

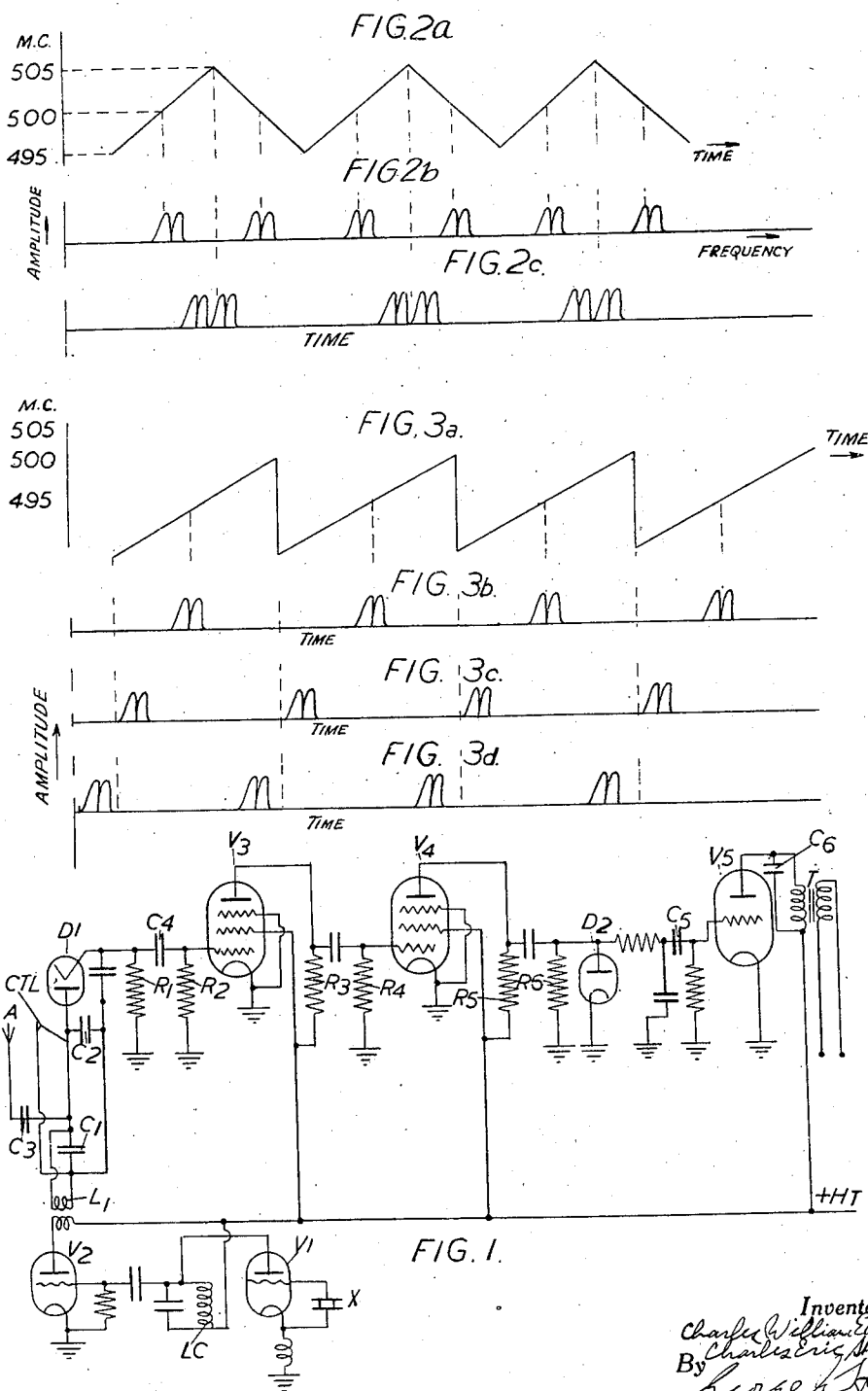
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C. W. EARP ET AL
ULTRA HIGH FREQUENCY SYSTEM

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2 Sheets-Sheet 1



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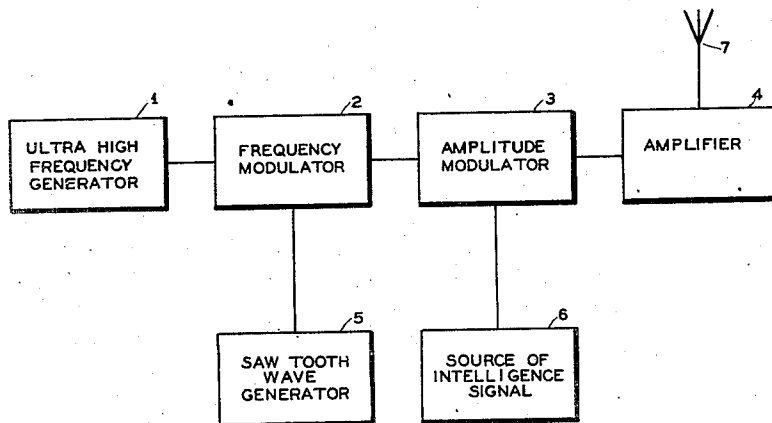


FIG. 4

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ULTRA HIGH FREQUENCY SYSTEM

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4 Claims. (Cl. 250—6)

1

The present invention relates to ultra high frequency radio signalling systems and has for its object to provide a very high frequency radio signalling system which is particularly suitable for radio navigational aid to aircraft or other mobile receivers. Though it has long been realized that considerable advantage may be gained for navigational systems—particularly for aircraft landing systems—by the use of very high radio frequencies, there has been the practical difficulty that suitable receivers have been complicated or costly. The orthodox superheterodyne receiver which can offer adequate sensitivity, frequency-stability and suppression of spurious responses such as “second-channel,” is liable to be heavy, costly, and difficult to produce. The system according to this invention comprises a new type of receiver which is used in conjunction with a special form of transmission, to give adequate performance without complication.

According to the present invention, a radio signalling system in which the intelligence is transmitted as an amplitude modulation of an ultra high frequency carrier wave, is characterized in this, that the carrier wave is frequency modulated about a mean frequency and that at the receiver the received wave is heterodyned with a constant frequency substantially equal to the mean carrier frequency.

Preferably the frequency modulation is a periodic frequency sweep about the mean carrier frequency.

The method of obtaining the frequency modulation of the transmitted wave, the frequency sweep of such modulation, the repetition frequency of the frequency modulation and the wave-form of the modulation will all depend upon the particular service required.

The repetition frequency of the frequency modulation, which will usually be constant must, in order that it shall not cause interference with any intelligence-bearing modulation, be higher than the highest frequency desired to be transmitted in the intelligence bearing modulation.

In a navigational aiding system, the intelligence bearing modulation may be amplitude modulation in the form of “dots” or “dashes” produced by keying the transmitter to an aerial system. In such a case, if it be desired to transmit “ n ” dots per second, the “dot” or “dash” wave may have to contain frequencies up to say, “ $5n$ ” cycles in order to maintain a suitable wave-form. Here, the repetition frequency of a periodic frequency modulation of the transmitter must exceed “ $5n$ ” cycles/second.

2

To take a practical case, in a glide path system, intelligence concerning the position of the aircraft is conveyed to the aircraft in the form of “dots” or “dashes” at about 6 per second. Suitable wave shape for a dot would be obtained in a bandwidth of 30 cycles, and the repetition frequency of the frequency modulation is 250 cycles/second.

If it should be desired to transmit intelligence in the form of speech, then the repetition frequency of the frequency modulation would take place at a frequency higher than 3000 cycles. A repetition frequency of 10 kc. or 20 kc. would be suitable.

In the case where the intelligence-bearing modulation contains very low frequencies only, the repetition frequency of the frequency modulation may take place at a low frequency. One convenient and practical arrangement for producing such modulation is the known arrangement using a rotating condenser, in which the capacity varies cyclically according to the rotation, this condenser contributing to the frequency-determining circuit of the transmitter oscillation.

If, however, very high mean carrier frequency stability is required, then the modulation may take the form of a known arrangement for phase modulation of a crystal controlled oscillation at a subharmonic of the radiated frequency, the latter being derived by harmonic generation from the phase-modulated oscillation.

Frequency modulation at super-audible frequency is not very practical by mechanical means, and is best carried out, according to known technique, by electronic methods.

For a better understanding of the invention, reference is had to the following description taken in connection with the accompanying drawings whereof:

Figure 1 is a diagrammatic showing of a typical receiver useful with our invention.

Figure 2a shows one form of frequency modulation wave, and,

Figures 2b and 2c show different wave-forms given by the receiver dependent on tuning;

Figure 3a shows another form of modulation wave, and,

Figures 3b, 3c, and 3d show different wave-forms given by the receiver depending on tuning, and,

Figure 4 is a block diagram of a transmitter circuit usable in our invention.

In the generalized schematic diagram in Figure 4, the output of the high frequency generator 1 is frequency modulated in the frequency modulat-

3

ing circuit 2 which is controlled by the saw tooth wave generator 3. The output of the circuit 2 is modulated in amplitude in the amplitude modulator 4 which is controlled by the intelligence signal from the source 5. The output of the modulator 4 is amplified in the amplifier 6 and transmitted from the antenna 7.

A receiver for use in carrying out the present invention is of the heterodyne type in which the heterodyning oscillator is applied at substantially the mean frequency of the transmission and the amplifier which follows the heterodyning stage is coupled thereto by a resistance-capacity coupling.

The essential details of a typical receiver are shown in Fig. 1 of the accompanying drawings.

V1 develops oscillation at 10 mc. by virtue of a quartz crystal plate X. The fourth harmonic (at 40 mc. is selected by tuned circuit LC in the plate circuit of V1 and passed to the grid of valve V2. A fourth harmonic is again generated at 160 mc. and LC1 is tuned to this frequency.

This 160 mc. wave is used as the oscillator injection to the diode frequency changer D1, which is connected at the high potential end of a resonant concentric transmission line CTL, tuned by condenser C2 to the signal frequency 480 mc. The antenna A is suitably coupled to the resonant line via capacity C3, and feeds the received signal frequency to the diode D1. The third harmonic of the oscillator injection of 160 mc. is effectively developed by the diode D1 to provide a wave at the mean signal frequency of 480 mc. as the heterodyne oscillator.

The beat frequency between signal and local oscillator is developed in resistance R1, and this is passed via condenser C4 to resistance R2, on the control grid of the first intermediate frequency amplifier V3. Further amplification is provided by valve V4 before the output in the form of pulses at a frequency of 500 per second obtained as hereinafter explained are detected in diode D2.

The L. F. envelope of the rectified wave is obtained from D2 and passed via condenser C5 to the low frequency amplifier V5, which feeds the output transformer T. The 500 cycle component of the signal envelope may be tuned in this transformer by means of C6 to provide noise suppression.

The coupling constants between D1 and V3, V3 to V4, and V4 to D2 are of some importance. R1, R2 and R3 are of such value that they are not appreciably shunted by valve capacities and strays at the highest frequency required to be passed. For example, if the total capacity across a coupling stage is 20 micromicrofarads, and the highest frequency to be passed is 1 mc./s., a suitable resistance value is about 10,000 ohms.

Coupling condensers are chosen to give a low-frequency cut-off at a frequency above that which is likely to be produced spuriously by vibration and microphonicity generally. For example, if $C_4=100 \mu\text{f.}$ and $R_2=100,000 \text{ ohms}$, amplification is reduced for frequencies below 10 kc./s.

Fundamentally, the amplitude of the transmitter frequency modulation must be sufficient to produce a beat note with the receiver oscillator which can, over an appreciable portion of the transmitter excursion, produce a response in the intermediate frequency amplifier following the heterodyning stage.

A maximum response in the intermediate frequency amplifier is obtained for a total frequency

4

excursion equal to twice the receiver bandwidth, when a minimum of signal is lost during the time the beat-note is too low in frequency to pass through the receiver intermediate frequency amplifier.

This receiver described is suitable for a frequency modulated transmission of mean frequency 480 mc. The resistance-capacity coupled intermediate frequency amplifier covers the approximate band 10 kc. to 1 mc. so that the frequency sweep should cover a 2-megacycle band, i. e. 479 to 481 mc.

A still larger frequency excursion may be used to ensure adequate frequency stability of the whole system. When the excursion is large compared with receiver band-width, much of the transmitted amplitude modulation signal is not received, the beat note produced at the extremity of the excursion being too high in frequency for the receiver intermediate frequency amplifier to respond. Signal energy in the output of the intermediate frequency amplifier is now a series of pulses corresponding to instants that the receiver is correctly tuned to a frequency in the transmitter frequency sweep. This effect may be used with advantage in some cases, by detecting the received signal pulses, and using the amplitude modulation of the detected signal at the repetition frequency of the frequency modulation to identify particular transmissions.

The wave-form of the frequency modulation may be of any shape, the simple sine wave modulation being suitable for most cases.

In cases where the frequency excursion is considerably larger than the receiver band width, in order to provide a factor of safety for the frequency stability of the whole system, it is desirable to spread the transmitted energy uniformly over a wide frequency band. Such uniform distribution of energy may be provided by a frequency modulation having the wave form shown in Figs. 2a and 3a of the accompanying drawings.

Suppose, now, that the frequency modulation wave-form of Figs. 2a and 3a are periodic at 250 cycles per second, and cover a frequency band of 500 megacycles ± 5 megacycles. Suppose, also, that the receiver used has a resistance coupled amplifier which amplifies the band of frequencies 50 kc./s. to 1 megacycle/second, for example as the one described in connection with Fig. 1.

Tuned accurately to the transmission shown in Fig. 2a, the receiver detector gives the output wave-form shown in Fig. 2b. This output contains a chief component of 500 cycles/sec., and the L. F. circuits may be tuned to this frequency to provide improved signal to noise ratio.

Now, frequency drift at transmitter or receiver may have the effect of tuning the receiver near one end of the transmitter frequency excursion. A receiver tuned to 504 megacycles receives the transmission shown in Fig. 2a to give the output wave shown in Fig. 2c. In this case, the predominant low frequency tone is 250 cycles/second, and very little output is obtained at 500 cycles. If the receiver output is to be tuned, then a maximum suppression of the effects of frequency drift are obtained by using the frequency sweep wave-form shown in Fig. 3a. Fig. 3b shows the output obtained when tuned to 500 mc.; the predominant output tone is at 250 cycles. Detuning to 496 mc. or to 504 mc. the output waves shown in Figs. 3c and 3d are obtained, which are of the same shape as shown in Fig. 3b.

5

the predominant output tone remaining at 250 cycles. Thus, with a frequency sweep as shown in Fig. 3a, for an overall frequency stability of about ± 1 per cent, performance of the system does not vary.

When the frequency excursion of the transmitter is sufficient to cause complete modulation of the received signal, the D. C. component of the detected signal from D2 may be filtered off and the modulation-envelope may be further amplified and used to obtain therefrom any intelligence-bearing modulation contained therein.

The following advantages over the orthodox superheterodyne receiver are obtained by a receiver of the type as described in connection with Fig. 1:

1. Frequency stability is dependent upon the heterodyning oscillator only, which may be crystal controlled. (There is no intermediate frequency drift.) Incidentally, the frequency stability required for reception of the frequency-modulated transmission is not high.

2. High sensitivity is obtained by use of a simple resistance-capacity-coupled amplifier which requires no tuning adjustments, contains no coils, and does not drift from its mean frequency of response-zero.

3. The receiver has no "second-channel" or "image" response, yet no appreciable signal-frequency selectivity is provided.

What is claimed is:

1. The method of signaling which comprises generating a carrier wave at an ultra high frequency, successively varying said carrier wave over a continuous frequency range at a uniform repetition rate negligibly low in comparison to any carrier frequency, amplitude modulating said carrier in accordance with intelligence bearing signals to be transmitted, said intelligence bearing signals being at frequencies lower than, but generally of the same order, as said repetition rate so that substantially all carrier energy is in said continuous range, transmitting said carrier to a receiving station, and beating said received carrier with a frequency substantially equal to the mean of said varied frequency, amplifying

6

the resulting beat frequency in an amplifier possessing a narrow band width relative to the frequency spectrum of the received signals whereby pairs of pulses repetitive at a rate proportional to said repetition rate and of amplitude proportional to said intelligence bearing signals are produced, detecting said pairs of pulses, and amplifying said pulses in an amplifier tuned to said repetition rate whereby the amplitude modulation corresponding to said intelligence bearing signals is obtained.

2. The method of claim 1 wherein said repetition rate is in the supersonic frequency range and wherein said intelligence bearing signals are in the audio frequency range.

3. The system of claim 1 wherein said carrier frequency variation characteristic is in the form of triangular waves.

4. The system of claim 1 wherein said carrier frequency variation characteristic is in the form of a saw-tooth wave.

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