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CARRIER-FREQUENCY RECEIVING SYSTEM

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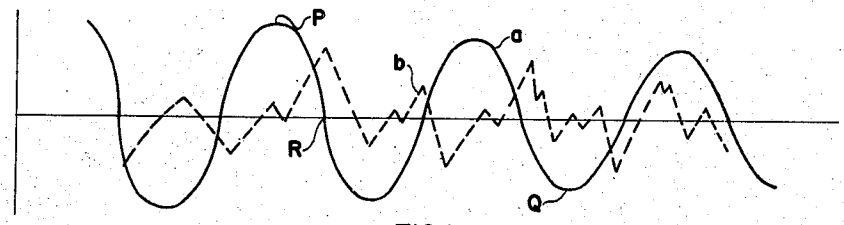


FIG. 1.

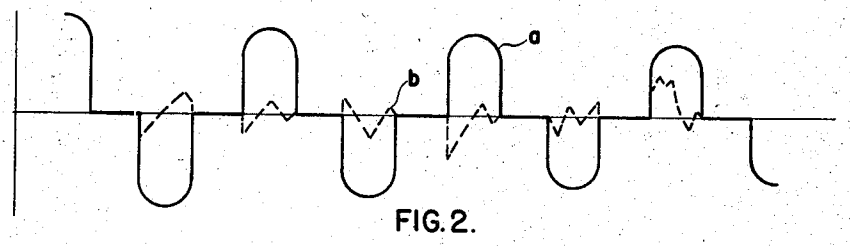


FIG. 2.

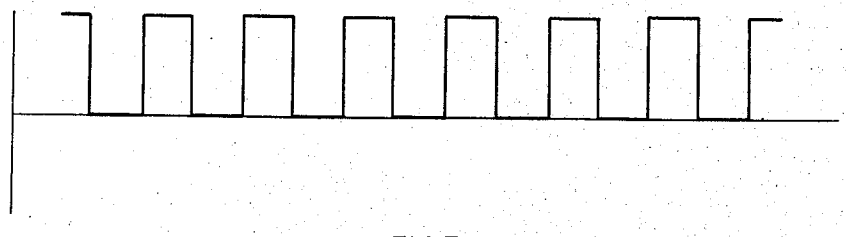


FIG. 3.

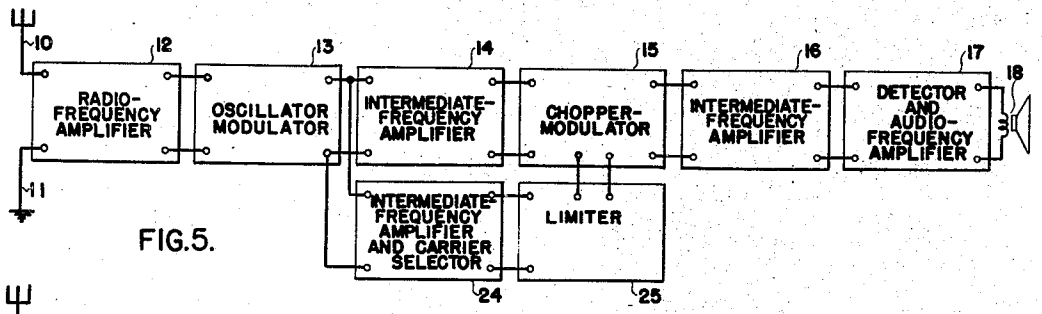


FIG. 5.

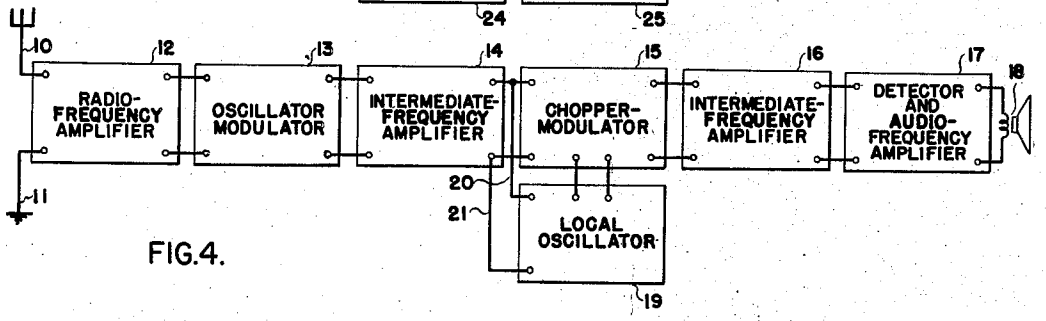


FIG. 4.

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CARRIER-FREQUENCY RECEIVING SYSTEM

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7 Claims. (Cl. 250—20)

This invention relates to modulated-carrier signal-receiving apparatus of the type adapted to receive information conveyed by a modulated-carrier wave and wherein the incoming signals, picked up by an antenna, pass through one or more carrier-frequency stages, which in the case of superheterodyne receivers includes intermediate-frequency stages, before the information, which may consist of audio or television signals, is detected in a detector stage and passed on to the output stage or stages.

In such apparatus it is known that there may be picked up by the antenna, together with the desired signals, "noise" signals which interfere with the reproduction of the desired signals and which, if of sufficient strength, may completely spoil reception of the desired signals. Such noise signals may be produced, for example, by atmospheric conditions or by electrical machines.

It is an object of this invention to provide means which increase the ratio of signal energy to noise energy transmitted from the antenna to the detector and output stages of modulated-carrier signal-receiving apparatus, thereby reducing the effect of received noise signals.

Figs. 1, 2, and 3 of the drawing are characteristic wave forms utilized to explain the invention while Figs. 4 and 5 are schematic circuit diagrams of different embodiments of the invention.

The principle underlying the invention is best explained with reference to Figs. 1, 2, and 3 of the accompanying drawing. In Fig. 1 curve (*a*) represents the wave form of several cycles of an amplitude-modulated carrier wave. Dotted curve (*b*) shows, by way of example, an irregular noise signal occurring within these cycles of the carrier wave. The energy of the carrier wave (*a*) varies regularly in time, being a maximum when the carrier amplitude is a maximum, for example, at P and Q, and a minimum when the carrier amplitude is zero, for example, at R. On the other hand, the times of maximum energy of noise signals (*b*) do not coincide, except by a rare chance, with the times of maximum energy of carrier wave (*a*). It will be seen that the mean value of the ratio of signal energy to noise energy transmitted from the antenna to the detector and output stages is increased if signals are allowed to pass only when the energy level of the carrier wave is high. This may be seen more readily from Fig. 2 which shows the effect at the detector input, of a carrier-wave signal-receiving system, of allowing signals to pass only during the quarter cycles in which the energy of the carrier wave is a maximum.

Fig. 2 illustrates one manner in which the said ratio may be increased. It will be understood that the intervals during which signals are allowed to pass may occur in every cycle, or in every group of cycles of the carrier wave; thus, if f is the frequency of the carrier wave, the frequency at which the active intervals occur may be $2f/n$, where n may be any finite integer. The frequency at which the intervals occur must not, however, be too low, for then the higher modulation frequencies may be lost. Maximum signal energy is applied to the detector when the frequency is $2f$ but it will be seen later that the frequency f is, in general, preferable. Furthermore, each interval during which signals are allowed to pass may be different from one quarter-cycle, so long as it is substantially less than one half-cycle, and not substantially less than one quarter-cycle. The effective signal-to-noise ratio increases as the interval during which signals are allowed to pass decreases, but the signal energy supplied to the detector simultaneously decreases; in practice it is found that such interval has a lower limit beyond which no perceptible further improvement in performance is obtained.

According to the invention modulated-carrier signal-receiving apparatus of the type specified comprises means for periodically opening and closing the path of the signals through the signal-translating channel of the apparatus at a point preceding the detector and output stages, the frequency of the opening and closing being $2f/n$, where f is the carrier frequency and n is any finite integer, preferably small, the phase of the open intervals being such that one peak of the carrier wave occurs during each open interval, and each open interval being substantially shorter than $\frac{1}{2}f$.

In order to produce the switching action, opening and closing the signal path in the signal-translating channel of the receiving apparatus, there may be included in the signal path a modulator of the type known as a "chopper". This type is well known in the art and requires no detailed description. As an example, a chopper modulator may comprise a rectangular-wave modulator in which the modulating oscillation consists of a rectangular wave which biases the non-linear elements of the modulator so as to render them conducting and non-conducting during alternate half-cycles; if the frequency of this modulating oscillation is $2f/n$ as aforesaid and its phase is suitably related to that of the incoming carrier, the signal path is then opened

during the conducting half-cycle and closed during the non-conducting half-cycle as required. The rectangular-wave modulator may comprise a multi-grid frequency changer valve of the type usual in the art, to one control grid of which is applied the incoming signal and to the other control grid of which is applied the rectangular wave or other modulating oscillation, the output being passed to the detector and output stages. Thus a wave of the form shown in Fig. 2 may be obtained by heterodyning the carrier wave of curve (*a*) of Fig. 1, in such a frequency changer or chopper-modulator, with a rectangular wave of the form shown in Fig. 3. The modulating oscillation of the rectangular-wave modulator may be produced locally, in which case the local oscillator is preferably electrically synchronized with the incoming carrier wave in known manner in order to maintain the correct phase relationship. A schematic circuit diagram of a system in accordance with the invention utilizing a local oscillator synchronized with the incoming carrier wave in the intermediate-frequency channel of a superheterodyne receiver is shown in Fig. 4. The receiver comprises, in cascade, an antenna-ground circuit **10**, **11**, a radio-frequency selector and amplifier **12**, a frequency changer or oscillator-modulator **13**, an intermediate-frequency amplifier **14**, a chopper-modulator **15**, a second intermediate-frequency amplifier **16**, a detector and audio-frequency amplifier **17**, and a sound reproducer **18**. In order to provide a control bias for causing chopper-modulator **15** to become conductive periodically, there is provided a local oscillator **19** for generating oscillations of the wave form illustrated in Fig. 3. These output oscillations of local oscillator **19** are applied to chopper-modulator **15** in order to provide the switching operations. A synchronizing signal, derived from a point in the signal-translating channel of the receiver preceding chopper-modulator **15**, is applied to local oscillator **19** through conductors **20, 21** to maintain the correct phase between the output of the locally-generated oscillations and that of the incoming signal.

Neglecting for the moment the operation of the parts of the system involved in the present invention, the system described includes the conventional features of a superheterodyne receiver. The operation of such receiver being well understood in the art, a detailed explanation thereof is deemed to be unnecessary. Briefly, however, a desired modulated-carrier signal intercepted by antenna **10** is selected and amplified in amplifier **12** and converted in oscillator-modulator **13** to an intermediate-frequency modulated-carrier signal. This signal is amplified by intermediate-frequency amplifier **14** and translated therefrom to intermediate-frequency amplifier **16** through chopper-modulator **15**. The output of intermediate-frequency amplifier **16** is detected and amplified by detector and audio-frequency amplifier **17** and reproduced by loudspeaker **18** in a conventional manner.

Local oscillator **19**, generating oscillations of the wave form of Fig. 3 and having the proper phase with reference to the intermediate-frequency signal, is utilized to turn the signal-translating channel of the receiver on and off at a predetermined frequency by means of chopper-modulator **15** in the manner described above. This means for turning the signal-translating channel of the receiver on and off includes means responsive to the synchronizing signal derived from conductors **20** and **21** for maintaining the phase of the open interval at the optimum value with respect to the carrier-frequency signal, that is, at such value that at least one maximum of the carrier-frequency signal occurs during each open interval.

The system of Fig. 5 is generally similar to that of Fig. 4 and similar circuit elements have been given identical reference numerals. The system of Fig. 5 differs from that of Fig. 4 primarily in the method of obtaining the rectangular-control voltage for chopper-modulator **15**. In order to provide this control, there is provided a highly-selective amplifier **24** and a limiter **25**, coupled to the intermediate-frequency channel of the receiver. Amplifier **24** may comprise a conventional amplifier circuit together with a highly selective circuit, the selective circuit being tuned to the intermediate frequency of the system. A sine wave of the frequency of the intermediate-frequency signal is thus provided by the output of selector **24**. This sine wave is limited at the proper values by limiter **25** to provide a signal having a substantially rectangular wave form. This wave form is applied to chopper-modulator **15** to provide switching of the signal-translating channel of the receiver in the manner described above. In the circuit of Fig. 5 exact synchronism is automatically ensured. This is one reason, as aforesaid, the frequency f is preferable.

Any of the other known arrangements for reducing the effects of noise, for example, amplitude-limiting devices, may be included in any embodiment of the invention.

While there have been described what are at present considered to be the preferred embodimens of this invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the invention, and it is, therefore, aimed in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of the invention.

What is claimed is:

1. A carrier-frequency signal-receiving system comprising, a signal-translating channel, means in said channel for effectively opening and closing the path of signals through said channel at a predetermined frequency, the frequency of said opening and closing being $2f/n$, where n is any finite integer, and f is the carrier frequency of said signal, and means included in said first-mentioned means for maintaining the phase of the open intervals such that one maximum of said carrier-frequency signal occurs during each open interval, each open interval being substantially shorter than $\frac{1}{2}f$.

2. A carrier-frequency signal-receiving system comprising, a signal-translating channel, means in said channel for effectively opening and closing the path of signals through said channel at a predetermined frequency, the frequency of said opening and closing being equal to the carrier frequency of said signal, and means included in said first-mentioned means for maintaining the phase of the open intervals such that one maximum of said carrier-frequency signal occurs during each open interval, each open interval being substantially smaller than one-half the period of said carrier frequency.

3. A carrier-frequency signal-receiving system comprising, a signal-translating channel, means comprising a chopper-modulator in said channel for effectively opening and closing the path of signals through said channel at a predeter-

mined frequency, the frequency of said opening and closing being $2f/n$, where n is any finite integer and f is the carrier frequency of said signal, and means included in said first-mentioned means for maintaining the phase of the open intervals such that one maximum of said carrier-frequency signal occurs during each open interval, each open interval being substantially shorter than $\frac{1}{2}f$.

4. A carrier-frequency signal-receiving system comprising, a signal-translating channel, means comprising a chopper-modulator in said channel for effectively opening and closing the path of signals through said channel at a predetermined frequency, a highly-selective circuit for deriving from said channel at a point preceding said modulator a voltage for controlling said opening and closing, the frequency of said opening and closing being $2f/n$ where n is any finite integer and f is the carrier frequency of said signal, and means included in said first-mentioned means for maintaining the phase of the open intervals such that one maximum of said carrier-frequency signal occurs during each open interval, each open interval being substantially shorter than $\frac{1}{2}f$.

5. A carrier-frequency signal-receiving system comprising, a signal-translating channel, means comprising a chopper-modulator in said channel for effectively opening and closing the path of signals through said channel at a predetermined frequency, a highly-selective circuit tuned to the carrier frequency of said signal for deriving a signal from said channel at a point preceding said modulator, means for limiting said derived signal, and means for utilizing said limited signal for controlling said opening and closing, the frequency of said opening and closing being $2f/n$, where n is any finite integer and f is the carrier frequency of said signal, the phase of the open interval being such that one maximum of said carrier-frequency signal occurs during each open interval and each open interval being substantially shorter than $\frac{1}{2}f$.

6. A carrier-frequency signal-receiving system comprising, a signal-translating channel, means comprising a chopper-modulator in said channel for effectively opening and closing the path of signals through said channel at a predetermined frequency, a local oscillator for generating control oscillations for said modulator, means for deriving a signal from said channel at a point preceding said modulator for determining the phase of said locally-generated oscillations, the frequency of said opening and closing being $2f/n$, where n is any finite integer and f is the carrier frequency of said signal, the phase of the open intervals being such that one maximum of said carrier-frequency signal occurs during each open interval and each open interval being substantially shorter than $\frac{1}{2}f$.

7. A carrier-frequency signal-receiving system of the superheterodyne type comprising, an intermediate-frequency signal-translating channel, means in said channel for effectively opening and closing the path of signals through said channel at a predetermined frequency, the frequency of said opening and closing being $2f/n$, where n is any finite integer and f is the carrier frequency of said signal, and means included in said first-mentioned means for maintaining the phase of said open intervals such that one maximum of said carrier-frequency signal occurs during each open interval, each open interval being substantially shorter than $\frac{1}{2}f$.

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