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RADIO RECEIVING SYSTEM

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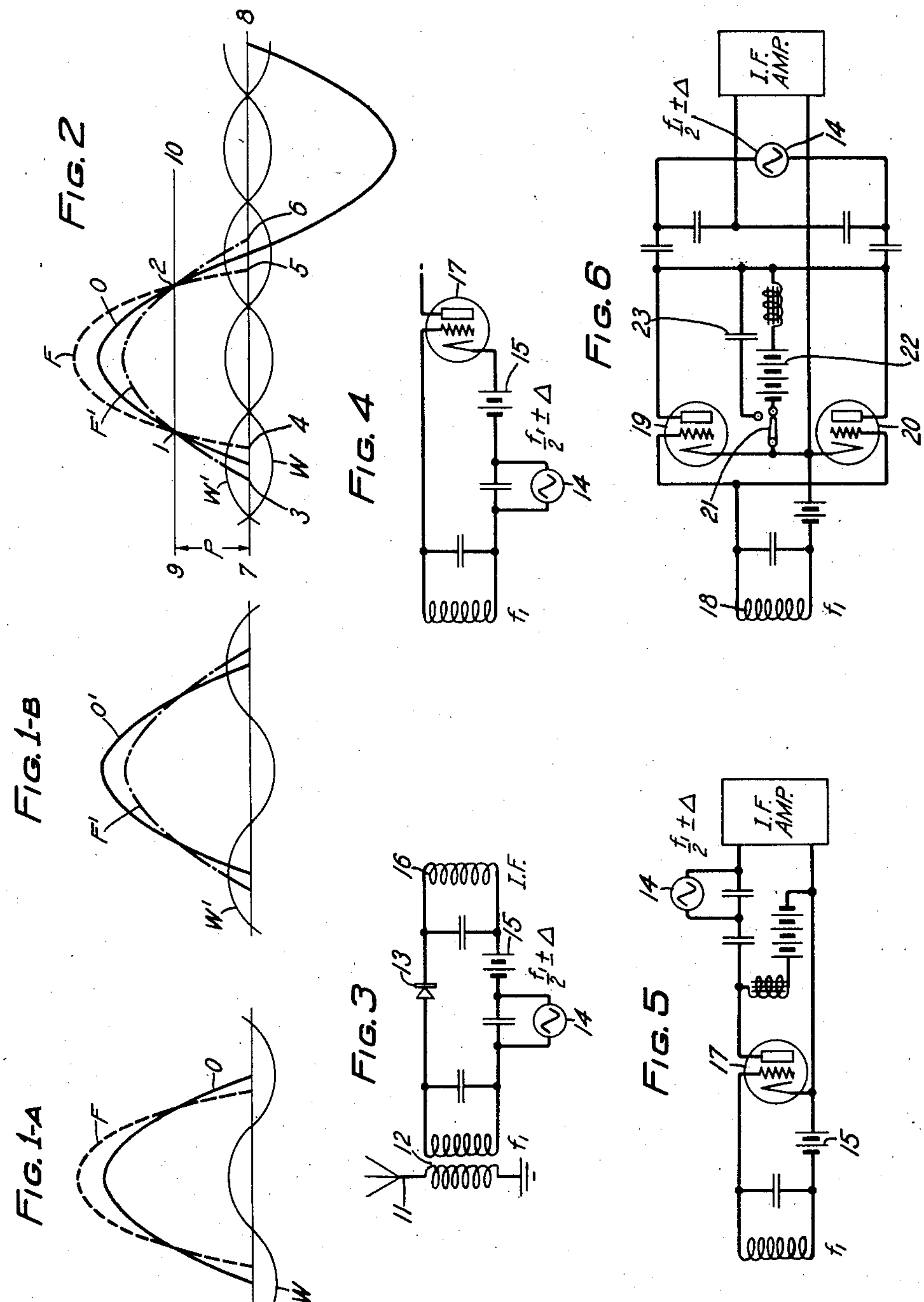

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RADIO RECEIVING SYSTEM

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This invention relates to radio receiving systems and more particularly to a method and means whereby a locally generated wave is combined with an incoming wave to change its frequency.

In short wave radio reception considerable difficulty has been experienced due to the extraneous capacitative and inductive effects of the leads, etc. To counteract such disadvantages extreme care is necessary in constructing a short wave receiving set, that is, the various leads must be made as short as possible, the different parts of the set must be carefully shielded from each other, etc.

Still other difficulties are experienced when short waves are to be received by the heterodyne method. Probably the most serious of these difficulties is that due to the coupling between the antenna circuit and the local oscillator circuit, which should be tuned to frequencies that are relatively close to each other, a change in the tuning of either circuit is likely to change the tuning of the other circuit. Correct tuning which is very important is therefore very difficult.

Another difficulty is that the locally supplied oscillations, which differ in frequency by but a slight amount from the frequency of the waves which it is desired to receive, are fed into the antenna system and are radiated.

To overcome the difficulties noted it has been proposed to use combining oscillations having a frequency which differs by a slight amount from one-half the frequency of the oscillations produced by the incoming waves. However, the amplitude of the intermediate frequency current produced by the combining action is much smaller than that resulting when the two oscillations are of substantially the same frequency. This is due to the fact that the locally supplied oscillations are effective in producing an intermediate frequency wave during less than one-half of each cycle of the local oscillations.

To offset the decrease in amplitude of the intermediate current, increased amplification of the radio frequency or intermediate frequency current has been resorted to, but with unsatisfactory results.

The present invention has as its main object the provision of means for combining incoming waves with locally generated oscillations of approximately one-half the incoming wave frequency in such manner that the resultant intermediate frequency wave will have a current amplitude comparable to that obtained when the incoming wave is combined with oscillations of substantially the same frequency.

The above object is accomplished by using a combining means and impressing thereon a negative potential of such value that current flows through the device during definite intervals corresponding to the peaks of the locally supplied oscillations. Such a negative potential causes the suppression of that portion of the resultant rectified current wave which is present when the locally applied oscillations and the incoming wave are 180° out of phase with each other, but which is not present when these waves are in phase, whereby the amplitude of the intermediate frequency wave is increased.

An incidental advantage resulting from the use of local oscillations of approximately one-half the frequency of the incoming wave is that it becomes unnecessary to balance the first detector.

Other objects and features will be evident and the invention better understood from the following description together with the attached drawings in which:

Figs. 1—A and 1—B illustrate graphically the relation existing between an incoming wave and the locally generated wave when the phase of the incoming wave has been changed through 180°;

Fig. 2 illustrates graphically the conditions of Figs. 1—A and 1—B superposed to facilitate comparison;

Fig. 3 illustrates schematically the application of the invention to a radio receiving system, while Figs. 4, 5 and 6 are schematics of modifications of the circuit of Fig. 3.

Referring particularly to Fig. 1—A the curve W represents the incoming wave, curve O represents the wave generated by a local source which has a frequency differing but slightly from one-half the frequency of the incoming wave.

As illustrated, waves O and W are in phase, and when they are combined one component of the resultant is represented by curve F. When waves O and W are in phase the desired intermediate frequency component F has an amplitude greater than that of the locally generated wave.

In Fig. 1—B curves W′, O′ and F′ represent the incoming wave, the locally generated wave and the desired intermediate frequency component, respectively. Wave W′ is 180° out of phase with the wave supplied by the local source and as a result the wave F′ has an amplitude smaller than that of the locally generated wave.

As is well known the average value of a variable quantity during a given interval of time may be determined from the graph of the quantity by dividing the area under the graph for that interval by the corresponding value representing the duration of the interval.

It is also well known that when two waves are combined the amplitude of the resultant wave is determined by the variation of the average values. More specifically, the intermediate frequency wave in a heterodyne receiver is the envelope of the average values of the combined waves as they vary from a maximum to a minimum in accordance with the change in phase relation. The amplitude of the intermediate frequency wave depends upon the variation between the average maximum value and the average minimum value, from which it follows that if the average minimum value can be decreased without decreasing the average maximum value to the same extent, the amplitude of the intermediate frequency wave will be increased.

The manner in which the average minimum value of a combined wave may be decreased without a corresponding decrease in the average maximum value, in accordance with the present invention, is shown in Fig. 2. W and W′ represent the incoming wave at phases 180° apart (Figs. 1—A and B superposed), O represents the locally generated wave and F and F′ represent the intermediate frequency components corresponding to W and W′, respectively.

Reading the foregoing statements in terms of Fig. 2, the amplitude of the intermediate frequency component depends upon the difference in area under the graphs F and F′. Of these areas, that portion designated by points 1, 2, 5, 4 is common to both F and F′, but the portions 1, 4, 3 and 2, 5, 6 are in the area under graph F′ and not under F. Since F′ represents the minimum, if the areas 1, 4, 3 and 2, 5, 6 can be eliminated, the minimum will be decreased without affecting the maximum.

Line 7, 8 represents the zero or reference line and waves W, W′ and O are illustrated as varying to either side of this line an equal amount. If now the reference line can be moved without changing the absolute positions of the graphs (or waves) certain of the areas noted can be eliminated. For instance, if line 9, 10 be drawn through points 1, 2 and the curves and areas under line 9, 10 made ineffective, the minimum area will have been reduced to a greater extent than the maximum area, or the intermediate frequency amplitude will have been increased.

In Fig. 3 a method of transferring the reference line 7, 8 to position 9, 10 is indicated. In this figure an antenna 11 is tuned to receive a wave of frequency f_1. The receiving circuit, containing rectifier or detector 13 and source of oscillations 14, is coupled to the antenna circuit by transformer 12. Source 14 is adapted to generate oscillations differing a small amount from one-half the frequency of the incoming wave, that is, a frequency

$$f_2=\frac{f_1}{2}\pm\Delta$$

A constant voltage source 15 is inserted in the receiving circuit as shown to impress on rectifying device 13 a negative potential of a value corresponding to P, Fig. 2. The rectifying device 13, Fig. 3, permits only those portions of the impressed waves to pass which are shown above line 9, 10 in Fig. 2. In this way, the undesired areas of Fig. 2 are eliminated and the amplitude of the intermediate frequency component which is impressed upon primary winding 16 is increased. This intermediate frequency wave may be amplified, etc. as is common practice in heterodyne receivers.

Fig. 4 illustrates a receiving circuit in which the rectifying or detecting device is represented as a space discharge device 17. In this case the negative potential is impressed upon the grid of device 17 to accomplish the desired result.

In Fig. 5 the negative potential source 15 is arranged to impress its potential on the grid of device 17, while the locally generated wave is impressed upon the plate of device 17. This arrangement, as will be readily understood by those skilled in the art, gives the same result as with the arrangements of Figs. 3 and 4.

The amplitude of the intermediate frequency component obtained by using the arrangements of Figs. 3, 4 and 5 is still not as large as that which would be obtained if the locally generated wave were of a frequency more nearly equal to that of the incoming wave. However, the amplitude may be increased by increasing the plate voltage applied to device 17 in Figs. 4 and 5 and at the same time adjusting the negative voltage applied to the grid by source 15.

A further method of increasing the amplitude is shown schematically in Fig. 6.

Here the incoming wave of frequency f_1 is impressed upon coil 18 included in the input circuits of two space discharge detectors 19 and 20. The input wave is impressed upon the grids of detectors 19 and 20 in parallel.

The output circuits of detectors 19 and 20 are arranged in such a manner that alternate half waves of the oscillations, having a frequency of

$$\frac{f_1}{2} \pm \triangle$$

supplied by source 14, are applied to the detectors 19 and 20. In this arrangement both half cycles of the locally generated wave are utilized instead of but one-half of this wave as is the case with the arrangements of Figs. 3, 4 and 5. Since more of the incoming energy is utilized, the amplitude of the intermediate frequency component is increased and the system becomes more efficient.

In connection with the arrangements of Figs. 5 and 6, if the amplitude of the locally generated wave is sufficiently large, the direct current voltage source for the plates of the space discharge devices will not be necessary. This is illustrated in Fig. 6, by the switch 21 which is adapted to complete the external plate-filament circuit through condenser 23 if desired or through source 22.

It is to be understood that whereas certain embodiments of the invention have been illustrated and described, the invention is not to be so limited but only as defined in the appended claims.

What is claimed is:

1. In a radio receiving system, a receiver for incoming waves, a source of oscillations having a frequency which differs by a small amount from one-half the frequency of the incoming waves, a space discharge device having a control electrode or grid in which said incoming waves and said oscillations are combined, and means for applying to the grid of said space discharge device a negative potential of such value that transmission of the combined wave therethrough is permitted only during portions of alternate half waves of said oscillations.

2. In a radio receiving system, a receiver for incoming waves, a source of oscillations having a frequency which differs by a small amount from one-half the frequency of the incoming waves, a pair of space discharge devices each including a control electrode or grid in which said incoming waves and said oscillations are combined, means whereby said incoming waves are impressed upon the grids of said devices in parallel, means whereby half waves of said oscillations are alternately impressed upon said devices, and means for impressing on the grids of said devices a negative potential of such value that transmission of the combined wave through said devices is permitted only during portions of the half waves of said oscillations.

3. In a heterodyne radio receiving system, the method comprising combining the incoming wave with local oscillations having a frequency differing from one-half that of the incoming wave by a small amount, and suppressing proportionally more of the resultant combined wave when the said two waves are 180° out of phase than when said two waves are in phase.

4. The method of heterodyne reception which comprises combining a received signal wave with a heterodyne wave having a frequency differing by a small amount from one-half the signal wave frequency and producing a current corresponding to the alternate crests of the combined wave.

5. The method of heterodyne reception which comprises combining a received signal wave with a heterodyne wave having a frequency differing by a small amount from one-half the signal wave frequency and producing current pulses corresponding to the alternate crests of the combined wave of duration substantially equal to one-half the signal wave period.

6. The method of heterodyne reception which comprises combining a received signal wave with a relatively stronger heterodyne wave having a frequency differing by a small amount from a subharmonic of the signal wave frequency and producing current pulses corresponding to the alternate crests of the combined wave of duration substantially equal to one-half the signal wave period.

7. The method of heterodyne reception which comprises combining a received signal wave with a relatively stronger heterodyne wave having a frequency differing by a small amount from a subharmonic of the signal wave frequency, producing periodic current pulses corresponding to the crests of the combined wave of duration substantially equal to one-half the signal wave period and selecting from the impulsive current a component of a desired beat frequency.

8. The method of heterodyne reception which comprises combining a received signal wave with a heterodyne wave having a frequency differing by a small amount from one-half the signal wave frequency and suppressing the effect of the combined wave during a substantial portion of each half cycle of the heterodyne wave.

9. The method of heterodyne reception which comprises combining a received signal wave with a heterodyne wave having a frequency differing by a small amount from a subharmonic of the signal wave frequency and suppressing the effect of the combined wave during a substantial portion of each half cycle of the heterodyne wave.

10. A heterodyne receiving system comprising a receiver for incoming signal waves,

a source of heterodyne oscillations having a frequency which differs by a small amount from one-half the signal wave frequency, means for combining the incoming signal waves with the heterodyne oscillations and means for suppressing the effect of the combined waves during a substantial portion of each half cycle of the heterodyne wave.

11. A heterodyne receiving system comprising a receiver for incoming signal waves, a source of heterodyne oscillations having a frequency which differs by a small amount from one-half the signal wave frequency, means for combining the incoming signal waves with the heterodyne oscillations and means for producing periodic current pulses corresponding to the crests of the combined wave of duration substantially equal to one-half the signal wave period.

12. A heterodyne receiving system comprising a receiver for incoming signal waves, a source of heterodyne oscillations adjusted to a frequency differing by a small amount from half the signal wave frequency, means for combining the incoming signal waves with the heterodyne oscillations, means for producing periodic current pulses corresponding to the crests of the combined wave of duration substantially equal to one-half the signal wave period, and means for selecting a wave of a desired beat frequency from the said impulsive current.

In witness whereof, I hereunto subscribe my name this 31st day of January, 1929.

RAYMOND A. HEISING.