May 14, 1946. W. D. McGUIGAN 2,400,127

RADIO BEACON

Filed Nov. 15, 1943 2 Sheets-Sheet 1

Fig. 1.

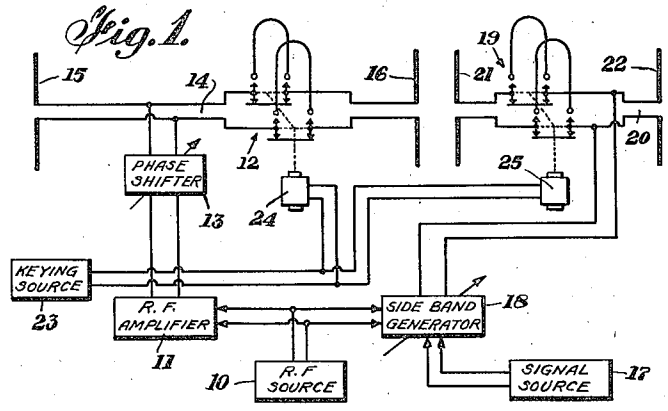
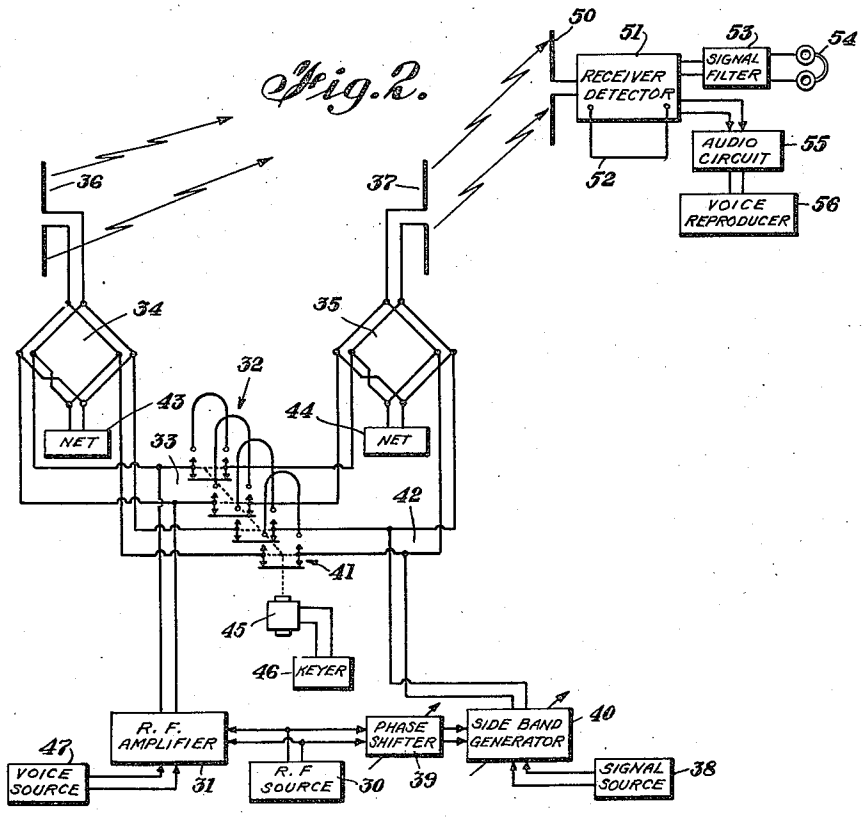


Fig. 2.



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Fig. 3.

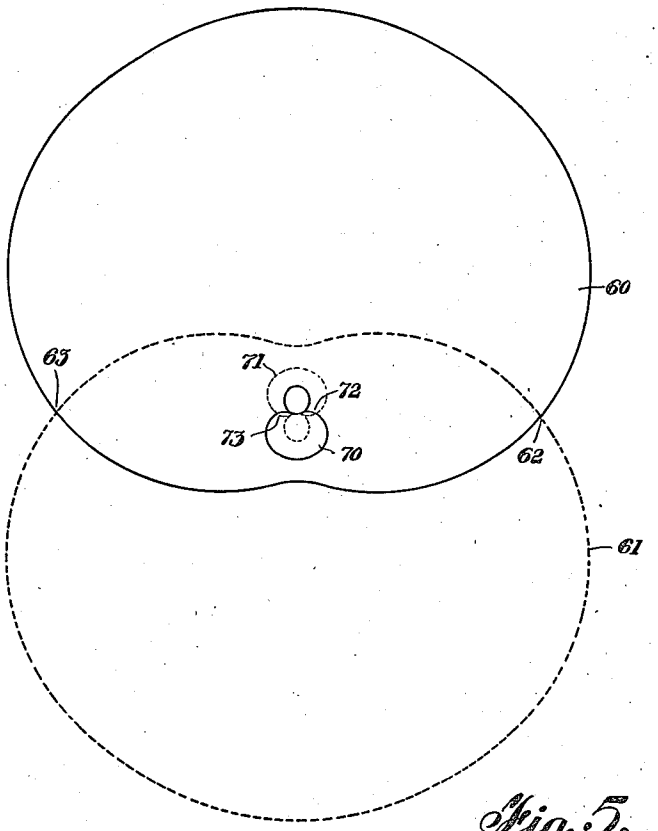


Fig. 4.

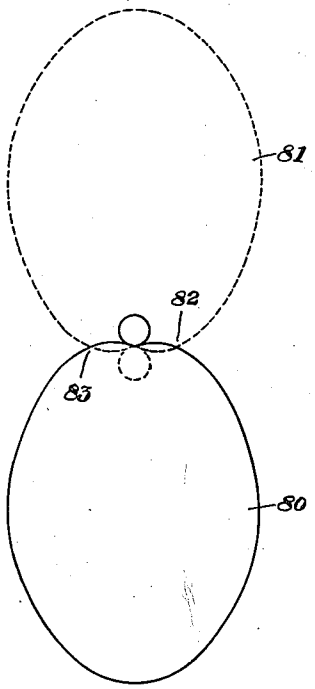
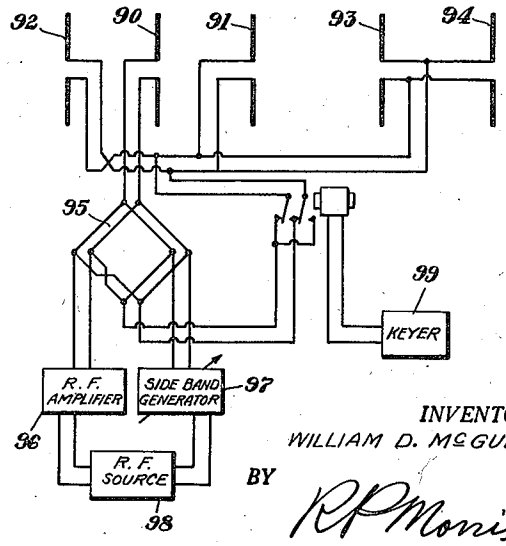


Fig. 5.



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UNITED STATES PATENT OFFICE

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RADIO BEACON

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Application November 15, 1943, Serial No. 510,265

12 Claims. (Cl. 250—11)

This invention relates to radio beacons and more particularly to radio beacons designed principally for use with indicating receivers having automatic volume control.

In radio beacon systems provided with automatic volume control radio receivers, the apparent sharpness of the course may be controlled by providing a radio beacon wherein the carrier level and the audio frequency level of the signals varies differently in amplitude in different directions about the beacon.

It is an object of my invention to provide a radio beacon which will produce a high degree of sharpness of course indication.

It is a further object of my invention to provide a radio beacon system in which there is apparent a large change in average signal level in the indicator with departure from course.

It is a still further object of my invention to provide a radio beacon system in which the carrier level of the sideband level of the signals is alternately reversed in phase and in which these levels are different one from another in different directions.

According to a feature of my invention, I provide an arrangement for producing at carrier frequency a given radiation pattern having a minimum in a predetermined direction. This minimum must be maintained at a level above zero for proper operation of the system. In conjunction with the carrier pattern, I provide a sideband pattern having a maximum aligned substantially with the minimum of the carrier pattern. These two patterns are then alternately reversed in phase to provide a pair of intersecting patterns defining a course line. On a craft using this beacon is provided a receiver having an automatic volume control, the gain of the receiver being varied proportionately with the level of the carrier energy so that the volume of the output signals will be controlled largely by the carrier energy and the directive pattern of the sideband energy. Thus, the sharpness of the course indication may be controlled by controlling the shape and position of the carrier and sideband patterns independently.

Since the course indicating signals need not reach 100% modulation level in any direction around the beacon, voice signals may be applied to modulate the carrier energy, the voice signal modulation being maintained at such a value as to produce not more than 100% modulation in combination with the course signals.

A better understanding of my invention and the objects and features thereof may be had by reference to the accompanying drawings, in which:

Fig. 1 illustrates in block diagram a simplified radio beacon circuit in accordance with my invention;

Fig. 2 illustrates in block diagram a circuit arrangement of a modified radio beacon in accordance with my invention, together with a receiver to be used therewith;

Fig. 3 illustrates a typical radiation pattern of the carrier and sideband signals from a radio beacon in accordance with my invention;

Fig. 4 illustrates the resultant indication produced in the output of a receiver by the signal patterns of Fig. 3; and

Fig. 5 illustrates a further modification of my invention showing its application to a known type of radio beacon.

Turning first to Fig. 1, 10 represents a radio frequency source supplying the carrier energy. Energy from source 10 is amplified in radio frequency amplifier 11 and applied therefrom over phase shifter 13 and line 14 and the contacts of switch 12 to the carrier frequency radiating means including antennas 15 and 16. By adjusting the feeding point of the coupling to line 14, a desired phase relation between energy in antennas 15 and 16 may be provided. Thus, for example, a radiation pattern of the type shown at 60, Fig. 3, may be obtained.

At the same time, both radio frequency energy from source 10 and signal energy from signal source 17 are applied to sideband generator 18. The signal from source 17 may be any suitable audio frequency tone, for example, 1020 cycles per second. Sideband generator 18 may be of the normal balanced modulator type so as to produce sidebands of energy and suppress substantially all the carrier therefrom. The sideband energy from generator 18 is similarly fed over switch 19 and line 20 to the sideband radiating means including antennas 21 and 22. The phasing of the sideband energy fed to antennas 21 and 22 is adjusted to produce a radiation pattern differing from the carrier radiation pattern and having a maximum substantially aligned with the minimum of the carrier radiation pattern, as indicated by curve 70 of Fig. 3. Likewise, the level of this sideband signal is maintained at a value below the minimum value of the carrier energy. To this end sideband generator 18 may be made adjustable and for the amplification in radio frequency amplifier 10, suitably controlled.

The two radiation patterns are simultaneously

alternately reversed in phase by energy from keying source 23 and relays 24 and 25 which serve to operate switches 12 and 19, respectively. Operation of these switches serves to connect into the shorter line a length of line or other phase shifting means equal electrically to twice the difference of the antenna phasing. This reverses patterns 60 and 70 into positions indicated at 61 and 71, respectively, providing intersections of equal field intensity at 62, 63 and 72, 73, as indicated. Thus, a resultant intersecting beacon pattern is provided in which the carrier energy and the sideband energy differ relatively to one another as a plane travels around the beacon. The difference in signal level and carrier level produces effectively a difference in percentage modulation of the received signals. With an automatic volume control on the receiver controlling the gain of the amplifier in accordance with carrier level, two resultant effective patterns, such as shown at 80 and 81 of Fig. 4 are produced, having intersections with one another at 82 and 83.

It is clear that in place of two antennas, such as shown at 15 and 16, some other form of directive radiator may be used and likewise a different form of radiating means may be used for the sideband energy in place of the antennas shown at 21 and 22.

In Fig. 2 is shown a further embodiment of my invention wherein two antennas are used simultaneously to produce both the carrier and the sideband radiation patterns. In this arrangement, radio frequency source 30 is coupled to amplifier 31 and over switch 32, line 33 and balancing bridges 34 and 35 to the antennas 36 and 37. The phasing of the energy supplied to antennas 36 and 37 is adjusted to provide the desired radiation pattern. Simultaneously, energy from source 30 is fed over phase shifter 39 to sideband generator 40 together with signal energy from signal source 38. From the output of sideband generator 40 the sideband energy is applied over switch 41, line 42 and bridges 34 and 35 to the same antennas 36 and 37. The phase of the sideband energy supplied to antennas 36 and 37 from the sideband generator is adjusted, however, to produce the same or a differently shaped radiation pattern from that produced by the carrier energy. Likewise, the amplitude of this sideband energy supplied to the radiators is maintained at a level below that supplied from amplifier 31 and described in connection with Fig. 1. Balancing networks 43 and 44 are connected to the terminals of bridges 34 and 35, respectively, to maintain proper balance in the bridges. The carrier and sideband radiation patterns are alternately reversed by keyer 46 and keying relay coil 45 serving to operate switches 32 and 41.

If desired, voice signals from voice source 47 may be applied to modulate the radio frequency energy in amplifier 31 so that the carrier energy will also have voice signal modulation. The degree of modulation of the carrier by the voice energy is determined by the maximum effective percentage modulation produced by the carrier and sideband patterns, i. e. by the minimum difference in level between the sideband radiation pattern and the carrier radiation pattern. It is clear that, since the directive patterns for the carrier and the sidebands are different, the percentage modulation of the beacon signals will vary around the beacon. The highest percentage modulation of the beacon signal and carrier is in line with the minimum of the carrier pattern and the maximum of the sideband pattern. Accordingly, this difference in level will determine the percentage modulation permissible in the voice signals.

In Fig. 2 is also illustrated a receiver suitable for use with beacon arrangements, such as shown in Fig. 1 or Fig. 2. This receiver includes a receiving antenna 50 and receiver-detector 51 provided with an automatic volume control lead 52 serving to control the level of energy in the receiver in accordance with the carrier energy level received. Such automatic volume control systems are well known in the art and need not be shown in detail for the purpose of illustrating this invention. In the output of the receiver is provided a signal filter 53 and a signal indicator 54 which may be simply a pair of head phones. Also, in the output of receiver 51 is provided audio circuit 55 coupled to a voice reproducer 56 for reproducing voice modulation signals.

In addition to the circuit elements and operational characteristics outlined above, it is desirable that the phase of the sideband signals, measured with respect to the suppressed carrier with which they were generated, and the carrier frequency energy be substantially cophasal or in phase opposition. If the sideband energy is substantially 90° in phase with respect to the carrier frequency energy in the receiver, harmonic distortion will take place and it will be difficult to filter out the beacon indicating signals. To this end, phase shifter 13 of Fig. 1 and phase shifter 39 of Fig. 2 are provided. These phase shifters are adjusted so that the effective carrier energy at the antennas is substantially in phase with the sideband energy supplied to the antennas.

The radiation patterns shown in Figs. 3 and 4 are calculated for a pair of antennas similar to that shown in Fig. 2. In this particular example, antennas 36 and 37 are spaced apart by distance equal to 45 electrical degrees and the carrier energy is fed to these antennas in 90° phase relationship one to the other. With this energization patterns such as shown at 60, 61 are produced having intersections at points 62 and 63. The energy supplied from the sideband generator to the two antennas 36 and 37 are phased apart 165° with respect to one another producing the modified figure 8 pattern defined by curves 70 and 71, having intersections at 82, 83. With this arrangement it is found that phase shifter 39 should be adjusted to provide a phase shift of substantially 45° in the carrier energy, as supplied to the radio frequency amplifier and the sideband generator in order to provide the proper phase relationship of the carrier and sideband energy. It should be clear, however, that this phase shift may be obtained equally well by placing the phase shifter in the output of the radio frequency amplifier, if desired, as shown in Fig. 1 or by placing the phase shifter in the output line from sideband generator 40.

With the carrier and sideband patterns of Fig. 3 the effective receiver indication patterns will be as shown in Fig. 4 at 80, 81 having intersections at points 82 and 83. Thus, with the arrangement outlined above, a course sharpness of substantially one decibel per degree departure from course may be obtained with a simple two-antenna array. It is clear that the directive pattern from either of the arrays may be modified over a wide range without departing from the scope of my invention. It is essential, however, that the carrier frequency pattern

be maintained at a level higher than the sideband frequency pattern and for this reason the antennas for the carrier frequency must be spaced apart a distance less than 180 electrical degrees. Also, the phase of the energy supplied to these units must be such that there will be no zero nulls in the directive radiation pattern. It is also clear that precautions must be taken to prevent multiple course production due to lobes of the sideband radiation pattern co-acting with the carrier radiation pattern.

In Fig. 5 is disclosed the application of my invention to a previously proposed type of radio beacon system. The radiating portion of the system comprises a central antenna **90** flanked on opposite sides with antenna units **91** and **92** coupled together in phase opposition and coupled to an unsymmetrically spaced antenna arrangement including antennas **93** and **94**. Energy is fed to the antenna **90** and to the other antenna units **91** to **94** from opposite diagonal points on a bridge network **95**. To the other bridge terminals are connected radio frequency amplifier **96** and sideband generator **97**, both supplied from a common radio frequency source **98**. The energy from sideband generator **97** is reduced to a sufficiently low level with respect to the carrier energy from amplifier **96** so that the sideband radiation pattern from the antenna system will at no place provide more than 100% modulation. Because of the transposition in one arm of the bridge **95**, the sideband and carrier patterns produced in the antenna array will be of opposite spaced distribution. Viewed in one light, this radio beacon may be considered as a special form of the beacon arrangement shown in Fig. 2 but with a more complex antenna array. In order to reverse the patterns to provide the desired beacon arrangement, the keyer **99** is provided.

It is clear that in accordance with my invention I have provided a simplified radio beacon which will produce a desired sharpness on course with a simple radiating system.

While I have described my invention in conjunction with specific forms of the apparatus, it is to be understood that this is given only by way of example and that my invention contemplates many modifications within the scope thereof as set forth in the objects of my invention and the appended claims.

What is claimed is:

1. A radio beacon comprising means for producing at carrier frequency a radiation pattern having a minimum radiation in a given direction, means for producing a signal sideband radiation pattern having a maximum radiation in said given direction, said sideband maximum being lower in amplitude than said carrier minimum, and means for alternately and simultaneously shifting similarly in phase said sideband and said radiation patterns.

2. A radio beacon according to claim 1, further comprising means for adjusting the relative phase of said carrier frequency energy and said sideband energy.

3. A radio beacon comprising two antenna means, means for energizing said two antenna means with carrier frequency energy, means for phasing the carrier frequency supplied to said two antenna means to produce a radiation pattern having a minimum in a predetermined direction, means for simultaneously energizing said two antenna means with sideband energy, means for phasing the sideband energy supplied to said two antenna means to produce a sideband radiation pattern having a maximum in said predetermined direction, means for adjusting the relative amplitudes of said carrier and sideband energy to maintain said sideband energy maximum at a lower value than said carrier minimum, and means for simultaneously reversing the phase of said carrier and sideband energy supplied to said alternate means.

4. A radio beacon according to claim 3, further comprising means for adjusting the relative phase between said carrier frequency energy and said sideband energy.

5. A radio beacon according to claim 3, further comprising a voice frequency source, and means for modulating said carrier frequency energy with energy from said voice source.

6. A radio beacon guiding system having a receiver provided with automatic volume control variable proportionally with the level of carrier of the received signals, and a course indicator for receiving and comparing the course signals, in combination with a radio beacon, comprising two antenna means, means for energizing said two antenna means with carrier frequency energy, means for phasing the carrier frequency supplied to said two antenna means to produce a radiation pattern having a minimum in a predetermined direction, means for simultaneously energizing said two antenna means with sideband energy, means for phasing the sideband energy supplied to said two antenna means to produce a sideband radiation pattern having a maximum in said predetermined direction, means for adjusting the relative amplitudes of said carrier and sideband energy to maintain said sideband energy maximum at a lower value than said carrier minimum, and means for simultaneously reversing the phase of said carrier and sideband energy supplied to said alternate means, whereby the course indications are relatively sharp.

7. A radio beacon guiding system having a receiver provided with automatic volume control variable proportionally with the level of carrier of the received signals, and a course indicator for receiving and comparing the course signals, in combination with a radio beacon, comprising means for producing a radiation pattern at carrier frequency having a minimum radiation in a given direction, means for producing a signal sideband radiation pattern having a maximum radiation in said given direction, said sideband maximum being lower in amplitude than said carrier minimum, and means for alternately and simultaneously reversing said sideband and said radiation patterns, whereby the course indications are relatively sharp.

8. A radio beacon system according to claim 7, further comprising phase control means in said beacon for controlling the relative phase displacement of said carrier frequency energy and said sideband energy.

9. A radio beacon system according to claim 7, further comprising voice signal output means and means for segregating said course signals and said voice signals in said receiver, and a voice frequency source, and means for modulating said carrier frequency with said voice signals at said beacon.

10. A method of providing a beacon for course indication, comprising producing a radiation pattern at carrier frequency having a minimum radiation in a given direction, producing a signal sideband radiation pattern having a maximum radiation in said given direction, said side-

band maximum being lower in amplitude than said carrier minimum, and alternately and simultaneously shifting similarly in phase the sideband and carrier frequency radiation patterns.

11. A method according to claim 10, further comprising adjusting the relative phase of said sideband and said carrier frequency energies to provide substantially cophasal relationship in said radiation pattern.

12. A method of providing a radio beacon by radiation from two antenna means spaced apart less than 180 electrical degrees, comprising energizing said antenna means with carrier energy, phasing the carrier energy supplied to said antenna means to provide a radiation pattern having a minimum greater than zero in a predetermined direction, simultaneously energizing said two antenna means with sideband energy, phasing said sideband energy supplied to said two antenna means to provide a radiation pattern having a maximum aligned with said minimum, controlling the relative amplitudes of said carrier and sideband energy so that said maximum is less than said minimum, and alternately simultaneously reversing the phase of the energies applied to said two antenna means.

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