Sept. 2, 1941. W. F. CURTIS 2,254,211

RECEIVER

Filed Aug. 13, 1937 2 Sheets-Sheet 1

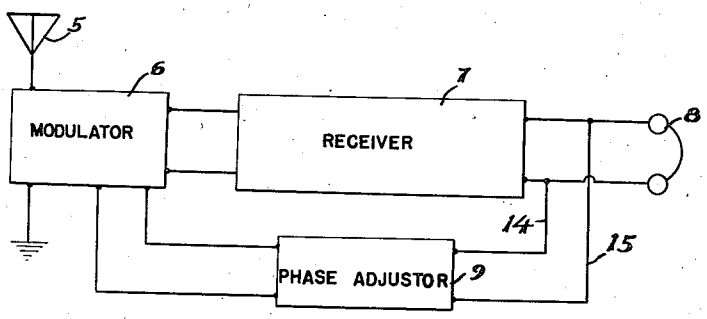

Fig. 1

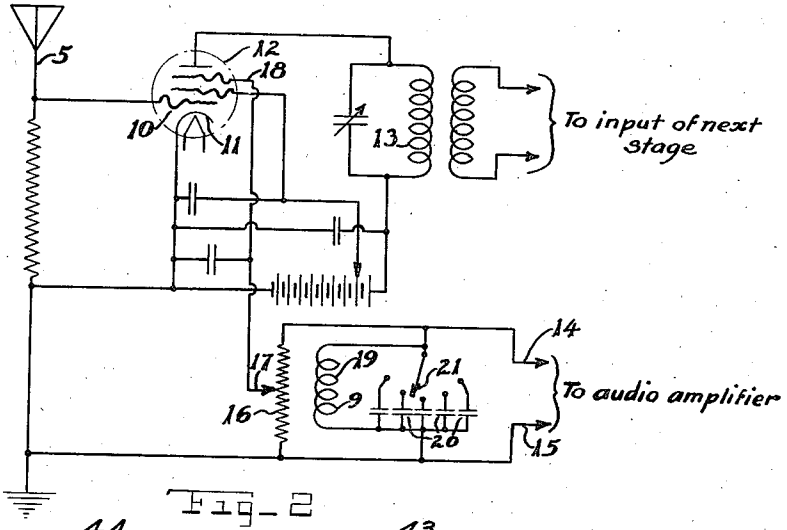

Fig. 2

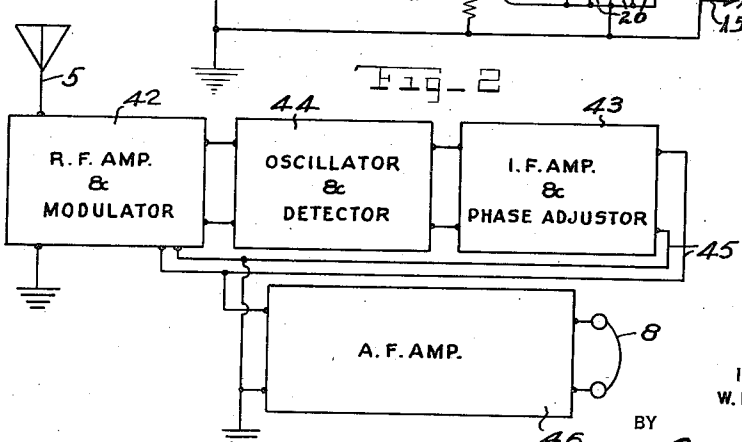

Fig. 4

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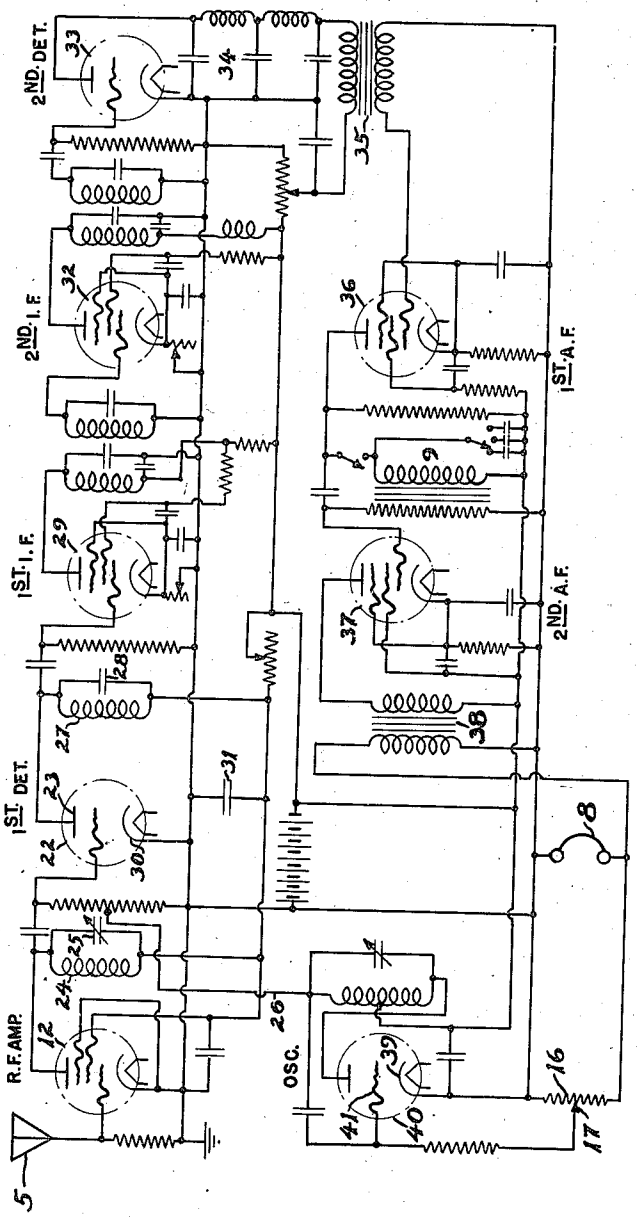

FIG. 3

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UNITED STATES PATENT OFFICE

2,254,211

RECEIVER

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Application August 13, 1937, Serial No. 158,943

17 Claims. (Cl. 250—8)

(Granted under the act of March 3, 1883, as amended April 30, 1928; 370 O. G. 757)

This invention relates to a receiver for continuous wave radio signals, and more particularly to one that is capable of receiving super-frequencies by the audible beat method, and which does not require impracticably great frequency stability.

Among the several objects of this invention are:

To provide a continuous wave receiver with a selectivity equal to that of some tuned amplifier therein, which may be either a carrier frequency amplifier or a transfer frequency amplifier;

To provide a receiver that will not respond to signals below a certain threshold amplitude and that is readily adjustable;

To provide a receiver wherein any signal of greater than threshold amplitude will produce maximum, or nearly maximum, output, that is, which has inherent automatic volume control;

To provide a receiver wherein response to signals of short duration (say less than 5 milliseconds) is much reduced, thereby lowering the noise level;

To provide a receiver capable of receiving modulated signals in the conventional manner, or raising the apparent percentage modulation of a modulated signal if originally less than 100 per cent.

In the drawings:

Fig. 1 is a conventional representation of the application of my invention to a receiver;

Fig. 2 is a detailed view of certain parts utilized in the invention as illustrated generally in Fig. 1;

Fig. 3 is a detailed diagrammatic showing of a receiver utilizing my invention wherein the modulation is applied to a beating oscillator;

Fig. 4 shows schematically another method of applying my invention.

In the present state of the radio art, audible beat reception of super-frequencies is seldom if ever used. The Naval Research Laboratory has accomplished beat reception at about 60 megacycles by using a crystal-controlled receiver, but as this limits the receiver to one frequency, the method is not generally applicable. The reason for this is obviously the extremely high frequency stability required. The difference between the transmitter and local oscillator frequencies should not be allowed to vary by more than a kilocycle. If we assume that the transmitter frequency can be held to one part in five million, this means that at 100 megacycles the local oscillator must also be held to a part in five million. It does not seem at all likely that the problem of designing an oscillator which can be adjusted quickly to within one kilocycle to any frequency in the range 30,000 to 100,000 or more kilocycles, and which will hold its frequency to one part in five million will be solved in the immediate future, particularly for use in a receiver which is subject to vibration and changes in supply voltages, as in a ship or airplane installation.

Nevertheless there are certain very desirable features about the use of C. W. signals, and if a system could be devised that would permit of their use without requiring such great stability, it should be of great communication value for many years. In this connection it should be noted that high selectivity is not likely to be an advantage in a super-frequency receiver for sometime to come, while it does have the disadvantage of requiring great frequency stability. Present tubes and circuits permit oscillations of the "feed-back" type up to at least 600 megacycles, and amplification up to nearly this frequency. If, then, transmitters were spaced .05 per cent apart in frequency, there could be 2000 channels between 40 and 100 mc., 4000 channels between 40 and 200 mc., and 8720 channels between 40 and 400 mc. In view of the fact that all but ship and aircraft channels could be duplicated every few hundred miles without interference, this scheme should not involve any undue overcrowding of the band for sometime to come. Yet, if the selectivity of the receivers used is not too great, this would require the frequency to be held to only two parts in ten thousand, which can be easily done. It therefore follows that there is a great field of usefulness for a receiver which will respond to C. W. signals, yet in which the selectivity can be set at any desired value.

The device by which these results are accomplished is very simple in construction. In a receiver effecting amplification on at least two frequencies, a voltage derived from an amplifier not at carrier frequency is impressed upon the carrier frequency signal as a modulation. Alternatively, it may be impressed upon a local oscillator as a modulation, in case transfer frequency amplification is employed. The modulation may be either frequency or amplitude modulation, and the modulating potential can be derived either from an audio frequency or a transfer frequency amplifier.

The principle of the present invention may be explained in connection with Fig. 1 of the draw-

ings, wherein the signal picked up by antenna 5 is fed into a suitable amplifying stage or to a detector, indicated generally by the numeral 6 and is subsequently amplified in the device represented by numeral 7 whereof the output goes to phones 8 or other suitable audio responsive means. A portion of the energy from the output of 7 is fed back to a phase adjustor 9, as will be hereinafter explained in detail, and the phase-adjusted signal impressed upon some part of the device 6. This fed back energy is modulated upon the signal at a higher frequency, either carrier or intermediate, but it is of course necessary that it be introduced in the proper phase. If the audio amplifier introduces no phase shifts of magnitudes other than 180° this becomes simply a question of proper polarity. Since most amplifiers do not fulfill this condition, it will usually be necessary to introduce a phase adjusting device, such as is shown in Fig. 2.

Referring now to Fig. 2, the antenna 5 is suitably connected to the grid 10 and cathode 11 of the carrier frequency amplifying tube 12 having a tunable output circuit 13 feeding into the next stage of the set. Audio frequency energy is carried by leads 14 and 15 that are connected to suitable points of the audio frequency amplifier, as, for example to the plate and the cathode of the last audio stage, respectively, and to the opposite terminals of a resistor 16 variably connected by movable contact 17 to grid 18 of tube 12. The phase adjustor is connected in parallel across leads 14 and 15 and comprises an inductance 19 in parallel with a plurality of capacitances 20 of different values that are selectively connectible into the circuit by the movable contact 21. As will be obvious to those skilled in this art, a suitable lag or lead of the voltage in conductors 14 and 15 may be effected by connecting in the condenser 20 having the proper value and thereby the potential variations across resistor 16 will be brought into suitable phase to effect the desired modulation of the output of tube 12.

Now suppose a constant potential of appropriate frequency (i. e. a "signal") is picked up by antenna 5. This signal is impressed on control grid 10, amplified by the tube, and passed on to the rest of the receiver. The onset of this signal will generate a transient in the detector immediately preceding the audio amplifier, which will be amplified and impressed upon tuned circuit 19—20, where it will produce a train of oscillations ("shock excitation") which would be rapidly damped out except for the arrangements shown and the presence of the signal. But when the shock-excited oscillation makes grid 18 negative, the flow of electrons to plate 12 is hindered, the mutual conductance of the tube is lessened, and the signal voltage passed on to the rest of the receiver is temporarily decreased. Likewise, when the shock-excited oscillation makes grid 18 positive, the mutual conductance of the tube is increased, and the signal voltage is temporarily increased. This constitutes a modulation of the signal voltage at an audio frequency; the signal thus modulated is amplified, detected, and the audio frequency component amplified and restored to parts 14 and 15, where it reinforces the otherwise diminishing oscillations in phase-adjuster 19—20. It can thus be seen that, if the amplification supplied by the receiver and the amplitude of the signal are sufficient, the oscillations will build up until limited by the onset of saturation in some tube of the chain. If phase-lags are present anywhere in the system, the frequency of oscillation will drift until the phase-displacement caused by working circuit 19—20 slightly off its natural frequency produces phase agreement between the direct and fed-back potentials. In the absence of signal there is of course no feed-back, and any oscillations excited by internal noise, etc., die out rapidly. While this explanation may be in error in some details, it is thought to be correct in principle. The circuit is known to be operative, as it has been reduced to practice and successfully operated.

While, for convenience, the phase adjustor is shown separately, it may be connected at any convenient point in the audio amplifier.

It will readily be seen that if a modulated signal is impressed on the antenna 5, the hook-up shown in Fig. 2 would result in increased output of tube 12 and the device can therefore be regarded as a means for increasing the percentage modulation of the signal. From another point of view, it amounts to a very special type of audio frequency regeneration, in which the feed back is dependent upon the radio frequency signal amplitude as well as upon the gain of all amplifiers in the chain, on the efficiency of any detectors therein, and the efficiency of the modulator. Naturally, if this regeneration exceeds a certain critical value, oscillations at audio frequency will be produced. These have been observed for both modulated and unmodulated signals, irrespective of whether or not the audio amplifier is tuned. An untuned amplifier gives a rough sounding note while a tuned amplifier gives a clear note, the tuning also serving to reduce the noise level.

As no feed back exists when there is no signal, the oscillations are heard only when signal is present. The device can therefore be used for the reception of unmodulated signals when the feed back is greater than the critical for the signal level being received and for modulated signals if the feed back is reduced below this level or the oscillations synchronized with the modulation. It is very stable if the signal input for critical regeneration that is, the continuous wave threshold amplitude, is not set too close to the noise level. The automatic volume control property above mentioned follows from the fact that once critical regeneration is exceeded, the oscillations rapidly go to saturation. The reduced response to very short signals follows from the fact that it takes several cycles of the audio frequency for oscillations to build up, and as many atmospheric and tube noises have a duration of only a few milliseconds they would be discriminated against.

The details of the circuit heretofore built and tried out are shown in Fig. 3. Here the antenna 5 feeds into the carrier frequency amplifying tube 12 which is followed by the first detector tube 22. The plate 23 of tube 22 is connected to the tuned output comprising inductance 27 and condenser 28 in parallel. A voltage from oscillator 40 is also applied to detector 22, the difference in frequency between the input signal and the voltage produced by oscillator 40 giving rise to a signal of intermediate frequency which is amplified by first intermediate frequency tube 29 and passed on to second intermediate frequency amplifier 32. The second intermediate frequency amplifier 32 feeds into second detector 33 in the output of which is a low pass filter network 34 which is coupled by audio transformer 35 to the first audio frequency amplifier tube 36. The output of tube 36 is amplified by second audio frequency tube 37 whereof the output is transmitted to phones

8 by audio transformer 38. The phase adjustor 9 is connected across the output of first audio frequency tube 36. One terminal of resistor 16 is connected to cathode 39 of beating oscillator tube 40 and an intermediate point on resistor 16 is connected to grid 41 of the oscillator 40 and thereby the audio signal energy fed back is modulated upon the output of oscillator 40 which is connected to first detector tube 22 through lead 26 to give rise to the intermediate frequency.

In Fig. 4 the antenna 5 is shown connected to a radio frequency amplifier and frequency modulating section 42 which is coupled to the intermediate frequency amplifying section and phase adjuster 43 through the oscillator and detector 44. The output of section 43 is carried by wires 45 back to section 42 where it is modulated upon the carrier frequency and also to the audio frequency amplifying section 46.

It is to be understood that the circuits shown herein and the description thereof are by way of illustration and explanation only and not of limitation, since the modulating potentials may be derived from either the intermediate frequency or the audio frequency and may be applied to the first detector or in the carrier frequency amplifier instead of to the oscillator.

It is recognized that continuous wave reception with selectivity characteristics similar to those of the present device can be obtained by apparatus well known in the art, the so-called ultradyne circuit, which modulates the carrier by means of a local oscillator. By suitably applying this principle, in combination with the superheterodyne principle, continuous wave signals can be received with any desired selectivity. However, the noise suppression and automatic volume control features of my invention are not provided by that prior art apparatus, and furthermore, an additional oscillator is required.

According to the provisions of the patent statutes I have set forth the principle and mode of operation of my invention and have illustrated and described what I now consider to represent its best embodiment. However, I desire to have it understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically illustrated and described.

The invention herein described and claimed may be used and/or manufactured by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

I claim:

1. A radio receiver, comprising a carrier frequency amplifying section including a tube having an anode, a grid and a cathode, a first detector operatively coupled thereto, said detector having an anode, a grid and a cathode, a tuned intermediate frequency amplifier coupled to said detector, a second detector coupled to the output of said intermediate frequency amplifier, a low pass filter connected in the output of said second detector, an audio frequency amplifying section coupled to said filter, phase adjusting means connected in said audio amplifying section, a beating oscillator connected to said first detector, and means to apply to said oscillator phase-adjusted modulating potentials from the output of said audio amplifying section.

2. A radio receiver, comprising a carrier frequency amplifying section including a tube having an anode, a grid and a cathode, a first detector operatively coupled thereto, said detector having an anode, a grid and a cathode, a tunable oscillatory output connected to the anode of said amplifier tube, a tuned intermediate frequency amplifier coupled to said detector, a second detector coupled to the output of said intermediate frequency amplifier, an audio frequency amplifying section operatively associated with said second detector, phase adjusting means fed with audio frequency signal energy from said audio amplifying section, a beating oscillator connected to said first detector, and means to apply to said oscillator phase-adjusted modulating potentials from said phase adjusting means.

3. A radio receiver, comprising a carrier frequency amplifying section including a tube having an anode, a grid and a cathode, a first detector operatively coupled thereto, said detector having an anode, a grid and a cathode, a tuned intermediate frequency amplifier coupled to said detector, a second detector coupled to the output of said intermediate frequency amplifier, an audio frequency amplifying section operatively associated with said second detector, phase adjusting means connected in said audio amplifying section, and means to effect modulation of the output of said first detector in accordance with phase-adjusted audio-signal potentials derived from the output of said audio amplifying section.

4. A radio receiver, comprising a carrier frequency amplifying section including a tube having an anode, a grid and a cathode, a first detector operatively coupled thereto, said detector having an anode, a grid and a cathode, a tunable oscillatory output circuit connected to the anode of said amplifier tube, a tuned intermediate frequency amplifying section including a tuned circuit in the input thereof connected to the output of said detector, a second detector coupled to the output of said intermediate frequency amplifying section, an audio frequency amplifying section operatively associated with said second detector, phase adjusting means fed with audio frequency signal energy from said audio amplifying section, and means to apply to said first detector phase adjusted potentials derived from said phase adjusting means to modulate the output of said detector.

5. A radio receiver, comprising a carrier frequency amplifying section, an intermediate frequency amplifying section and an audio frequency amplifying section operably associated together, phase adjusting means, means to supply to said phase adjusting means potentials derived from said intermediate frequency section, and means to apply to a stage of said carrier frequency amplifying section phase-adjusted potentials from said phase adjusting means to modulate the output of said radio frequency amplifying section.

6. A radio receiver, comprising a carrier frequency amplifying section, an intermediate frequency amplifying section and an audio frequency amplifying section operably associated together, phase adjusting means, means to supply to said phase adjusting means potentials derived from said audio frequency section, and means to apply to a stage of said carrier frequency amplifying section phase-adjusted potentials from said phase adjusting means to modulate the output of said radio frequency amplifying section.

7. A radio receiver, comprising a carrier frequency amplifying section, an intermediate frequency amplifying section, a detector coupled be-

tween said sections, an oscillator coupled to said detector, an audio frequency amplifying section, means to feed back signal bearing energy from said audio section into said oscillator to modulate the output of said oscillator and means to adjust the phase of the feed-back energy to be in proper phase with said oscillator to increase the percentage of modulation of a signal borne by said fed-back energy.

8. A radio receiver, comprising a carrier frequency amplifying section, a continuously operating intermediate frequency amplifying section, a detector coupled between said sections, an oscillator coupled to said detector, an audio frequency amplifying section, means to feed back energy from said intermediate section into said oscillator to modulate the output of said oscillator and means to adjust the phase of the feed-back energy to be in proper phase with said oscillator to effect in said detector an increase in the percentage of modulation of a signal borne by said fed-back energy.

9. A radio receiver, comprising a carrier frequency amplifying section, a continuously operating intermediate frequency amplifying section, a detector coupled between said sections, an oscillator coupled to said detector, an audio frequency amplifying section, and means to feed back signal bearing energy from one of the lower frequency sections into said oscillator in proper phase to modulate the output of said oscillator.

10. A radio receiver having audio frequency output, comprising means to amplify a received continuous signal wave at more than one frequency including a continuously operating oscillator means to produce a lower frequency from a higher frequency, means to feed back amplified signal energy of audio frequency into said oscillator to modulate the output of said oscillator means, and means to adjust the phase of the feed-back energy.

11. A radio receiver, comprising means to amplify a received modulated signal at more than one frequency including a continuously operating oscillator means to produce a lower frequency from a higher frequency, means to feed back amplified signal energy from a stage at a lower frequency into said oscillator means to increase the percentage of modulation of the output of said oscillator means, and means to adjust the phase of feed-back energy.

12. A radio receiver, comprising means for amplifying a received signal at carrier frequency and at a frequency lower than carrier frequency, and means including a continuously operating local oscillator to feed back amplified signal energy at a lower frequency in proper phase relation to modulate the output of said carrier frequency amplifying means.

13. A radio receiver, comprising means for amplifying received signal energy at carrier frequency, at intermediate frequency and at audio frequency, and means including a continuously operating local oscillator to feed back amplified signal energy from one of the lower frequency amplifying means in proper phase to modulate the output of the carrier frequency amplifying means.

14. The method of receiving unmodulated continuous wave radio signals at super-frequencies, which comprises the steps of amplifying the received signal on at least carrier frequency and audio frequency, feeding back amplified signal energy of audio frequency to produce regeneration greater than the value above which oscillation begins at the signal level being received, and modulating the feed-back energy upon the signal at carrier frequency.

15. The method of receiving unmodulated continuous wave radio signals, which comprises the steps of amplifying the received signal on at least carrier frequency and audio frequency, feeding back amplified signal energy of audio frequency to produce regeneration greater than the value above which oscillation begins at the signal level being received, and modulating the feed-back energy upon the signal at carrier frequency.

16. The method of receiving unmodulated continuous wave radio signals at super-frequencies, which comprises the steps of amplifying the received signal on at least two frequencies, feeding back amplified signal energy of a lower frequency and modulating it upon the signal at a higher frequency to produce regeneration greater than the value above which oscillation begins at the signal level being received.

17. The method of receiving unmodulated continuous wave radio signals at super-frequencies, which comprises the steps of amplifying the received signal on at least carrier frequency and audio frequency, feeding back amplified signal energy of audio frequency, and modulating said fed-back energy upon the carrier with sufficient amplitude to produce oscillations in the audio frequency amplifier which are sustained as long as a carrier of sufficient amplitude is present.

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