Dec. 30, 1947. C. W. EARP 2,433,351

RADIO BEACON

Filed Aug. 11, 1943 2 Sheets-Sheet 1

FIG. 1.

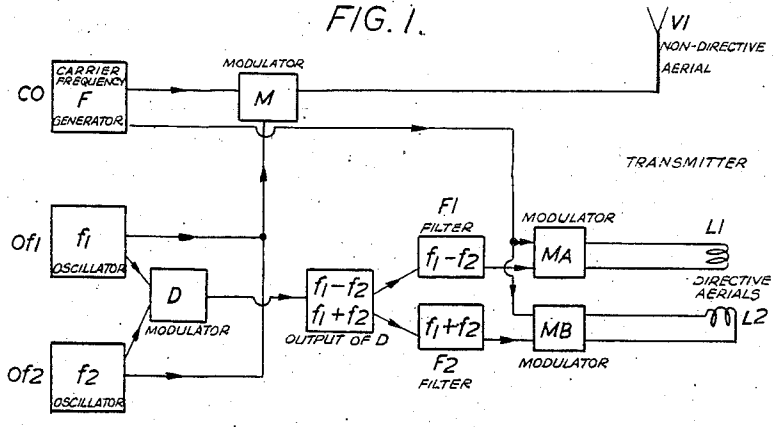


FIG. 2a.

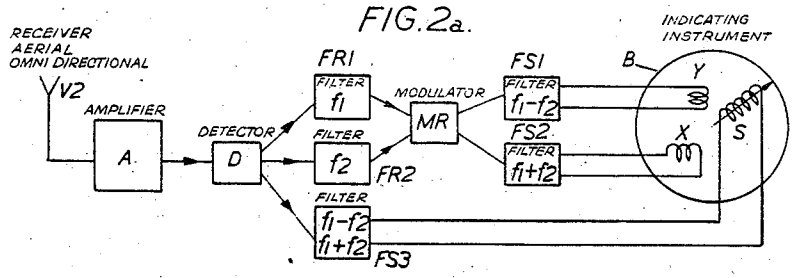


FIG. 2b.

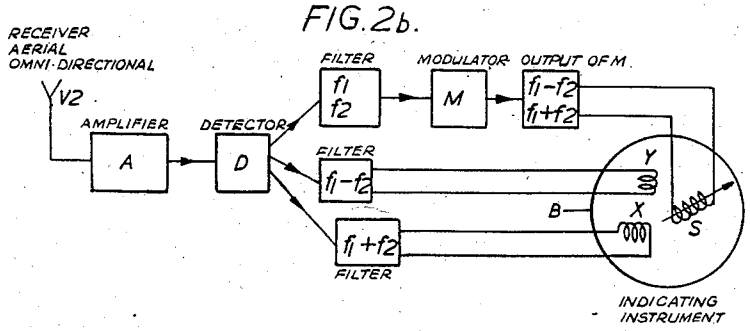
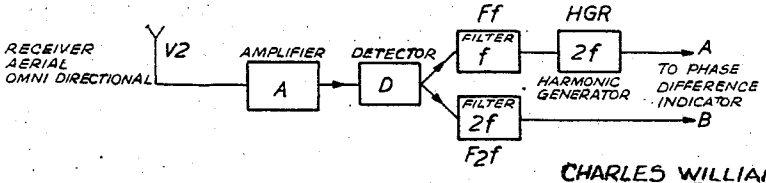


FIG. 4.



Inventor
CHARLES WILLIAM EARP
By
Edward D. Kinney
Attorney

Dec. 30, 1947. C. W. EARP 2,433,351

RADIO BEACON

Filed Aug. 11, 1943 2 Sheets-Sheet 2

FIG.3.

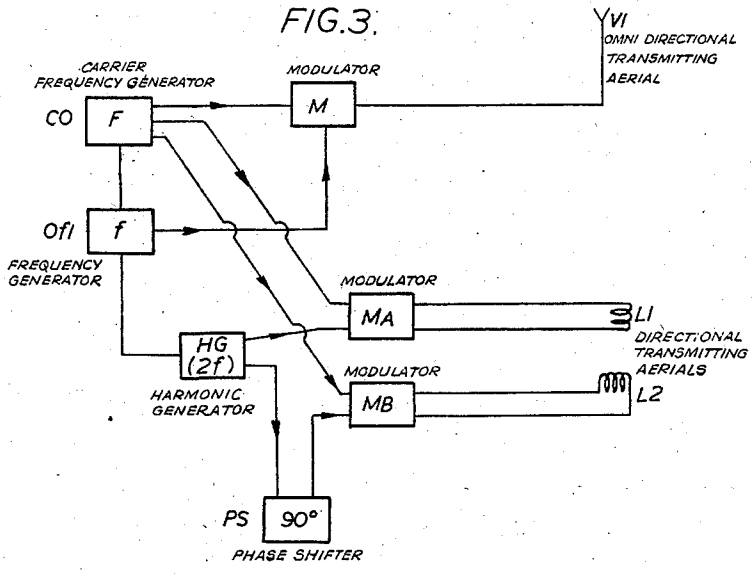


FIG.5.

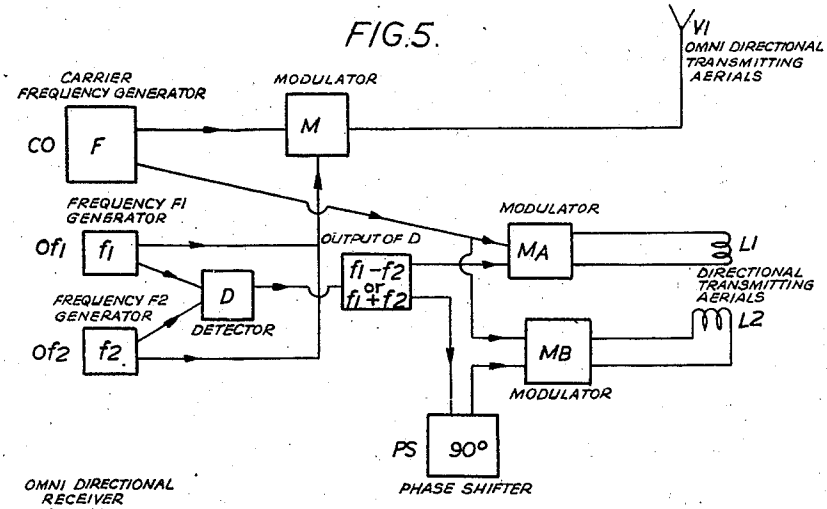
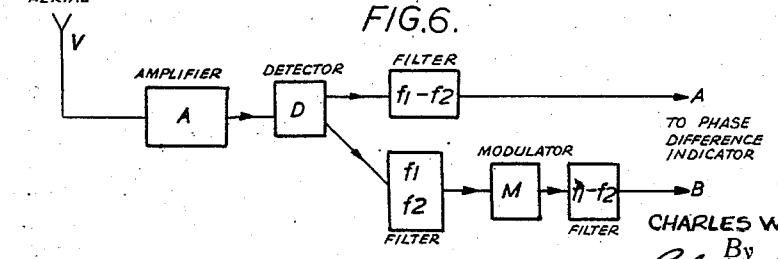


FIG.6.



Inventor
CHARLES WILLIAM EARP
By
Edward D. Kinney
Attorney

Patented Dec. 30, 1947 2,433,351

UNITED STATES PATENT OFFICE

2,433,351

RADIO BEACON

Charles William Earp, London, England, assignor, by mesne assignments, to International Standard Electric Corporation, New York, N. Y., a corporation of Delaware

Application August 11, 1943, Serial No. 498,197
In Great Britain February 23, 1940

Section 1, Public Law 690, August 8, 1946
Patent expires February 23, 1960

16 Claims. (Cl. 250—11)

1

The present invention relates to a two-tone radio beacon, the true geographic bearing of which can be obtained on a mobile vehicle on a directly reading indicator. In a known system, two separate transmissions are necessary, and two receivers are required on the vehicle. It is the object of the present invention to provide a two-tone beacon which requires one transmission carrier wave only, and one receiver.

In the known system, a carrier wave is applied to an omni-directional aerial, and is modulated also by two tones of frequencies f_1 and f_2 in separate modulators, the outputs from which are applied to two directive aerials. A comparison of the relative levels of the two modulations (both in amplitude and sense of phase) at the mobile receiver gives a direct indication of the bearing. It is necessary, however, to radiate a "comparison" transmission in which the two tones are sent out omni-directionally, and this necessitated a second carrier frequency to be used. According to the present invention two auxiliary tones are radiated omni-directionally as sidebands of the original carrier wave, and the comparison tones are derived from these two auxiliary tones.

The invention will be better understood from the following description taken in conjunction with the accompanying drawings in which:

Fig. 1 shows diagrammatically the circuit arrangements of the transmitter according to the invention.

Figs. 2*a* and 2*b* show diagrammatically circuit arrangements of two receivers for working in conjunction with the transmitter shown in Fig. 1;

Fig. 3 shows the arrangement of Fig. 1 modified for the case in which $f_1=f_2$, but a phase displacement is given to one of the modulating components, hence producing in effect a rotating beacon;

Fig. 4 shows a modified form of receiver for use in conjunction with the transmission system of Fig. 3;

Fig. 5 shows diagrammatically the circuit arrangements of a transmitter of another embodiment of the invention; and

Fig. 6 shows the circuit arrangements for a receiver for use in conjunction with the transmitter shown in Fig. 5.

Referring to Fig. 1, the carrier frequency F from generator CO is modulated in modulator M by both low frequencies f_1 and f_2 generated in oscillators Of_1 and Of_2 and represented respectively by $e_1 \sin 2\pi f_1 t$ and $e_2 \sin 2\pi f_2 t$, the

2

output from modulator M, containing both carrier and sidebands being applied to an omni-directional aerial V1.

The two low frequencies f_1 and f_2 from oscillators Of_1 and Of_2 are also combined in a modulator D to give two derived frequencies (f_1-f_2) and (f_1+f_2) which are filtered from each other in filters F1 and F2 before each is applied with carrier frequency wave to modulators MA and MB respectively. The outputs from MA and MB, each composed of two sidebands, are applied to two directional aerial systems L1 and L2 which each have "figure of eight" directive characteristics arranged perpendicularly to each other.

Figs. 2*a* and 2*b* show suitable receivers for the beacon transmission of Fig. 1. Figs. 2*a* and 2*b* are so similar that Fig. 2*a* only will be explained in detail. The modulated waves are received on a single omni-directional antenna V2 and are amplified in amplifier A from which the output is applied to a detector D from which the four modulation frequencies f_1, f_2, f_1-f_2 and f_1+f_2 are produced. Frequencies f_1 and f_2 are selected by filters FR1 and FR2 respectively and passed to a modulator MR which produces two derived frequencies f_1-f_2 and f_1+f_2. These derived frequencies are filtered by filters FS1 and FS2 respectively and applied to the field coils Y, X of the indicator B respectively.

The frequencies f_1-f_2 and f_1+f_2 produced in the detector D are filtered out by filter FS3 and applied to the third windings S of the indicator B.

The amplitude of the received frequency f_1-f_2 will depend on the position of the receiver with respect to the field pattern of the antenna L1 and the amplitude of the received frequency f_1+f_2 will depend on the position of the receiver with respect to the field pattern of the antenna L2. Voltages at these two frequencies and at the relative values depending on the position of the receiver are delivered by the filter FS3 to the deflected member S of the indicator B. The windings X and Y at right angles to each other are supplied by the derived frequencies f_1-f_2 and f_1+f_2 from the modulator MR. These frequencies have equal amplitude, since they are derived from the modulation on the omni-directional antenna V1. The result is that the deflected member S will assume a rotational position with respect to the deflecting members X and Y which will be determined by the relative amplitudes of the frequencies in the winding S.

Alternatively, as shown in Fig. 2*b* the derived frequencies (f_1+f_2) and (f_1-f_2) may be applied

to the winding S of the indicator B, and the sum frequency (f_1+f_2) applied to one stationary winding X and the difference frequency (f_1-f_2) to the other stationary winding Y. Here the relative amplitudes of the frequencies in the windings X and Y will depend on the position of the receiver with respect to the field patterns of antennas L1 and L2 while the derived frequencies applied to the member S are equal. However the same result of positioning the member S will be obtained. After the description of Fig. 2*a* the arrangement shown in Fig. 2*b* is considered to be self-explanatory and requires no further description.

Reverting to Fig. 1, if the carrier frequency is F, the carrier wave is represented by E sin $2\pi Ft$, the total omni-directional transmission can be represented by: E sin $2\pi Ft+e_1$ sin $2\pi Ft$ sin $2\pi f_1 t+e_2$ sin $2\pi Ft$ sin $2\pi f_2 t$

The directional transmissions are:

R sin $2\pi Ft$ sin $2\pi(f_1-f_2)t$ from MA and L1

and R sin $2\pi Ft$ sin $2\pi(f_1+f_2)t$ from, MB and L2 in which R is a constant depending upon E, e_1 and e_2.

At the receiver which is in a direction making an angle θ with the direction of zero transmission from the directional aerial L1 fed by MA the received signal is proportional to:

$$E \sin 2\pi Ft+e_1 \sin 2\pi Ft \sin 2\pi f_1 t+$$
$$e_2 \sin 2\pi Ft \sin 2\pi f_2 t+R \sin 2\pi Ft \sin 2\pi(f_1-f_2)t \sin\theta+$$
$$R \sin 2\pi Ft \sin 2\pi(f_1+f_2)t \sin\left(\theta+\frac{\pi}{2}\right)$$

On detection in the receiver of Fig. 2*a*, the output will contain components at frequencies f_1, f_2, f_1-f_2, f_1+f_2 in the following proportions:

f_1,	e_1
f_2,	e_2
f_1-f_2,	$R \sin\theta$
f_1+f_2,	$R \sin\left(\theta+\frac{\pi}{2}\right)$

The components f_1-f_2 and f_1+f_2 are applied to the moving coil of a dynamometer type indicator, which takes up an angle φ with one field coil.

The components f_1 and f_2 are applied to the modulator MR which delivers two components which are or are arranged to be of equal intensity at (f_1-f_2) and (f_1+f_2) to the field coils Y and X.

For equilibrium of the indicator:

$$\sin\theta \sin\left(\phi+\frac{\pi}{2}\right)=\sin\left(\theta+\frac{\pi}{2}\right)\sin\phi$$

$$\therefore \theta=\phi$$

Thus, the true bearing of the mobile can be read off directly from the indicator.

The same principle for sending a comparison signal on the same transmission carrier wave may also be applied to the special case where the same frequency is used to modulate the signal applied to each directive aerial of the transmitter. In this case the modulating wave has different phase for the two modulators MA and MB. The effect is exactly equivalent to the rotation of a single directive aerial at the modulating frequency and the invention may be applied to such system.

This modification of Fig. 1 is shown in Fig. 3, where f_1 and f_2 of Fig. 1 have both become f, so that $f_1+f_2=2f$ and $f_1-f_2=0$. In Fig. 3 the carrier frequency F and frequency f are combined

in M, and the non-directional radiation from V1 can be represented by:

$$E \sin 2\pi Ft+e \sin 2\pi Ft \sin 2\pi ft$$

where the wave of frequency f is represented by $e \sin 2\pi ft$.

The low frequency wave of frequency f is also doubled in frequency in harmonic generator HG, and the double frequency $2f$ is split into diphase current before application to the modulators MA and MB. For this purpose a portion of the output from harmonic generator HG is applied directly to modulator MA and another portion is passed to a 90 degree phase shifter PS before application to modulator MB.

The directional radiation can be represented by:

$R_1 \sin 2\pi Ft \sin 4\pi ft$ from MA, or L1

and

$$R_1 \sin 2\pi Ft \sin\left(4\pi ft+\frac{\pi}{2}\right)$$ from MB or L2,

R_1 being the amplitude of the wave.

Fig. 4 shows the modified form of receiver which is used with the transmission system shown in Fig. 3. The waves received from omni-directional antenna V2 are amplified in amplifier A and detected in detector D in the output of which are the frequencies f and $2f$. These frequencies are filtered out separately by filters Ff and F2f and the frequency f is doubled in harmonic generator HGR and the outputs at A and B from harmonic generator HGR and filter F2f are applied to a suitable phase difference indicator.

In the distance, at an angle θ from the direction of zero transmission from antenna L1, the total signal picked up by the receiver shown in Fig. 4 is proportional to:

$$E \sin 2\pi Ft+e \sin 2\pi Ft \sin 2\pi ft+$$
$$R_1 \sin 2\pi Ft \sin 4\pi ft \sin\theta+$$
$$R_1 \sin 2\pi Ft \sin\left(4\pi ft+\frac{\pi}{2}\right)\sin\left(\theta+\frac{\pi}{2}\right)$$

The low frequency output from detector D contains components of f and $2f$ and this latter can be represented by:

$$K\left[e \sin 2\pi ft+R_1 \sin 4\pi ft \sin\theta+\right.$$
$$\left.R_1 \sin\left(4\pi ft+\frac{\pi}{2}\right)\sin\left(\theta+\frac{\pi}{2}\right)\right]=$$
$$K[e \sin 2\pi ft+R_1 \cos(4\pi ft-\theta)]$$

where K is a constant depending upon E, e and R_1. The output from harmonic generator HGR is

$$K1 \sin^2 2\pi ft=\frac{K^1}{2}(1-\cos 4\pi ft)$$

where K1 is a constant.

The outputs at A and B, of frequency $2f$, therefore differ in phase by $(\pi-\theta)$, so that a phasemeter actuated by them can be arranged to give a direct indication of the bearing of the transmitter.

As there are innumerable possible ways of sending the necessary "comparison signal" as modulation of the carrier wave, another particular case is shown in Fig. 5. In this case the omni-directional carrier F is modulated by f_1 and f_2, and the directional antennae L1L2 are fed by sidebands derived from (f_1-f_2) or (f_1+f_2) and that same wave dephased by

$$\frac{\pi}{2}$$

respectively.

A suitable receiver is depicted in Fig. 6, the outputs from A and B being applied to a phase difference indicating meter. It is considered that these two figures are self-explanatory after the foregoing description and that no detailed description is necessary.

In all the systems described hereinbefore, there is a possible source of error in the receiving equipment, namely, the generation of tones in the low frequency detector in incorrect proportions, due to non-linearity of detection. In Fig. 2*a* for example, the output of detector D may contain frequencies (f_1-f_2) and (f_1+f_2) due, not only to the modulation of the directive signals, but to the modulation frequencies f_1 and f_2. Such an effect will, of course, be minimised by careful design of apparatus, and also by the use of less intense modulation by f_1 and f_2 than by (f_1-f_2) and (f_1+f_2).

A still further refinement is provided by the use of a different relationship between modulation frequencies for the directive and comparison or omni-directional sidebands. For example, if f_1 and f_2 are used to modulate the omni-directional carrier F, then the frequencies $2(f_1-f_2)$ and $2(f_1+f_2)$ may be derived for modulation of the directive radiations, by first generating the harmonics $2f_1$ and $2f_2$, then beating together to produce $2(f_1-f_2)$ and $2(f_1+f_2)$.

The receiver would be modified in a similar manner, the low frequencies $2(f_1-f_2)$ and $2(f_1+f_2)$ being both applied to the deflected member of the indicator, and the equal amplitudes of $2(f_1-f_2)$ and $2(f_1+f_2)$ for the deflecting members being derived from f_1 and f_2 as in the transmitter.

Though in the description hereinbefore given the carrier wave has been modulated by low frequencies, the scope of the invention is not confined to the use of valve modulators.

In order to maintain the high degree of balance between the modulators MA and MB of Fig. 1 without the use of automatic correction circuits, so that the field pattern radiated does not vary, it is possible to use the mechanical form of modulator. Applied to the system of Fig. 1, four mechanical modulators would be used, geared together for relative speeds of rotation of f_1, f_2, f_1-f_2, and f_1+f_2.

The system should preferably use double sidebands for each modulation, as in this case there is less likely to be phase distortion of the low frequency waves produced in the receiver. The scope of the invention is, however, not confined to the use of double sideband transmissions.

As in the known arrangements the omni-directional carrier may be modulated by speech or other intelligence, simultaneously with the normal navigation service.

What is claimed is:

1. A radio beacon system for obtaining directly on a mobile receiver the angular position with respect to the transmitting station comprising means to generate a single radio frequency carrier wave, means to generate a plurality of low frequency waves, means to modulate the single radio frequency carrier wave by a pair of low frequency waves, means for radiating omni-directionally at least one of the sidebands corresponding to the pair of waves, means for modulating the carrier frequency with two waves from at least one other low frequency wave, an angularly related directive aerial system and means connecting one modulator of the other low frequency wave to one directive aerial and the other

modulator to another directive aerial for radiating the sidebands corresponding to the other of the low frequency waves.

2. A radio beacon system as claimed in claim 1 comprising at a receiver means for obtaining the sideband frequencies radiated from the directive antennae, means for applying said sideband frequencies to the deflecting members of an indicating instrument, means for obtaining the sideband frequencies from the omni-directional antenna, means for deriving from these last mentioned side band frequencies the same sideband frequencies as those from the directive antennae and for applying the derived sideband frequencies to the deflected member of the indicator.

3. A radio beacon comprising means for modulating a carrier wave of frequency F by two low frequencies f_1 and f_2 an omni-directional antenna system for radiating the modulated carrier frequency, means for applying the two frequencies f_1, f_2 to a detector thereby producing at the output thereof two resulting frequencies (f_1+f_2) and (f_1-f_2), means for applying said frequencies (f_1+f_2) and (f_1-f_2) separately to modulate carrier frequency F, means for radiating the sidebands thus produced from two directive antenna systems, whose directive axes are angularly related to each other, means at a receiver for receiving the radiated waves on a single antenna, means for amplifying and detecting the received waves, means for separating out the frequencies f_1 and f_2 from the detected products and for applying said frequencies f_1, f_2 to a modulator to derive frequencies (f_1+f_2) and (f_1-f_2), means for applying the derived frequencies (f_1+f_2) and (f_1-f_2) respectively to the deflecting members of an indicating instrument, means for separating the frequencies (f_1-f_2) and (f_1+f_2) from the output of said detected products and means for applying these latter frequencies (f_1-f_2) and (f_1+f_2) to the deflected member of said indicating instrument.

4. A radio beacon as claimed in claim 3 in which at the receiver the derived frequencies (f_1+f_2) and (f_1-f_2) are applied together to the deflected member of an indicating instrument and the frequencies (f_1+f_2) and (f_1-f_2) obtained directly from the detected received waves are applied separately to the deflecting members of said indicating instrument.

5. A radio beacon system comprising means for modulating a carrier wave frequency F by two low frequencies f_1, f_2 an omni-directional antenna system for radiating the modulated frequency F, a detector to which the frequencies f_1, f_2 are applied to produce one of the sum and difference frequency products (f_1-f_2), (f_1+f_2) from the output thereof, means for modulating carrier frequency F with a portion of the output of said detector, and for radiating the resulting modulated carrier from one of two angularly related directive systems, a phase shifter to which another portion from the output of said detector is applied to shift the phase thereof 90°, means for applying the phase shifted frequency to modulate carrier frequency F and means for radiating the resulting modulated frequency from the other of said two angularly related systems, and at a receiver a single antenna for receiving said radiated waves, means for amplifying and detecting said waves to obtain therefrom the said one of the sum and difference products (f_1-f_2), (f_1+f_2), means for applying said one frequency to one member of a phase difference indicator, means for separating the frequencies f_1 and f_2 out from

the detected products of the receiver, a modulator to which these frequencies f_1 and f_2 are applied, means for obtaining the said one frequency from the output of said modulator and for applying the said one frequency so obtained to the other member of said phase difference indicator.

6. A radio beacon system comprising means for modulating a carrier frequency F by two low frequencies f_1 and f_2, an omni-directional antenna system for radiating the modulated carrier frequency, directive antenna systems for radiating the frequencies $2(f_1-f_2)$ and $2(f_1+f_2)$ respectively, a single antenna on a mobile receiver for receiving said radiated frequencies, means for amplifying and detecting the received waves, means for separating out the frequencies f_1 and f_2 from the detected products and for applying said frequencies f_1 and f_2 to a modulator to produce frequencies (f_1+f_2) and (f_1-f_2), means for doubling said frequencies (f_1+f_2) and (f_1-f_2) to produce the frequencies $2(f_1+f_2)$ and $2(f_1-f_2)$, and means for applying these doubled frequencies to the deflected member of an indicating instrument, means for separating frequencies $2(f_1+f_2)$ and $2(f_1-f_2)$ out from the said detected products and for applying them respectively to the deflecting members of said indicating instrument.

7. A radio beacon system as claimed in claim 1 comprising at a receiver an indicating instrument having deflecting members and a deflected member, means for obtaining the sideband frequencies radiated from the directive antennae, means for applying said sideband frequencies to either said deflecting members or said deflected member, means for obtaining the sideband frequencies from the omni-directional antenna, means for deriving from these last-mentioned sideband frequencies the same sideband frequencies as those from the directive antennae, and means for applying said derived sideband frequencies to whichever of said deflecting members or deflected member said first mentioned sideband frequencies have not been applied.

8. A radio beacon system for obtaining directly on a mobile receiver the angular position (bearing or direction) with respect to the transmitting station comprising means for radiating omni-directionally a carrier frequency F modulated with frequencies f_1 and f_2 means for radiating two directive beams angularly related to each other of said carrier F angularly related to each other and modulated by two auxiliary frequencies derived from f_1 and f_2, and at the receiver means for obtaining from said auxiliary frequencies the two frequencies f_1 and f_2, and means for utilizing the obtained frequencies for comparison with the corresponding received frequencies f_1, f_2 from the omni-directionally transmitted beam.

9. A radio beacon system for obtaining directly on a mobile receiver the angular position with respect to the transmitting station comprising means to generate a single radio frequency carrier wave, means to generate a plurality of low frequency waves, means to modulate a single radio frequency carrier wave by a plurality of low frequency waves, means for radiating omni-directionally at least one of the sidebands corresponding to two of these waves, means for modulating the carrier frequency with two other low frequency waves, an angularly related aerial system for radiating at least two beams, and means connecting one modulator of the other low frequency waves to one directive aerial and the other modulator to another directive aerial for radiating from each of the angularly related directive aerials a beam corresponding to the other of the low frequency waves.

10. A radio beacon system for obtaining directly on a mobile receiver the angular position (bearing or direction) with respect to a transmitting station comprising an omni-directional radiating means, means to generate a carrier frequency F, means to generate frequencies f_1 and f_2, means to modulate the carrier frequency with frequencies f_1 and f_2, means for radiating two directive beams angularly related to each other, means deriving two auxiliary frequencies from frequencies f_1 and f_2, means modulating said carrier frequency F by each of the two auxiliary frequencies derived from frequencies f_1 and f_2, connections from one modulator of an auxiliary frequency with one of the directive radiating means and from the modulator of the other auxiliary frequency to the other directive radiating means, and at the receiver, means for obtaining said auxiliary frequencies from the two received frequencies f_1 and f_2, and means for utilizing the obtained frequencies for comparison with the corresponding received auxiliary frequencies from the directionally transmitted beam.

11. A radio beacon system for obtaining directly on a mobile receiver the angular position (bearing or direction) with respect to the transmitting station comprising an omni-directional radiating means, means to generate a carrier frequency F, means to generate frequencies f_1 and f_2, means to modulate the carrier frequency with frequencies f_1 and f_2, means for radiating two directive beams angularly related to each other, means generating two auxiliary frequencies derived from frequencies f_1 and f_2 means modulating said carrier frequency F by each of the two auxiliary frequencies derived from frequencies f_1 and f_2, connections from one modulator of an auxiliary frequency with one of the directive radiating means and from the modulator of the other auxiliary frequency to the other directive radiating means.

12. A radio beacon system for obtaining directly on a mobile receiver the angular position (bearing or direction) with respect to the transmitting station comprising an omni-directional radiating means, means to generate a carrier frequency F, means to generate frequencies f_1 and f_2, means to modulate the carrier frequency with frequencies f_1 and f_2, means for radiating two directive beams angularly related to each other, means generating two auxiliary waves derived from frequencies f_1 and f_2 and having a frequency differing therefrom, means modulating said carrier frequency F by each of the two auxiliary waves derived from frequencies f_1 and f_2, connections from one modulator of an auxiliary wave with one of the directive radiating means and from the other modulator to the other directive radiating means, and at the receiver, means for obtaining from said auxiliary frequencies the two frequencies f_1 and f_2, and means for utilizing the obtained frequencies for comparison with the corresponding received frequencies f_1, and f_2 from the omni-directionally transmitted beam.

13. A radio beacon system for obtaining directly on a mobile receiver the angular position (bearing or direction) with respect to the transmitting station comprising an omni-directional radiating means, means to generate a carrier frequency F, means to generate frequencies f_1 and f_2, means to modulate the carrier frequency with frequencies f_1 and f_2, means for radiating two directive beams angularly related to each other,

means generating two auxiliary waves derived from frequencies f_1 and f_2 and having a frequency differing therefrom, means modulating said carrier frequency F by each of the two auxiliary waves derived from frequencies f_1 and f_2, and connections from one modulator of an auxiliary wave with one of the directive radiating means and from the other modulator to the other directive radiating means.

14. A radio beacon system for obtaining directly on a mobile receiver the angular position (bearing or direction) with respect to the transmitting station comprising an omni-directional radiating means, means to generate a carrier frequency F, means to generate at least one modulating frequency, means to modulate the carrier frequency with each modulating frequency, means for radiating two directive beams angularly related to each other, means generating two auxiliary waves derived from the modulating frequency and having a frequency differing therefrom, means modulating said carrier F by each of the two auxiliary waves, and connections from one modulator of an auxiliary wave with one of the directive radiating means and from the other modulator to the other directive radiating means.

15. A radio beacon system for obtaining directly on a mobile receiver the angular position (bearing or direction) with respect to the transmitting station comprising an omni-directional radiating means, means to generate a carrier frequency F, means to generate at least one modulating frequency, means to modulate the carrier frequency F with each modulating frequency, means for radiating two directive beams angularly related to each other, means generating two auxiliary waves derived from at least one modulating frequency and having a frequency differing from the latter, means modulating said carrier frequency F by each of the two auxiliary waves, connections from one modulator of an auxiliary wave with one of the directive radiating means and from the other modulator of an auxiliary wave to the other directive radiating means, and at the receiver, means for obtaining said auxiliary waves, and means for utilizing the obtained waves for comparison with the received modulating frequency from the omni-directionally transmitted beam.

16. A radio beacon system for obtaining directly on a mobile receiver the angular position (bearing or direction) with respect to the transmitting station comprising an omni-directional radiating means, means to generate a carrier frequency F, means to generate at least one modulating frequency, means to modulate the carrier frequency F with each modulating frequency, means for radiating two directive beams angularly related to each other, means generating two auxiliary waves derived from at least one modulating frequency and having a frequency differing from the latter, means modulating said carrier frequency F by each of the two derived auxiliary waves, connections from one modulator of an auxiliary wave with one of the directive radiating means and from the other modulator of an auxiliary wave to the other directive radiating means.

CHARLES WILLIAM EARP.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,922,677	Greig et al.	Aug. 15, 1933
2,129,004	Greig	Sept. 6, 1938
2,252,699	Byrne	Aug. 19, 1941
2,253,958	Luck	Aug. 26, 1941
1,815,246	Englund	July 21, 1931

FOREIGN PATENTS

Number	Country	Date
525,182	Great Britain	Aug. 22, 1940