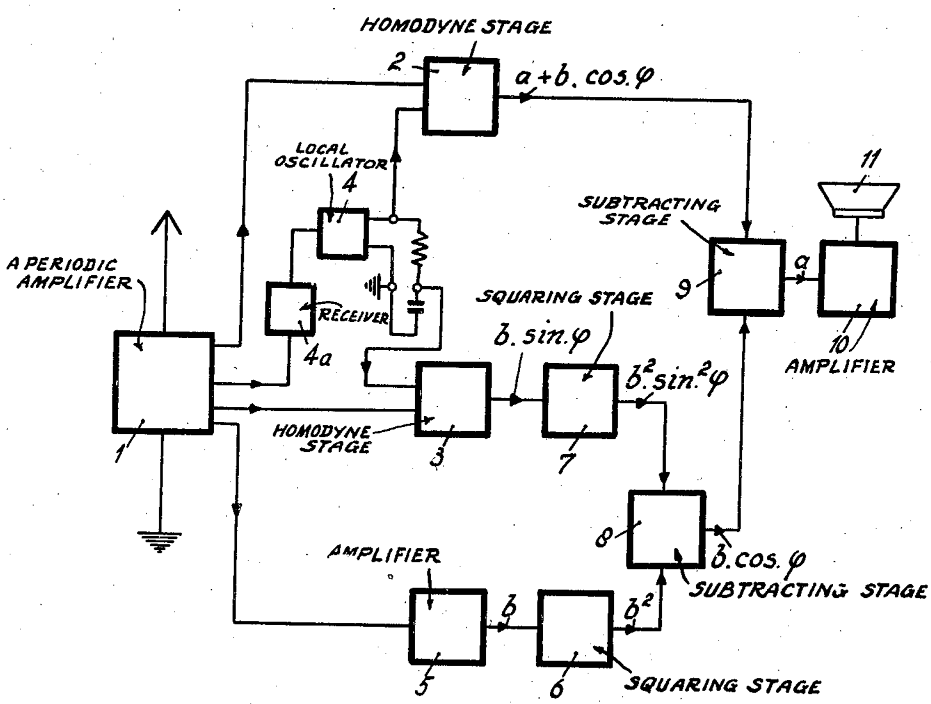
Jan. 6, 1942. Z. BAY 2,268,998

REDUCING DISTURBANCES IN RADIO RECEPTION

Filed Nov. 2, 1939 2 Sheets-Sheet 1

FIG. 1



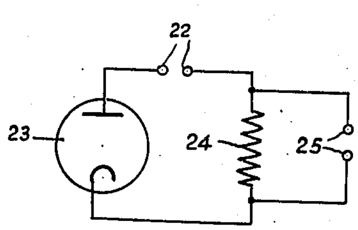


FIG. 1a

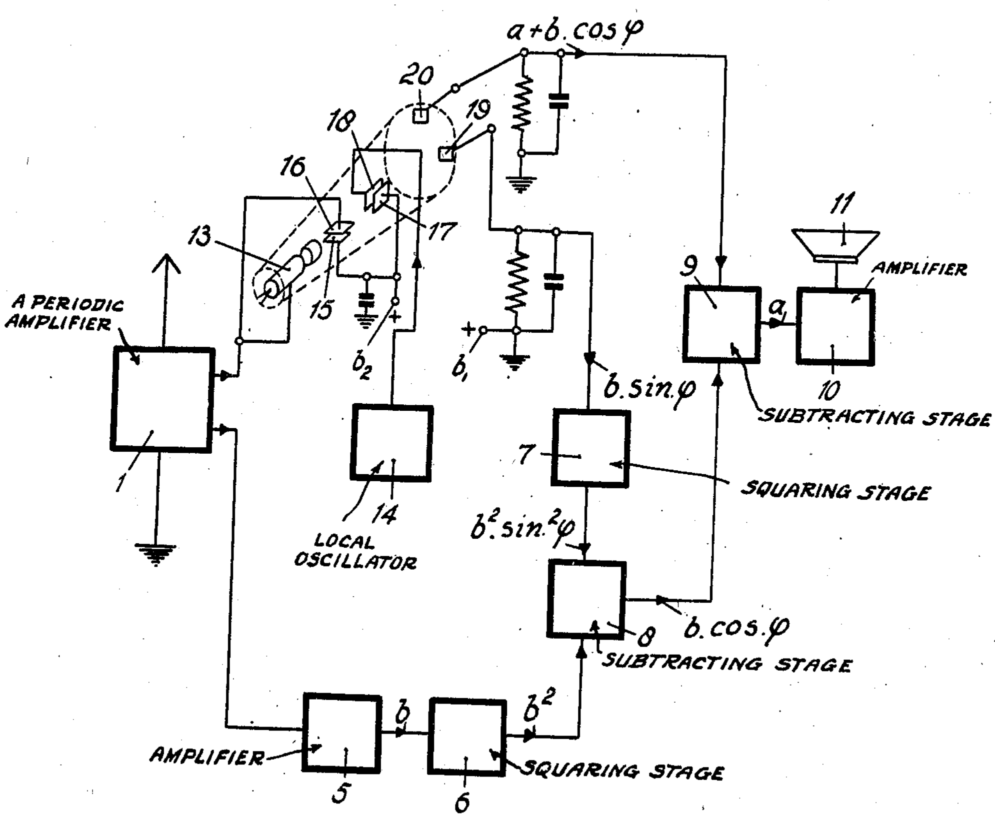
Inventor:
Zoltán Bay
by Walter S. Bleston
ATTORNEY

Jan. 6, 1942. Z. BAY 2,268,998

REDUCING DISTURBANCES IN RADIO RECEPTION

Filed Nov. 2, 1939 2 Sheets-Sheet 2

FIG. 2



Inventor:
Zoltán Bay
by Walter S. Bleston
ATTORNEY

Patented Jan. 6, 1942

2,268,998

UNITED STATES PATENT OFFICE

2,268,998

REDUCING DISTURBANCES IN RADIO RECEPTION

Zoltan Bay, Ujpest, near Budapest, Hungary, assignor to Magyar Wolframlámpa Gyár Kremenezky János Részvénytársaság, Budapest, Hungary, a Hungarian company

Application November 2, 1939, Serial No. 302,566
In Hungary October 18, 1938

10 Claims. (Cl. 250—20)

In a known system for the elimination of disturbances in radio reception by compensation, two receivers are used one of which is tuned to the desired wave band and receives the desired station together with the disturbances, whereas the other receiver is tuned to an auxiliary wave band not occupied by any transmitter and receives the disturbances only. After rectification the disturbances received on the auxiliary wave band are subtracted from the combined signal and disturbances received on the desired wave band. It has been found that a complete elimination of the disturbance is not obtainable in a system of this kind owing to the fact that the interaction between the signal and the disturbances leads to the production of an interference preventing the required complete compensation from being attained.

In the method for the elimination of disturbances according to the invention the compensation of the disturbances is also carried out in a low frequency stage, but in such a manner that the interfering component impairing the reception is not produced, so that a complete compensation is obtained.

According to the invention this result is attained in that by means of the disturbances received in the auxiliary wave band and by means of the combined signal and disturbances received in the desired wave band a current component is produced which is equal to the component disturbing the reception and which is used for compensating the latter.

The signal, the disturbances and the combined signal and disturbances may be expressed by the following formula in which S is the signal, a the signal amplitude, B the disturbance and b the disturbance amplitude:

$$S=a \sin \omega t \qquad \text{I}$$

$$B=b \sin (\omega t+\phi) \qquad \text{II}$$

$$S+B=a \sin \omega t+b \sin (\omega t+\phi) \qquad \text{III}$$

The latter oscillation is that received in the main waveband.

If the oscillation represented by Formula III is submitted to a detection, for instance on the homodyne principle, in such a manner that this oscillation is multiplicatively mixed with a local oscillation of the same frequency and phase a new combined oscillation is produced which after suppression of those components incorporating the double frequency may be expressed as:

$$a+b \cos \phi \qquad \text{IV}$$

From this quantity that will be termed the intermediate quantity, the undisturbed signal modulation a may be derived only by producing, in some suitable manner, a compensating quantity $b \cos \phi$ and by subtracting this compensating quantity from the intermediate quantity

$$a+b \cos \phi$$

The production of the compensating quantity $b \cos \phi$ is, however, not possible directly.

In order to produce this quantity it is necessary to derive from the oscillations received in the auxiliary wave band a quantity

$$b \sin \phi \qquad \text{V}$$

and this quantity $b \sin \phi$ is to be transformed into the quantity $b \cos \phi$, which may be done as follows. The quantity $b \sin \phi$ and the disturbance amplitude b received in the auxiliary wave band are both raised to a square and after this the square of the former quantity is subtracted from the square of the latter so that a new quantity:

$$b^2-b^2 \sin^2 \phi=b^2(1-\sin^2 \phi)=b^2 \cos^2 \phi \qquad \text{VI}$$

is obtained from which the desired compensating quantity $b \cos \phi$ may be produced by extraction of roots. If the square root thus obtained is subtracted from the quantity IV the undisturbed signal a will be obtained.

According to the invention all the operations mentioned above are produced by electrical means, as shown by the following examples.

In one method for the production of the quantities IV and V the high frequency signal oscillations, by being mixed on the homodyne principle with a locally produced identical unmodulated oscillation, are rectified in two distinct stages in such a manner that the signal oscillations and the local oscillation are multiplicatively combined with the same phase in one homodyne stage and are multiplicatively combined with a relative phase difference of 90° in the other homodyne stage, thus producing a quantity $a+b \cos \phi$ in one stage and a quantity $b \sin \phi$ in the other stage, both of these being proportional to the intermediate quantity IV.

Another example for the production of the quantities IV and V is that a cathode ray tube having two pairs of deflecting plates is employed in such a manner that one of these pairs is supplied with the desired high frequency signal oscillations, and the other pair is supplied with the unmodulated local oscillation of the same frequency and phase, while the intensity of the cathode ray is controlled in the rhythm of the signal oscillations and the cathode ray current is collected by two collecting electrodes having a relative displacement of 90°. In this case the quantity $b \sin \phi$ will appear at one of the collecting points and the quantity $a+b \cos \phi$ will appear to the other collecting point. These quantities are proportional to the intermediate quantity IV. It is to be observed that this method, as far as its working principle is concerned, is the same as the first method. For, in the cathode ray tube the homodyne rectification described above is likewise produced.

The squaring to be executed according to the invention may be realised by means of a diode provided with a suitable external resistance; the relation between the voltage produced by the diode current in the external resistance, and the input voltage is substantially a quadratic relation. So, if the voltage the square of which is to be produced is supplied by way of input to the diode, an output voltage may be derived from the external resistance which is substantially proportional to the square of the input voltage.

The extraction of roots according to the invention is realised for instance by means of the upper bend of the characteristic of a suitable electron discharge tube; in this bend the relation between the grid voltage and the anode current is known to be substantially quadratic. Likewise the lower bend of the characteristic of a tube of this type may be employed for the squaring according to the invention.

Further the squaring and the extraction of roots may be realised by means of a conventional cathode ray tube in which the cathode ray is brought in the shape of a line by means of electron lenses. This line shaped cathode ray is moved by means of deflecting electrodes over a collecting electrode which is so cut away that the relation between the voltage supplied to the deflecting electrodes and the current delivered by the collecting electrode is of substantial quadratic nature.

In the drawings some circuit arrangements are shown by way of example for realising the method for the elimination of disturbances according to the invention. Fig. 1 is a diagram of a circuit in which two homodyne stages are used; Fig. 1*a* is a diagram of an embodiment of one of the squaring stages in the circuit of Fig. 1; and Fig. 2 is a diagram of a circuit in which a cathode ray tube is employed.

The modification shown in Fig. 1 comprises an aperiodic amplifier **1** delivering the received oscillations represented by the Formula III. The aperiodic amplifier has connected thereto two homodyne stages **2** and **3**. The purpose of these stages may be explained as follows: A local oscillator **4** produces oscillations having the same frequency as the received oscillations represented by the Formula III. These local oscillations are supplied to the homodyne stages **2** and **3** and in these homodyne stages they are multiplicatively mixed with the received oscillations supplied from the aperiodic amplifier **1**. In the homodyne stage **2** the local oscillations and the received oscillations have the same phase, and in the homodyne stage **3** there is a relative phase displacement of 90° between the local oscillations and the received oscillations. Consequently, in stage **2** a quantity is produced which is proportional to $a+b \cos \phi$, and in stage **3** a quantity is produced which is proportional to $b \sin \phi$. The quantity $a+b \cos \phi$ is supplied to a stage **9** the purpose of which will be discussed later on.

The quantity $b \sin \phi$ is supplied to the squaring stage **7** where it is electrically squared so that a quantity $b^2 \sin^2 \phi$ is obtained. The quantity $b^2 \sin^2 \phi$ is supplied to a stage **8** the purpose of which will be discussed later on.

To the aperiodic amplifier **1** there is further connected a disturbance and amplifier **5**. From the received oscillations delivered by the aperiodic amplifier **1** and represented by the Formula III the disturbance receiver and amplifier selects the disturbance represented by the Formula II. This disturbance is supplied to the stage **6** where it is electrically squared with the result that a quantity proportional to b^2 is supplied by the stage **6** to the following stage **8**. In stage **8** the difference between the quantity b^2 supplied by the stage **6** and the quantity $b^2 \sin^2 \phi$ supplied by the stage **7** is produced and the square root of this difference is formed so that the quantity $b \cos \phi$ is obtained. In stage **9** this quantity is subtracted from the quantity $a+b \cos \phi$ supplied by the stage **2** and finally the quantity a thus obtained, that is the undisturbed modulation, is amplified by the final amplifier **10** and supplied to a loud speaker or other suitable reproducing device **11**. Between the local oscillator **4** and the aperiodic amplifier **1** a receiving apparatus **4*a*** is connected for synchronising purposes, said apparatus being adapted to supply the required synchronising voltage to the local oscillator **4**, particularly at low signal amplitudes. The squaring stages **6** and **7** may be of the type shown in Fig. 1*a*, wherein **22** are the input terminals of one of the squaring stages, **23** a diode, **24** an external resistance for the diode, and **25** the output terminals of the stage.

The method and arrangement according to the invention may be advantageously combined with means limiting or suppressing the amplitude on the occurrence of disturbances; for when disturbances occur the increased amplitude causes the effect of the compensation to be substantially reduced owing to the distortion produced. For this purpose amplitude limiters may be provided in the circuit of Fig. 1 at the input of the individual stages.

The modification shown in Fig. 2 is different from that of Fig. 1 in that the quantity $a+b \cos \phi$ as well as the quantity $b \sin \phi$ are produced by means of a cathode ray tube having two pairs of deflecting plates. The pair **15**, **16** is supplied with the received signal voltage represented by the Formula III, and the pair **17**, **18** is supplied with an unmodulated oscillation produced by the local oscillator **14** and having a frequency equal to that of the received high frequency oscillation, but being 90° out of phase therewith. Under these conditions the combined influence of the pair of deflecting plates **15**, **16** and the pair of deflecting plates **17**, **18** will cause the cathode ray to describe a circle on the screen of the tube. If under these conditions a collecting electrode **19** is provided at a point of the circle described by the cathode ray the current flowing to this collecting electrode will be proportional to $\sin \omega t$ in view of the fact that the cathode ray revolves and the collecting electrode remains stationary. The current to another collecting electrode **20** also provided on the circle described by the cathode ray but being displaced 90°

$$\left(\text{or } \frac{\pi}{2}\right)$$

with respect to the collecting electrode **19** will be 90° out of phase with the current to the electrode **19**, that is, will be proportional to $\sin (\omega t+90)$. If now the cathode ray is not maintained constant but is modulated by means of the Wehnelt cylinder **13** in the rhythm of the received high frequency oscillations represented by the Formula III, as indicated in Fig. 2, the currents flowing to the collecting electrodes **19** and **20** will not be proportional to sin $_\omega t$ and sin $(_\omega t+90)$, as stated above, but will be proportional to the products of these quantities with the quantity III, that is to b sin ϕ and $a+b$ cos ϕ. Thus, by means of the cathode ray tube of Fig. 2 with collecting electrodes **19** and **20** the same result will be obtained as by means of the homodyne stages **2** and **3** of Fig. 1. The other parts of the circuit of Fig. 2 are the same as those of Fig. 1, which is indicated by corresponding reference characters b_1 and b_2 are sources of current.

I claim:

1. In a method of reducing disturbances in the low frequency stage of a radio receiver, the steps which comprise receiving, in a desired wave band, oscillations which include transmitted signals and disturbances, simultaneously receiving said disturbances in an auxiliary band not occupied by a transmitter operating at the time, producing of the disturbances received in both said bands a quantity b cos ϕ which is equal to a quantity representing the disturbances and wherein b is the amplitude of the disturbances and ϕ is the phase angle between the signal to be received and the disturbance of the same frequency, and using said quantity for compensating the disturbances.

2. A method according to claim 1 wherein the effect of disturbances of great amplitude is reduced by reducing the amplitude for the time of the disturbance.

3. In a method of reducing disturbances in the low frequency stage of a radio receiver, the steps which comprise receiving in a desired wave band, oscillations which include transmitted signals and disturbances, simultaneously receiving said disturbances in an auxiliary band not occupied by a transmitter operating at the time, producing of the oscillations received in the desired wave band a quantity b sin ϕ wherein b is the amplitude of the disturbances and ϕ is the phase angle between the signal to be received and the disturbance of the same frequency; squaring said quantity so as to form the squared quantity b^2 sin^2 ϕ, squaring the amplitude of the disturbances received in the auxiliary band so as to form the quantity b^2, subtracting said quantity b^2 sin^2 ϕ from the quantity b^2, forming the square root of the quantity resulting from said subtraction so as to obtain a compensating quantity b cos ϕ, producing of the oscillations received in the desired wave band the quantity $a+b$ cos ϕ wherein a is the signal amplitude, and subtracting said compensating quantity from said quantity $a+b$ cos ϕ.

4. In a method of reducing disturbances in the low frequency stage of a radio receiver, the steps which comprise mixing high frequency signal oscillations, on the homodyne principle, with a local oscillation of equal frequency and in equal phase so as to produce a quantity $a+b$ cos ϕ wherein a is the signal amplitude, b the disturbance amplitude and ϕ the phase angle between the signal to be received and the disturbance of the same frequency, simultaneously mixing the high frequency signal oscillations, on the homodyne principle, with a local oscillation of equal frequency and of a phase difference of 90° so as to produce a quantity b sin ϕ, using the last-mentioned quantity in producing a third quantity b cos ϕ, and subtracting said third quantity from the first-mentioned quantity.

5. In a method of reducing disturbances in the low frequency stage of a radio receiver with the aid of a cathode ray tube having two pairs of deflecting plates and two collecting electrodes with a spatial displacement of 90°, the steps which consist in the supplying of high frequency signal oscillations to the one pair of deflecting plates, simultaneously supplying a local unmodulated oscillation of the same frequency and phase to the other pair of deflecting plates, while modulating the intensity of the cathode ray in the rhythm of the signal oscillations, and collecting the currents from each of the collecting electrodes, thereby to produce two quantities $a+b$ cos ϕ and b sin ϕ respectively wherein a is the signal amplitude, b the disturbance amplitude and ϕ the phase angle between the signal to be received and the disturbance of the same frequency, preparatory to forming a third quantity b cos ϕ and subtracting the last-mentioned quantity from the quantity $a+b$ cos ϕ.

6. In a system for reducing disturbances in the low frequency stage of a radio receiver the combination of means for receiving oscillations which include transmitted signals and disturbances, a local oscillator operative with the frequency and in phase with the signal oscillations, means for combining said signal and disturbance oscillations with the in-phase oscillations of said oscillator to produce a quantity $a+b$ cos ϕ wherein a is the signal amplitude, b the disturbance amplitude and ϕ the phase angle between the signal to be received and the disturbance of the same frequency, means for combining, 90° out of phase, the signal and disturbance oscillations with the oscillations of said oscillator to produce a quantity b sin ϕ, means for transforming the quantity b sin ϕ into the quantity b cos ϕ, and means for subtracting the last-mentioned quantity from the quantity $a+b$ cos ϕ.

7. In a system according to claim 6 the combination of a diode and an external resistance as a square law translating device for quantities such as said quantity b sin ϕ.

8. A system according to claim 6 comprising an electron discharge tube having a lower curved part of its characteristic adapted to serve as a means for squaring quantities such as b sin ϕ.

9. A system according to claim 6 comprising an electron discharge tube having an upper curved part of its characteristic adapted to serve as a means for extracting the root of quantities such as b^2 cos^2 ϕ.

10. A system according to claim 6 comprising a cathode ray tube adapted to produce the square of a quantity such as b sin ϕ and the square root of a quantity such as b^2 cos^2 ϕ.

ZOLTAN BAY.