circuit with said resistor and electrically connected with the anode circuits of said tubes, said resistor being connected with said last-named means at a point where the voltage of said last-named means is negative, with respect to the ground and of a value equal to the voltage drop across said resistor minus the bias required for said first-named tube.

11. In a noise-cancellation apparatus for a radio receiver, a controlled amplifier including a vacuum tube, having a cathode, a grid and an anode; band-pass filter means for separating the wanted signal impulses and the noise impulses, having frequencies within the filter pass band, from the detector and passing frequencies differing from the wanted signal impulses, in the same phase as the impulses reaching the grid of said tube; means for electrically connecting said controlled amplifier to said receiver; means for electrically connecting said filter means to said receiver; means for receiving said noise impulses from said first-named means and inverting the wave form thereof, including a vacuum tube, having an anode, a biasing resistor therefor, and plate load resistor means for developing said inverted wave form across said plate load resistor; means for receiving said inverted wave form, including

a vacuum tube, having a cathode and an anode, means electrically connecting together the cathodes of said first and third tubes so that they are at substantially the same operating potentials at all times, a common electrical resistor for the cathode circuits of said first and third tubes; and electric current generating means in circuit with said common electrical resistor and electrically connected with the anode circuits of said tubes, said common electrical resistor being connected with said last-named means at a point where the voltage of said last-named means is negative, with respect to the ground, and of a value equal to the voltage drop across said common electrical resistor minus the bias required for said first-named vacuum tube.

12. In a noise-cancellation apparatus for a radio receiver, a controlled amplifier including a vacuum tube having a cathode, a grid, and an anode; filter means for separating the wanted signal impulses and the noise impulses, having frequencies lower than the lowest desired signal frequency, and passing only said noise impulses, in the same phase as the impulses reaching the grid of said tube; means for electrically connecting said controlled amplifier to said receiver; means for electrically connecting said filter means to said receiver; means for receiving said noise impulses from said first-named means and inverting the wave form thereof, including a vacuum tube, having an anode, a biasing resistor therefor, and plate load resistor means for developing said inverted wave form across said plate load resistor;

means for receiving said inverted wave form, including a vacuum tube, having a cathode and an anode, means electrically connecting together the cathodes of said first and third tubes so that they are at substantially the same operating potentials at all times, a common electrical resistor for the cathode circuits of said first and third tubes; and electric current generating means in circuit with said common electrical resistor and electrically connected with the anode circuits of said tubes, said common electrical resistor being connected with said last-named means at a point where the voltage of said last-named means is negative, with respect to the ground, and of a value equal to the voltage drop across said common electrical resistor minus the bias required for said first-named vacuum tube.

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REFERENCES CITED

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

UNITED STATES PATENTS

Number	Name	Date
1,722,789	DeBellescize	July 30, 1929
1,748,277	Chaffee	Feb. 25, 1930
1,981,056	Lohrmann	Nov. 20, 1934
2,138,123	Sargent	Nov. 29, 1938
2,183,714	Franke et al.	Dec. 19, 1939
2,192,275	Royer	Mar. 5, 1940
2,227,057	Blumlein	Dec. 31, 1940
2,255,374	Beverage	Sept. 9, 1941