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RADIO BEACON TRANSMITTER

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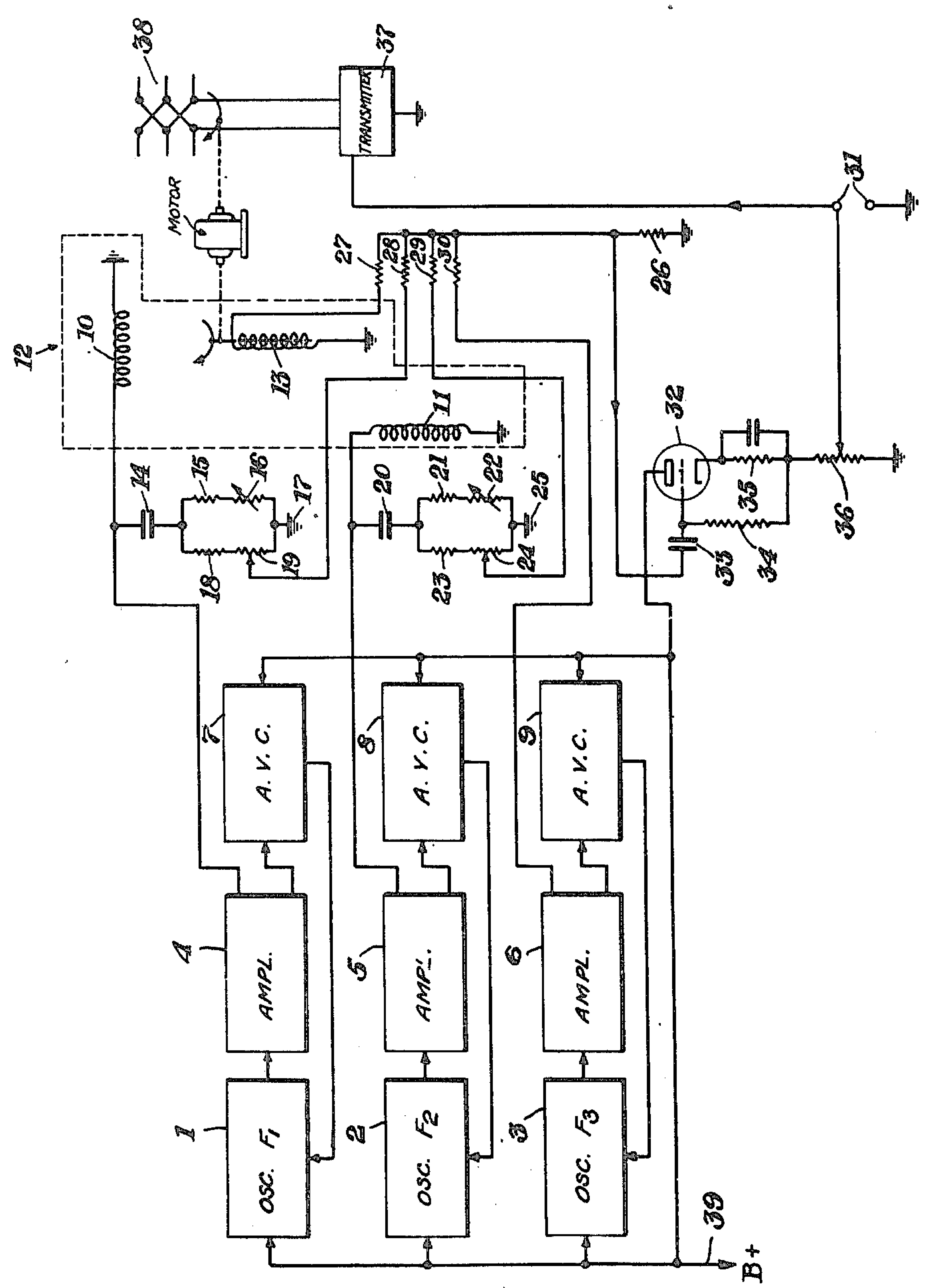

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RADIO BEACON TRANSMITTER

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This invention relates to signal combining and control circuits and more particularly to such circuits applied to radio beacon transmitters of the omnidirectional type.

The copending application of E. Labin and D. D. Grieg, Ser. No. 581,974, filed March 10, 1945, discloses a beacon system which is applicable to various modulation methods wherein a directive radio beam is rotated and which is modulated in synchronism with its rotation about the transmitter position. The modulation of the beam is such that continuous indications may be had from an indicator at the receiver station in contrast to indications by azimuth segments as in some previous systems. In order that the bearings obtained with such a system remain independent of supply voltage changes or input or output signal changes and so forth, the transmitter signals are maintained in the form of ratios rather than absolute signal values. By this means the accuracy of the system may be maintained independent of the operating parameters at either the transmitter or the receiver.

It is an object of my invention to provide for an omni-directional radio beacon system of the above-mentioned type, apparatus suitable for transmitting signal ratios from which directional information may be obtained by a receiver.

It is also an object of my invention to provide for a radio beacon system a transmitter in which the beacon signal is characterized in part by two different signal components varying in amplitude relative to one another with the rotation of the beacon beam according to sine and cosine functions respectively, the two signals being combined with a further constant amplitude signal to render these varying amplitude signals at the receiver point usable to produce indications in 360 degree angles.

It is a still further object of this invention to provide in a transmitter of the above defined type circuit means for combining two component varying amplitude signals.

Still another object is to provide in a transmitter wherein three component signals are combined, circuit means for regulating the relative phase and volume of at least two of the combining signals to obtain a properly matched combination of the component signals.

According to a feature of this invention, a beacon transmitter when used with a cross coil ratiometer indicator at the receiver, as contemplated in the above-mentioned copending application, requires a modulating composite signal varying in time according to the sum of a signal

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having a given first frequency and varying as the sine, a second signal having another given frequency and varying as the cosine, of the angle of rotation of the transmitter antenna, and a third signal having a third given frequency which has a constant amplitude, A. This may be obtained by applying the first signal to the modulating effect of a variometer, the rotary coil of which rotates in synchronism with the rotating antenna of the transmitter and producing thereby a signal whose amplitude varies sinusoidally with the rotation, as described in detail hereinbelow. This azimuth modulated signal together with the unmodulated signal obtained directly is applied to an adding circuit resulting in a signal which varies from a minimum to a maximum value and back to the minimum value with the complete rotation of the antenna.

A similar signal component is obtained from a second oscillator. In this case, however, the output of the variometer is made to vary as a cosine function. The output of a third oscillator remains at constant amplitude independent of the rotating antenna and is applied together with the previous two component signals to a common mixer device. Thus the output of the transmitter modulating unit consists of a composite signal made up of the three signals with different frequencies at constant amplitude and of two components having amplitudes varying in accordance with a sine and a cosine function respectively. The output of the modulating unit contains all the information necessary for indicating the bearings of a receiver which may be on a ship or plane. This composite signal may be applied directly to modulate the transmitter.

The variation in amplitude of two of the audio frequency signals is effected, as hereinbefore stated, by a variometer driven mechanically in synchronism with the transmitter antenna. The variometer has two stator coils physically disposed at an angle of 90° to each other and one rotary coil. Due to the physical positions of the two stator coils, the amplitude variations induced in the rotary coil are 90° out-of-phase, that is, one is a sine function and the other a cosine function of the rotary angle. The signals of varying amplitude obtained from the rotary coil and the currents of fixed amplitude obtained from the inputs to the stator coils are added in a mixing resistor to provide the required composite of the fixed and the sinusoidally varying amplitudes. Due to the fact that any voltage supplied to the stator coils will be somewhat out-of-phase with respect to the voltages induced in the rotary coil, phase adjustment controls have been provided to overcome any discrepancy of that sort. To attain accurate composite sine and cosine functions, voltage amplitude regulators have also been provided for the two voltages, components of which are to be varied in amplitude.

These and other features and objects of my invention will be better understood in connection with the detailed description of the drawing, in which the single figure represents, partly in block and partly in schematic form, the circuit diagram of a beacon transmitter incorporating my invention.

The transmitter is shown to comprise three oscillators 1, 2 and 3 producing signals at frequencies F_1, F_2, and F_3, respectively. These signals may be amplified in the respective amplifiers 4, 5 and 6 and from there applied to energize automatic volume control circuits 7, 8 and 9 which, as disclosed in my copending application L. Dubin (3), Ser. No. 586,225, filed April 2, 1945, which issued August 5, 1947 as Patent No. 2,424,972 serves to preserve the stability of the oscillator outputs. The signal voltages of the first and second oscillators, as obtained from amplifiers 4, and 5, are fed to stator coils 10 and 11 of a variometer 12. A rotary coil of the variometer 12 is indicated at 13. The inputs to the two stator coils are subjected to an adjustment in phase by means of a phase adjustment control comprised of a condenser 14 and resistors 15 and 16 in series therewith to ground at 17. Resistor 16 is shown to be adjustable to permit a variation in phase of the output voltage of the oscillator 1. In order to be able to vary the oscillator output voltage with respect to that of the other two oscillators a resistance circuit comprising a resistor 18 and a potentiometer 19 in parallel with the resistors 15 and 16 has been provided. A similar circuit including a phase adjusting circuit comprising a condenser 20, resistors 21 and 22 and an oscillator voltage regulating circuit comprising resistor 23 and a potentiometer 24 grounded at 25 are supplied for the second oscillator 2. In order to attain the composite modulating signal as required, the various signal components are combined in a mixing resistor 26. To reduce loading of each voltage source by the combined impedance of all other circuits, to reduce the voltage drop across each coil due to currents of all other voltage sources and to reduce the effects of variation of the impedance of the stator and rotary coils due to various positions of the rotary coil, each voltage source is connected to the mixing resistor 26 through an individual series resistor which is preferably high compared with the voltage source impedances. The signal output of the rotary coil 13 which combines the two varying amplitude components is applied to the mixer 26 through a resistor 27. The phase and amplitude-adjusted voltage output of the first oscillator, which at this point is of fixed amplitude, is fed to the mixer through a resistor 28, the analogous output of the second oscillator being fed through a resistor 29. The output signal component of the third oscillator is fed directly at constant amplitude to the mixing resistor 26 through a series resistor 30.

To bring the resultant composite signal up to the value required and to match a given load impedance, a cathode-follower stage is used between the mixer 26 and output terminals 31. The cathode-follower stage comprises an amplifier tube 32, the grid of which is coupled to the mixer 26 by means of a coupling condenser 33. The tube 32 is biased by a grid resistor 34, and a condenser and resistor 35 in its cathode circuit. A cathode-follower resistor 36 which may be in the form of a potentiometer serves as an output level control for the composite signal. This composite signal may then be applied as a modulating voltage to a transmitter 37 provided with an antenna 38 which is rotated in synchronism with the rotary coil 13.

In order to improve the stability of operation of the oscillator circuits and to preserve the signal ratios, automatic volume control circuits 7, 8 and 9 are preferably given a common bias from a B+ voltage supply at 39 which also serves to provide the plate potential for the three oscillators.

In operation, the constant amplitude signal output S of the three oscillators may be expressed as follows:

$$S_1 = A \text{ sine } (2\pi F_1 t)$$
$$S_2 = A \text{ sine } (2\pi F_2 t)$$
$$S_3 = A \text{ sine } (2\pi F_3 t)$$

for the three respective oscillators. As the rotary coil 13 rotates past the two stationary coils 10 and 11, it has induced therein two voltages due to the stator coil fields, which vary in amplitude sinusoidally with the rotation thereof. As already defined above, the relative 90 degree angularity of the two stator coils causes the two induced voltages in the rotary coil to be 90° out-of-phase, that is, one to be a sine and the other a cosine function of the rotary or azimuth angle. The rotary coil is therefore acting to combine the two varying amplitude signals which are applied in their combined form to the series resistor 27 in the mixer circuit. The expressions for the two amplitude varying components in the rotary coil may be represented in this form:

$$B \text{ sine } \theta \ (A \text{ sine } 2\pi F_1 t)$$

due to the first and

$$B \text{ cosine } \theta \ (A \text{ sine } 2\pi F_2 t)$$

due to the second oscillator. (In these expressions, B is the maximum amplitude of the voltage developed in the rotary coil and θ is the antenna azimuth angle.) The sum of these two signals is available in the adding circuit represented by the resistor 27. The other resistors 28, 29, and 30 of the adding circuit serve to add to this the three constant amplitude signal components as originally generated by the oscillators and as adjusted in the phase and amplitude control circuits for oscillators 1 and 2.

In order to obtain accurate composite sine and cosine functions, the fixed amplitude and the variable amplitude current components for each frequency must be in exact phase. To overcome the effect of the coil resistance which will effect a slight phase shift of the voltage induced in the rotary coil with respect to that of the stator coil, the fixed amplitude component is obtained over the phase adjusting circuit as described above, consisting of the condenser 14, the resistor 15 and the adjustable resistor 16. By proper adjustment of the respective phase, the stator voltages may be brought into phase with the corresponding rotary voltage. The resistor 16 is connected in such a way as to prevent the adjustment of circuit 15 and 16 down to zero in order to avoid a short-circuiting of the input voltage to ground.

In addition to the phase adjustment, the fixed amplitude and the maximum value of the varying amplitude for each frequency signal must be adjusted so that the latter at most is equal to or less than the former if desired sine and cosine functions are to be obtained. The relative amplitude of the currents in the rotary and the stator coils is dependent on the ratio of the turns of the coils which may be for instance 1/N. A possibility for adjusting the relative amplitudes is therefore provided so as to adjust the fixed amplitude current to approximate the desired ratio with respect to the maximum value of the varying amplitude current. The resistances 18 and 19 connected in parallel with resistors 15 and 16 serve this purpose by means of the adjustability of the resistance 19. Similarly the resistors 23 and 24 serve an analogous purpose for the second oscillator. The ratio of adjustment in the potentiometers 19 and 24, is proportional to the turns ratio, that is, 1/N, and will result in a possible variation of the fixed amplitude signal from an amplitude of zero to 1/N of the stator voltages.

The three fixed amplitude and the two varying amplitude signals are then combined in the resistor 26 through their respective series resistors 27 thru 30. The mixing resistor 26, across which the composite modulating output voltage may be obtained, is preferably high compared to that of the series resistors, in order to utilize a large portion of the developed voltage for the output. Assuming that all the fixed amplitudes and the maximum values of the varying amplitudes are adjusted to the same value A and that all signals add in phase, the sum of the five amplitudes may be expressed as follows:

$$A(1+\text{sine } \theta+1+\text{cosine } \theta+1)$$

Before the adjustment of the component signals, the composite is the sum of the following:

$$(A+AB \text{ sine } \theta) \text{ sine } (2\pi F_1 t)$$
$$(A+AB \text{ cosine } \theta) \text{ sine } (2\pi F_2 t)$$

and

$$A \text{ sine } 2 F_3 t$$

(where B is a fraction of A, depending on the turns ratio of the coils, but of course having a predetermined desired value).

It will be understood from the above, that in the description, when the quantity A is used to define the amplitude of one of the signals, the final, that is, the value of the amplitude after adjustments, is meant.

For cooperation with this beacon transmitter there is provided, as disclosed in the copending application of E. Labin, et al. (92–104), Ser. No. 581,974, filed, March 10, 1945, a radio receiver unit which will receive and detect the radio beam energy. In the output of the receiver-detector unit the three signals are then separated and applied to subtracting circuits for removing the envelope of the constant amplitude signal from the two variable amplitude signals. As a result there will be two output energies, one proportional to the sine function and the other proportional to the cosine function. These two energies may then be applied to a ratiometer to measure the ratio of the energy received thereby producing an indication of direction.

While I have described above the principles of my invention in connection with specific apparatus, it is to be clearly understood that this description is made only by way of example and not as a limitation on the scope of my invention as set forth in the objects of my invention and the accompanying claims.

I claim:

1. In a directionally shiftable radio beacon transmitter, a source of unmodulated signal having a given frequency, means for modulating the amplitude of said signal in accordance with the directional shift of said beacon, and means for mixing said unmodulated signal with the output of said last named means.

2. In a directionally shiftable radio beacon transmitter, a source of unmodulated signal having a given frequency, a variometer for modulating the amplitude of said signal including a coil rotated in synchronism with the radiation pattern of the transmitter antenna, and means for mixing said unmodulated signal with the output of said last named means.

3. In a directionally shiftable radio beacon transmitter, a source of unmodulated signal having a given frequency, means for modulating the amplitude of said signal in accordance with the directional shift of said beacon, two output resistors, one for said signal and one for said last named means, and a resistor for mixing said unmodulated signal with the output of said last named means in series with said two output resistors.

4. A transmitter in accordance with claim 3, further including an amplifying cathode-follower type output stage following said last-named resistor.

5. In a directional shiftable radio beacon transmitter, sources of two unmodulated component signals having a first and a second frequency respectively, means for combining said two signals with their amplitude ratios varying in accordance with the directional shift of said beacon, and means for mixing at least one of said unmodulated signal components with the output of said means-for-combining.

6. A transmitter in accordance with claim 5, wherein said first named means comprises a variometer having a coil rotated in synchronism with the radiation pattern of the transmitter antenna.

7. A transmitter in accordance with claim 5, wherein said means for mixing comprises a resistor for the output of said means-for-combining and one resistor each for said two signal sources, and an output mixing resistor in series with each of the other resistors.

8. A transmitter in accordance with claim 5, further including an amplifying cathode-follower type output stage.

9. A radio beacon transmitter, comprising sources of unmodulated component signals having a first, a second and a third frequency respectively, means for combining said first and second frequency signals with their amplitude ratios varying in accordance with the directional shift of said beacon, and means for mixing the output of said means-for-combining with said unmodulated first, and third component signals.

10. A transmitter in accordance with claim 9, wherein said first named means comprises a variometer having a coil rotated in synchronism with the radiative pattern of the transmitter antenna.

11. A transmitter in accordance with claim 9, wherein said means for mixing comprises a resistor for the output of said means-for-combining and one resistor each for said three signal sources, and an output mixing resistor in series with the other resistors.

12. A transmitter in accordance with claim 9, further including an amplifying cathode-follower type output stage.

13. In a rotary beacon transmitter, the combination comprising means for producing a signal having a given frequency, a second means for producing a signal having another given fre-

quency, and rotatable coupling means for combining said first and second signals in a manner to give said two signals a modulation in accordance with a sine and a cosine function respectively.

14. The combination in accordance with claim 13, wherein said means for combining comprises a variometer having two stator coils and one rotary coil, said two signals being applied to said two stator coils respectively.

15. A rotary radio beacon transmitter for producing a composite signal containing component signal functions of (A+sine θ) and (A+cosine θ) where θ is the rotating radiation pattern azimuth angle, comprising respective sources for producing signals having a first, a second and a third frequency, means for combining the first and second signals to give said first and said second signals a modulation in accordance with a sine and a cosine function respectively, means for mixing with the output of said means-for-combining said unmodulated first, second and third component signals, and means for controlling the application to said mixing means of the unmodulated first and second signals with respect to the corresponding modulated components to produce a resultant summation.

16. A transmitter in accordance with claim 15, wherein said means for controlling includes a phase adjuster for said first and said second signals, whereby in-phase mixing of the component signals is obtainable.

17. A transmitter in accordance with claim 15, wherein said means for controlling includes an amplitude adjuster for each of said two signals, whereby the maximum amplitude of the modulated components and the amplitude of the unmodulated components may be equalized.

18. In a directional shiftable radio beacon transmitter which comprises respective sources for producing a plurality of signals having given frequencies, means for producing a summation of signal components modulated in accordance with the directional shift of said beacon of a group of said plurality of signals with the unmodulated components of another group of said signals; the means for controlling the phase of the unmodulated signals, the components of which have been modulated, with respect to said corresponding modulated components; and means for controlling the voltage amplitude of said same unmodulated signals.

19. Means for controlling the phase and means for controlling the voltage amplitude in accordance with claim 18, wherein said first named means comprises a condenser and an adjustable resistor circuit in series therewith to ground and wherein said second named means comprises in said condenser a potentiometer circuit to ground.

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