May 10, 1938. E. H. ARMSTRONG 2,116,501

RADIO RECEIVING SYSTEM

Original Filed Sept. 14, 1935 2 Sheets-Sheet 1

Fig. 1.

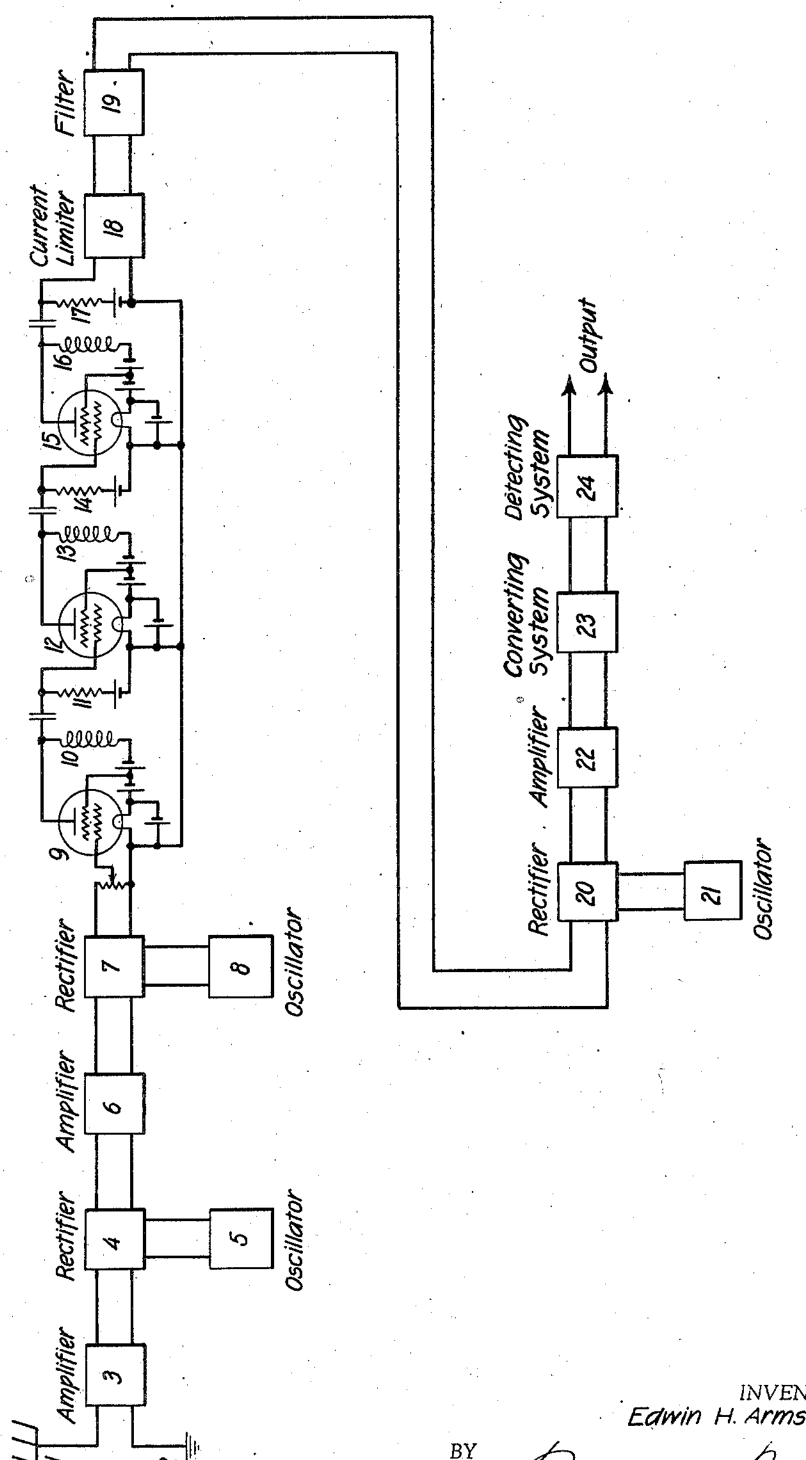

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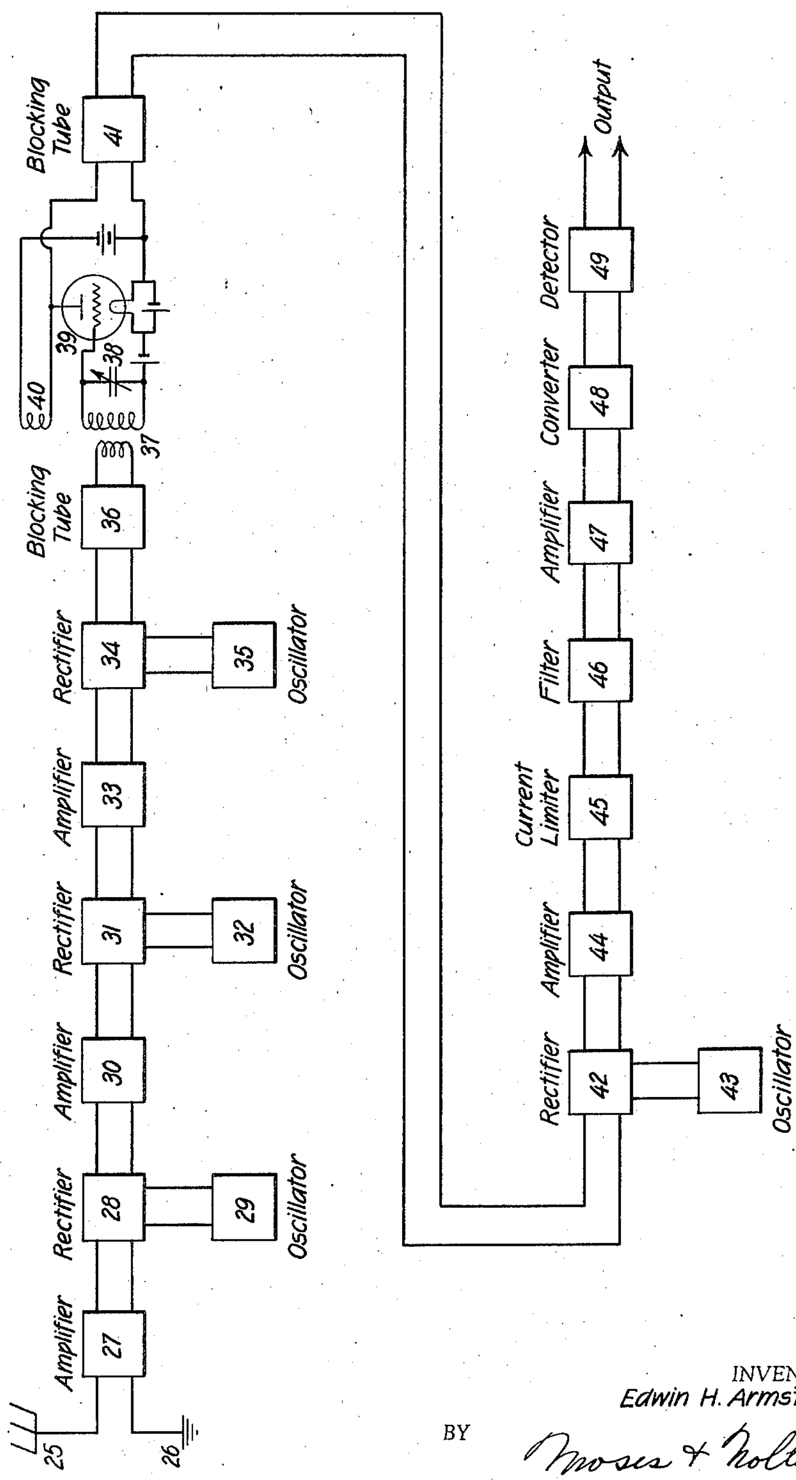
Fig. 2.



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RADIO RECEIVING SYSTEM

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Application September 14, 1935, Serial No. 40,544
Renewed July 28, 1937

2 Claims. (Cl. 250—20)

This invention relates to a method of improving the operation of the receiving apparatus described in my U. S. Patent No. 1,941,069. The object of the invention is to improve the signal to noise ratio so that communication may be effected over greater distances or with a minimum of power over a given distance.

In the patent above referred to disturbances are eliminated by producing at the transmitter a frequency modulated wave having a frequency deviation which is large compared to the frequency of the modulations to be transmitted and providing receiving means which are not responsive to amplitude variations and which respond substantially only to frequency deviations of the magnitude of those produced by the transmitter.

As the frequency deviations which can be set up in the receiver by natural disturbances are relatively small at the modulation frequencies when compared to those produced by the transmitter, the response to natural disturbances is much reduced and the ratio of the amount of noise with respect to the signal is much improved. The operation of the system is strictly quantitative as long as the signal carrier is greater in amplitude than the amplitude of the disturbances and the signal to noise ratio can be reduced to practically any desired ratio by increasing the deviation of the transmitted wave with respect to the frequency of modulation and proportioning the receiver to it. Under these conditions where the signal carrier is greater in amplitude than the amplitude of the disturbing currents they usually manifest themselves in the speaker as a hiss of uniform amplitude. When, however, the amplitude of the disturbances become commensurate with the amplitude of the signal a form of interference occurs which cannot be so effectively dealt with by the receiver. This type of interference occurs when a disturbing current having substantially the amplitude of the signal arrives in opposite phase to the phase of the signaling current, the two cancel out and the current thru the limiting system drops below the cutoff value. Where the disturbance is a repeated oscillation or has the nature of a spectrum a large number of such coincidences occur and they manifest themselves by producing a continuous rattle in the speaker.

There occurs also a type of interference different from either of the two mentioned which takes place when an impulse much larger than the signal arrives and blanks out the signal in the current limiter producing thereby a rapid change of the phase of the current passing thru the current limiter which results in wide variations of frequency.

It is the purpose of this specification to describe a method by which these types of disturbance can be much reduced. This method consists in providing at the receiving station a local oscillation which is greater in amplitude than that of the received signal and which has the characteristic of synchronizing readily and remaining in synchronism with the incoming signal as it varies in frequency in accordance with the modulations impressed upon it. By this process the combined currents of the local oscillation and the incoming signal become then in effect a new signal having an amplitude greater than the disturbing currents so that it is no longer possible for these currents to cancel out the signal. This method is also effective when the amplitude of the disturbing current is small compared to the amplitude of the signaling current as it is the relative amplitudes of the two which determine the signal-noise ratio in the speaker. As a consequence of this the hiss type of disturbance can also be greatly reduced.

Referring now to the diagrams which form a part of this specification Fig. 1 illustrates an arrangement for carrying out the method of the invention.

Fig. 2 illustrates an alternative way of producing the same result.

Referring now specifically to Fig. 1, 1–2 represents the antenna system, 3 an amplifier for the received currents, 4 a rectifier and 5 an oscillator for converting the incoming frequency to an intermediate value, 6 an amplifier for the intermediate frequency and 7 a rectifier for this frequency. 8 is an oscillator for converting the first intermediate frequency to a lower intermediate frequency. 9–17 represents a three stage amplifier for this second intermediate frequency and 18 current limiter therefor. 19 is a filtering system for removing harmonics created by the current limiter. 20, 21 is a rectifier oscillator combination for changing the second intermediate frequency to a third intermediate frequency. 22 is an amplifying system for the third intermediate frequency and 23, 24 a system for translating the variations in frequency in the third intermediate frequency into amplitude variations and detecting them in the manner described in the patent to which reference has already been made.

The manner of operation of the system is as follows: The currents set up in the antenna are duly amplified and converted by the system 3–8 into currents of the second intermediate frequency and supplied to the input of the amplifier 9–17. This amplifier is so designed that it will oscillate over a wide range of frequency and can be readily synchronized with a current applied to its input. This is accomplished by winding the coils 10, 13 and 16 with resistance wire and shunting them by resistances 11, 14 and 17. By adjusting the amount of amplification it is possible to set up an oscillation of the proper strength in the system so that it will readily synchronize with the signaling current. If the adjustments have been properly made and if the incoming signal is not too weak relatively to the strength of the local oscillation then the local oscillation will follow the deviations of the incoming signal thruout its course.

The combined incoming and local current is then applied to the current limiter 18, limited thereby and then converted to a third intermediate frequency where it is translated into amplitude variations and detected as described in Patent No. 1,941,069.

The particular arrangement of intermediate frequencies which has been described here is used for the following reason. It is necessary, in order to synchronize a local oscillating system, to use a current of substantial value therefore the amplifiers 3 and 6 are used ahead of the oscillating system 9–17. In order to prevent overall reactions and oscillations no other amplifying system than that which is producing the local oscillation should be used at that frequency. Therefore the amplifying system 9–17 is given a frequency of its own. Similarly, since the output of the current limiter 18 is hardly sufficient to operate the translating and detecting system well without further amplification, the necessary amplitude is obtained by converting to a third intermediate frequency, amplifying that frequency and then performing the operations of translation and detection.

Fig. 2 illustrates an arrangement which employs a single oscillator as the source of the local oscillation instead of the multi-stage oscillator of the system of Fig. 1. While the fundamental principle of synchronizing a local oscillator with an incoming signal is the same as in Fig. 1 the method of carrying it out is different. A single tube oscillator is desirable because it is more readily controllable in its adjustment. Because of this greater controllability it is less amenable to synchronization than a multi-stage oscillator and will follow the incoming frequency thru a range which is a lower percentage of its mean frequency than will the multi-stage oscillator. If the frequency of oscillation of the local source is sufficiently high the percentage of this frequency thru which the local source will keep in step with the signal will be equal numerically to the number of cycles actual deviation of the incoming signal. Therefore the expedient is adopted of selecting some high frequency of oscillation, amplifying the incoming signal by ordinary superheterodyne methods and then heterodyning the output of the last intermediate frequency current up in frequency to a sufficiently high value to match the frequency of the oscillator. After synchronizing the local oscillation the combined currents are heterodyned down in frequency to some suitable value, amplified, limited, translated into amplitude variations and detected.

Referring now to Fig. 2, 27–33 represents a two intermediate frequency superheterodyne amplifier. The two intermediate amplifiers 30 and 33 are each successively lower in frequency than the radio frequency amplifier 27. 34 is a rectifier and 35 an oscillator for heterodyning up the frequency of the output of 33 to a value which coinsides with that of the oscillating system 37–40. The oscillator is isolated from reactions which may be produced by the rest of the circuits by the input and output blocking tubes 36 and 41. The synchronized signaling and local currents are heterodyned down in frequency again by the rectifier 42 and oscillator 43, amplified by 44, limited by 45, the harmonics removed by the filter 46, and the resulting current amplified translated and detected by 47, 48, 49 in the manner described in my patents previously referred to.

This arrangement operates very effectively and while it requires more changes of frequency than the arrangement of Fig. 1 when once the proper settings have been made, is just as simple to handle.

I claim:

1. The method of reducing interference in radio reception of frequency modulated waves, which consists in generating at the receiving station a local oscillation greater in amplitude than that of the received signal, synchronizing the local oscillation with the received oscillations, removing amplitude changes from the synchronized oscillations, and detecting the changes in frequency.

2. A system for reducing interference in radio reception of frequency modulated waves, comprising means at the receiver for providing local oscillations greater in amplitude than that of the received signal, means for synchronizing said local oscillations with the received oscillations and combining the same, means responding to said combined oscillations to produce oscillations varying in frequency but not in amplitude, and means for detecting said variations in frequency.

EDWIN H. ARMSTRONG.