April 20, 1943. D. G. C. LUCK 2,317,071

ANTENNA CIRCUIT MODULATION SYSTEM

Original Filed Dec. 30, 1938

FIG. 1.

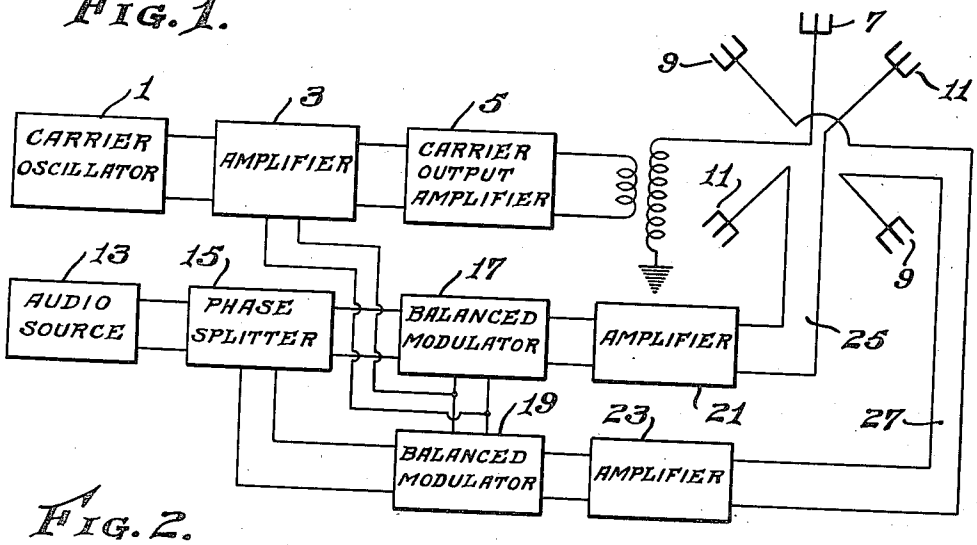


FIG. 2.

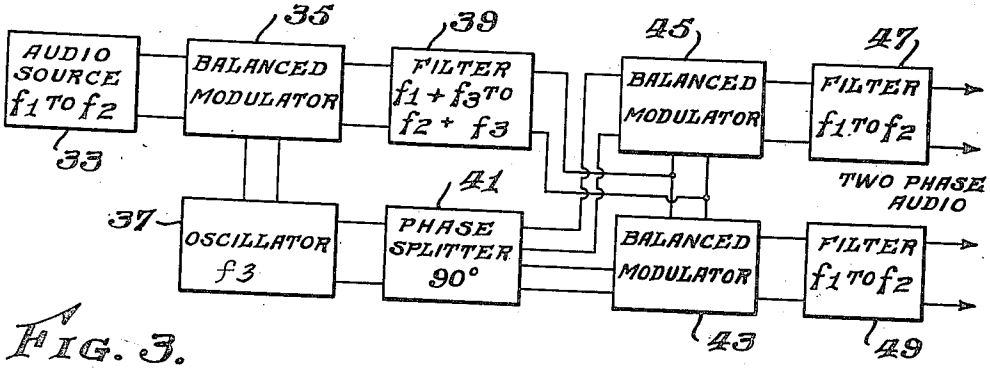
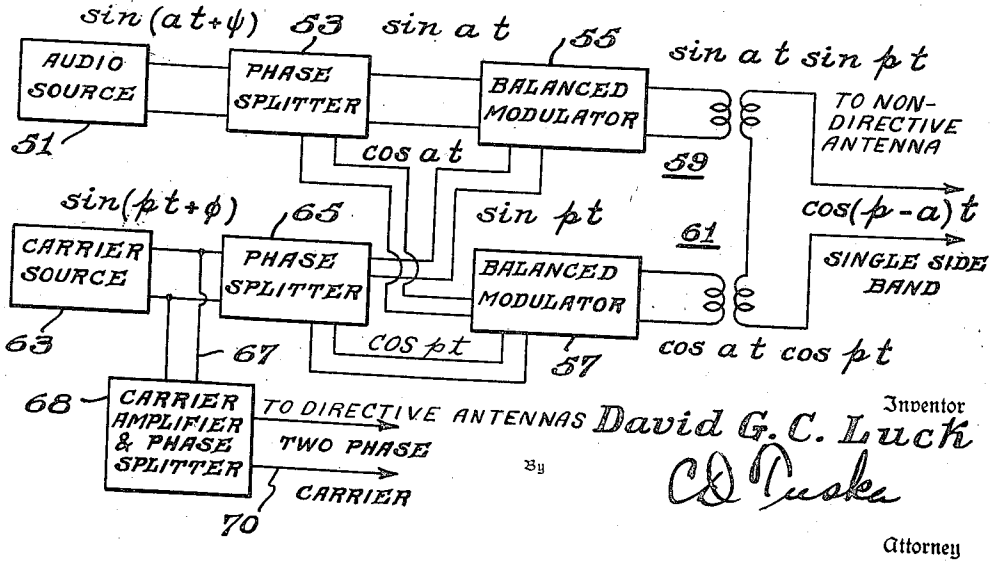


FIG. 3.



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Patented Apr. 20, 1943 2,317,071

UNITED STATES PATENT OFFICE

2,317,071

ANTENNA CIRCUIT MODULATION SYSTEM

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Original application December 30, 1938, Serial No. 248,567. Divided and this application January 31, 1942, Serial No. 429,004

4 Claims. (Cl. 250—17)

This application is a division of my patent application Serial No. 248,567, filed December 30, 1938.

This invention relates to antenna circuit modulation systems and more especially to a system in which the carrier is transmitted on one channel and the signal frequencies on a separate channel.

In U. S. Patent 2,098,373 which issued on November 9, 1937, to G. H. Brown, a system is described in which currents of carrier frequency are applied to one antenna and currents of modulation frequencies are applied in push-pull relation to one or more pairs of vertical antennas which are decoupled with respect to the antenna to which the carrier frequency currents are applied. In this system the field pattern is not circular but may approximate a figure of eight. This means that the signals are not received with equal strength in all directions and in some directions may not be received at all.

The present invention provides means for establishing radiation which is substantially equal in all directions about the antenna array and in which the carrier frequency currents are applied to one channel and the currents of modulation frequency are applied to another channel. This separation of functions results in a much higher efficiency than can be obtained with the conventional modulation systems. In such systems, the output amplifiers must be capable of handling a peak signal, at full modulation, of twice the carrier amplitude or four times the carrier power. In the system of the invention it is only necessary to provide a high frequency, class C carrier channel amplifier, of capacity capable of handling the normal carrier, and linear side band equipment capable of handling peak power equal to the carrier power loads which are applied to the separate channels. The proposed system is of especial advantage in the transmission of reduced carrier broadcasting and of still further advantage in the transmission of reduced carrier and single side band.

One of the objects of this invention is to provide means for producing a broadcast pattern of a modulated signal and a carrier by applying respectively the signal and carrier to separate channels. Another object of the invention is to provide means for the efficient transmission of a carrier and a single side band. A further object of the invention is to provide means for establishing a non-directional carrier field and for establishing a rotating modulation field. A still further object is to provide means for radiating a non-directional field including single side band modulation and means for radiating a rotating carrier frequency field.

The invention will be described by reference to the accompanying drawing in which

Figure 1 is a schematic diagram representing one embodiment of the invention; Figure 2 represents a phase splitter which is used in the embodiment of Fig. 1; and Figure 3 is a schematic diagram of a single side band generating system.

Referring to Fig. 1, a carrier frequency oscillator or generator 1 is connected through an amplifier 3 to a carrier output amplifier. The carrier output circuit is coupled to a non-directive antenna 7, which is preferably symmetrically located with respect to pairs of directive antennas 9, 11. The directive antennas are preferably uniformly arranged at the corners of a square. A source 13 of single phase modulation currents is connected to a phase splitter 15, which will be more fully described. One phase of the two-phase output of the phase splitter is connected to a balanced modulator 17 and the other phase to a second balanced modulator 19. The balanced modulators 17, 19 are also fed from the carrier amplifier 3. The output circuits of the balanced modulators are connected to amplifiers 21, 23. The output circuits of the amplifiers are coupled through transmission lines 25, 27 to the pairs of antennas 11 and 9, respectively.

The operation of the foregoing arrangement is essentially as follows: Currents from the carrier frequency oscillator 1 are amplified through one or more amplifier stages and are applied to the antenna 7, from which the carrier is radiated in all directions, as well as to the balanced modulators 17, 19. The modulation currents from the audio source 13 are applied to the phase splitter 15 from which two phases are derived, the currents of one phase leading the other by 90°. The two phase currents thus derived are applied respectively to the balanced modulators, in which the carrier is suppressed. The currents of side band frequency produced by these balanced modulators are amplified in the amplifier stages 21, 23 and are applied to the pairs of antennas 9, 11 in push-pull arrangement with respect to the antennas of each pair and in quadrature phase with respect to the currents in antenna 7. The resultant field is a rotational one in which the frequency of rotation corresponds to the frequency of the modulation currents. Thus, at any space within the fields, currents may be derived, from the field corresponding to the carrier and the modulation fre-

quencies, and combined in a conventional radio receiver.

While any phase splitter which will produce audio currents having quadrature phase may be used, it should be recognized that the phase splitter should cause approximately the same phase shift for currents of all the frequencies within the desired modulation band. One suitable arrangement for obtaining currents of two phases from the audio or modulation source is shown in Fig. 2. In this arrangement the currents, of frequencies f_1 to f_2, from the source **33** are applied to first balanced modulator **35**. The balanced modulator is excited by an oscillator **37**, which generates currents of a frequency f_3 and feeds a filter **39**. The filter is designed to pass currents of frequencies f_1+f_3 to f_2+f_3, corresponding to the upper sideband only. The oscillator is also connected to a phase splitter **41**. The phase splitter provides two currents in quadrature phase. One of these currents is applied to a second balanced modulator **43**. The other current is applied to a third balanced modulator **45**. The second and third balanced modulators are connected together and to the filter **39**. The outputs from the balanced modulators are applied to filters which pass the band of modulation frequencies f_1 to f_2 and in the filter outputs there appear two phase audio frequency currents, corresponding to the original single phase modulation currents.

The system may be adapted to the transmission of a single side band. If a single side band system is to be used, the currents of the side band frequency are applied to the non-directive antenna, while the currents of the carrier frequency are used to establish a rotating field. Referring to Fig. 3, single side band currents may be produced if the currents from an audio source **51** are applied to a phase splitter **53**, which may be of the type described above. The two phase modulation frequency currents from the phase splitter are applied to a first **55** and second **57** balanced modulator. The carrier current source **63** is connected to a phase splitter **65** whose outputs are impressed respectively upon the first and second balanced modulators. The outputs from the balanced modulators are additively applied, through transformers **59**, **61**, to the amplifier or antenna circuit to which the single side band currents are applied. The nature and phase of the several currents in the single side band generator are indicated in Fig. 3. The carrier source is also connected by transmission line **67** to an amplifier, phase splitter **68** and transmission line **70**, and hence to directive antennas.

Thus, the invention has been described as a signal modulation system in which the modulation is transmitted on one channel and the carrier on another. A conventional system using a depressed carrier (if the carrier is equal to the side band at ten percent modulation) requires, for side band output of 100 kilowatts at full modulation, a linear output amplifier of 121 kilowatts capacity. In the present system, a 100 kilowatt linear amplifier provides sufficient capacity for the side band currents and a separate 1 kilowatt carrier frequency amplifier will provide sufficient carrier currents. Thus, relative efficiency will be improved nearly twenty percent, which represents a substantial saving. With respect to the phase splitter for the modulation currents, it should be understood that any type of device may be used provided the relative phase angle produced is substantially the same throughout the range of frequencies employed. The separate non-directive antenna may be avoided, if desired, by the well known expedient of feeding the non-directive signal to the four directive antennas in parallel against ground, in addition to the push-pull directive signal feed to each antenna pair.

I claim as my invention:

1. An antenna modulation system including in combination means for creating a rotating carrier frequency field, a source of modulation currents of the character required for the simultaneous transmission of a band of frequencies, means for deriving a current of single side band frequencies from said source, and means for establishing an omnidirectional field including said single side band frequencies.

2. The method of transmitting intelligence requiring the simultaneous transmission of currents covering a band of modulation frequencies which includes deriving from said band of modulation currents single side band currents, radiating a nondirectional field corresponding to said single side band currents, and establishing a rotating field of carrier frequency.

3. The method of signalling simultaneously with a wide band of modulation currents which includes deriving from said band of modulating currents single side band currents, radiating a nondirectional field corresponding to said single side band currents, establishing a rotating field of carrier frequency, and deriving signalling currents from said fields at a point remote from the origin of said fields.

4. The method of transmitting signals covering simultaneously a band of frequencies which includes generating single phase carrier frequency currents, splitting said single phase carrier currents into two currents of quadrature phases, creating a rotating field corresponding to said currents of quadrature phases, deriving from a double side band source of modulation currents single side band currents, and creating a nondirectional field corresponding to said single side band currents.

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