June 1, 1943. F. G. KEAR 2,320,521

RADIO BEACON SYSTEM

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Fig. 1

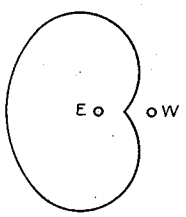


Fig. 2

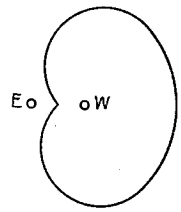


Fig. 3

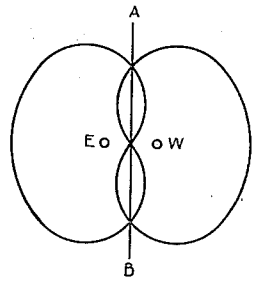


Fig. 4

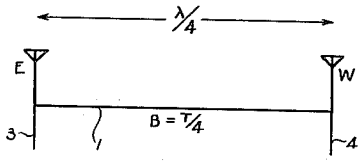


Fig. 5

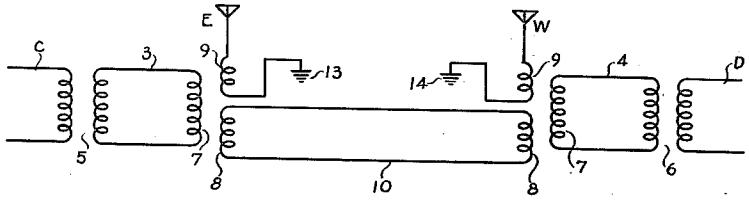


Fig. 6

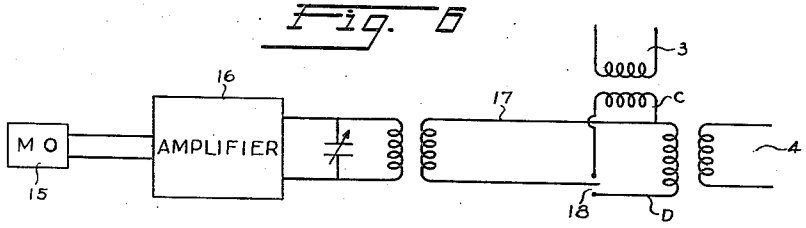
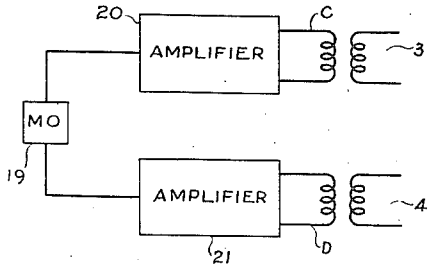


Fig. 7



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RADIO BEACON SYSTEM

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Fig. 8

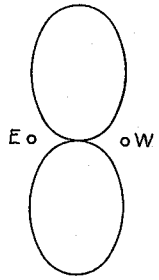


Fig. 9

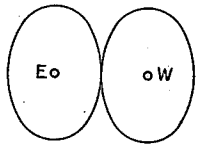


Fig. 10

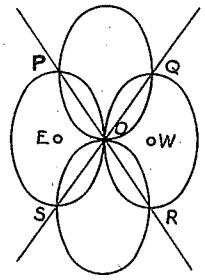


Fig. 11

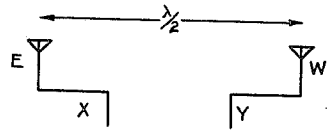


Fig. 12

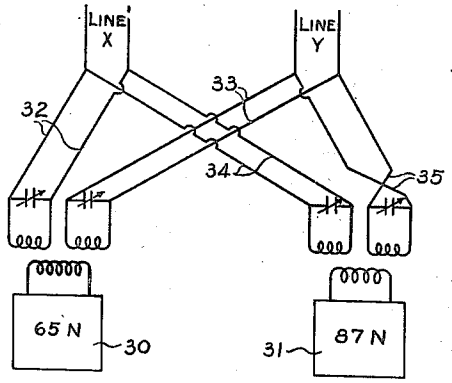


Fig. 13

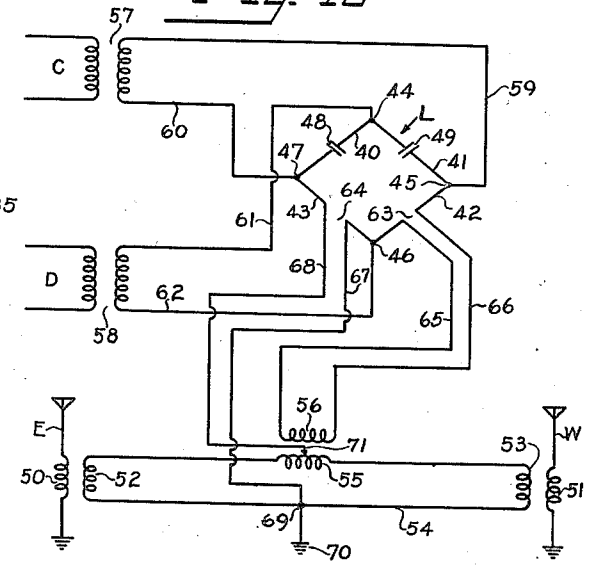
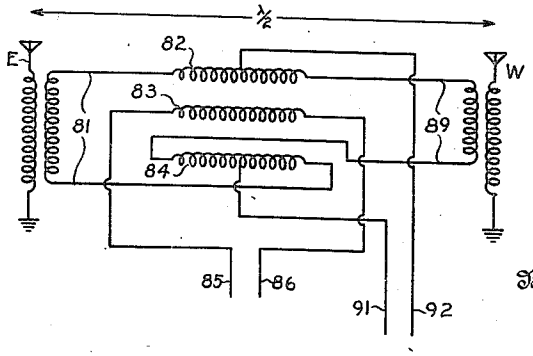


Fig. 14



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UNITED STATES PATENT OFFICE

2,320,521

RADIO BEACON SYSTEM

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Application February 27, 1935, Serial No. 8,541

20 Claims. (Cl. 250—11)

This invention relates to radio beacon systems and, more particularly, to the establishing of a two-course or four-course beacon system by the use of non-directional radiators.

It has heretofore been proposed to substitute for the crossed loop transmitting means, as originally employed in radio beacon transmission, a system employing four vertical antennas, such change being proposed in order to do away with the errors introduced into the radio beacon operation by the inherent nature of the crossed loop system. It has been found, however, that the systems employing four vertical antennas are not entirely free from certain disadvantages inherent in the crossed loop systems. In the use of a beacon system employing either the crossed loop or four-vertical antenna types of array, the characteristic signal is reversed on opposite sides of the beacon transmitter. Thus, in a visual system, it is necessary to turn the reed box over as the transmitter is passed, in order to maintain the previous relation of the characteristic signals. In an aural system the pilot, when passing the beacon transmitter, must constantly remember the reversed arrangement of signals in order to correctly orient the aircraft with respect to the transmitter. It may also be noted that the use of the four vertical antennas has materially increased the installation cost of the system. Further, in the use of a system employing four vertical antennas as a transmitting array, it is necessary to maintain the tuning of the vertical antennas and the phasing of the currents in them in order to maintain the stability of the courses, it being necessary in such systems to correctly tune and phase four circuits.

It is therefore an object of the present invention to provide transmitting means for providing a two-course or four-course beacon, which means will not be subject to the errors and disadvantages of prior systems.

A primary object of the invention is to provide a transmitting system for providing either a two-course or four-course beacon, which system will employ, in either case, only two non-directional radiators.

Another object of the invention is to provide a transmitting system for providing either a two-course or four-course beacon, which system will not be subject to errors resulting from reflection from the Kennelly-Heaviside layer.

Another object is to provide a transmitting system for a two-course beacon in which system the same characteristic signal will always be found on the same side of the beacon course, thereby further aiding in simplifying the navigation of aircraft.

A further object is to provide a transmitting antenna array which will require less tuning and phase adjustment than prior systems in order to maintain course stability.

A further object is to provide circuit arrangements and means for energizing two non-directional radiators to provide either a two-course or four-course beacon.

Other objects and novel features of the invention will be made apparent to those skilled in the art by the following description and the annexed drawings which, it will be understood, are merely illustrative of the invention and impose no limitation thereon not imposed by the appended claims.

Referring to the drawings, in which similar reference numerals refer to like parts,

Fig. 1 illustrates the field pattern resulting from the energization of the antennas of a two-antenna system in one manner,

Fig. 2 illustrates the field pattern resulting from the energization of the antennas of a two-antenna system in a second manner,

Fig. 3 illustrates the combined field pattern resulting from the combination of the field patterns of Figs. 1 and 2, according to the present invention,

Fig. 4 is a schematic drawing of an antenna arrangement for producing the field patterns of Figs. 1, 2 and 3,

Fig. 5 discloses a circuit arrangement for the antennas in accordance with the schematic showing of Fig. 4,

Fig. 6 discloses a circuit arrangement for energizing the circuit of Fig. 5,

Fig. 7 discloses a second circuit for energizing the circuit of Fig. 5,

Fig. 8 illustrates the field pattern resulting from the energization of two non-directional radiators in a system for the production of a four-course beacon,

Fig. 9 illustrates the field pattern resulting from the energization, in a different manner, of two non-directional radiators, for the production of a four-course beacon,

Fig. 10 illustrates the combination of the field patterns of Figs. 8 and 9,

Fig. 11 is a schematic view showing the arrangement of two non-directional radiators for transmission of a four-course beacon,

Fig. 12 is a schematic showing of a system for energizing the antennas of Fig. 11,

Fig. 13 is a circuit diagram illustrating a sec-

ond circuit arrangement for transmitting a two-course beacon from two non-directional radiators, and

Fig. 14 is a circuit diagram illustrating a second circuit arrangement for transmitting a four-course beacon from two non-directional radiators.

It has been determined that if two non-directional radiators be so spaced and the currents in the antennas so phased that the algebraic sum of the space and time phase angles is 180°, a space pattern of cardioid form will be produced, the maximum of which will extend along a line joining the two antennas and in the direction of the lagging antenna. This effect is illustrated in Fig. 1, it being noted that in this example the antennas are spaced one-quarter wave length or 90° and the energization of antenna W leads that of antenna E by 90°. If a current be supplied to the antennas so that the energization of antenna W lags that of antenna E by 90°, a cardioid extending in the opposite direction will be produced. This effect is illustrated in Fig. 2 and it will be noted that in this case the maximum of the cardioid pattern is on the line joining the two antennas and in the direction of antenna W. If, now, the antennas be energized either alternately or simultaneously in the manner described above, two superposed cardioid field patterns the maximums of which extend in opposite directions along the line joining the two antennas will be produced. This effect is illustrated in Fig. 3 and it will be seen that the line A—B joining the points of intersection of the two cardioid patterns, and along which the signal intensity from each of the two cardioids is equal, provides two courses in space.

In the following descriptions of the various systems according to the invention, it will be assumed and stated that the antennas for a two-course beacon are separated 90° in space and are energized by currents displaced 90° in time phase. It is to be understood that these values are only a special case of the invention and are employed only for the purpose of simplifying the discussion. It is contemplated by the invention that the two non-directional radiators be spaced K degrees apart and energized by currents displaced R degrees in time phase, when $K+R \cong 180°$.

In Fig. 4 there is schematically illustrated a radiating array according to the present invention which is so arranged as to establish radiation fields providing two courses in space. This arrangement comprises the antennas E, W which will be assumed to be spaced a quarter wavelength apart. These antennas may be supplied with modulated radio frequency energy through transmission lines 3, 4 and, according to the present invention, are connected by a transmission line 1 which in this example has an electrical length of 90°. It will be apparent that voltage supplied to radiator E will produce a similar voltage in radiator W with a 90° time lag, while a voltage supplied to radiator W will produce a similar voltage in radiator E with a 90° time lag.

A circuit arrangement for the antenna system illustrated in Fig. 4 is disclosed in Fig. 5 and it will be seen that in this circuit arrangement radio frequency voltages modulated by differing characteristic signals are applied at C, D from a radio frequency source (not shown) to the transmission lines 3, 4 through coupling transformers 5, 6. Each of the transmission lines 3, 4 includes the primary 7 of a transformer, each of said transformers having two secondaries 8, 9. The secondary 8 of each transformer is connected in a circuit 10 comprising a transmission line having an electrical length of 90°, while the secondaries 9 are respectively connected to non-directional radiators E, W which are grounded at 13 and 14, respectively. It will be noted that the antennas E, W are spaced a quarter wavelength apart in accordance with the schematic showing of Fig. 4, although as stated above, the invention contemplates that the antennas be spaced K degrees apart and energized by currents displaced R degrees in time phase, when $K+R \cong 180°$.

It will be seen that if a voltage is supplied to antenna E through the transmission line 3, primary 7 and secondary 9, a similar voltage will be supplied to the transmission line 10 through primary 7 and secondary 8 and a similar voltage with a 90° time lag will, therefore, be produced in antenna W. A cardioid field pattern will be produced by such energization and such pattern will have its maximum in a line joining the antennas E, W and extending in the direction of antenna W. Similarly, energy supplied directly to antenna W through transmission line 4, primary 7 and secondary 9 will be transmitted to antenna E through transmission line 10 and will appear there with a lag equal to the length of line 10. A second cardioid-shaped field will be produced by the radiation of this energy, the maximum of such field being in the line E, W and in the direction of antenna E. If equal power is supplied to antennas E or W either simultaneously or alternately, reverse-phase cardioids will be produced in the manner described and their intersection will lie on a line perpendicularly bisecting a line joining the two antennas, such line of intersection providing a course extending in two directions from the antenna station.

The radio frequency energy supplied to the two antennas may be modulated with any desired signals in order to define the course. The usual A and N signals for aural beacons or the 87 and 65 cycle signals for visual beacons may be employed. In the operation of a system employing characteristic signals of this type, one of the two cardioids will be produced from the radio frequency energy modulated by the A or 87 cycle signal, while the other cardioid will be produced from the radio frequency energy modulated by the N or 65 cycle signal. It will, therefore, be seen that each of the two cardioids will be impressed with only one of the two characteristic signals. Each signal will therefore always be greater than the other on one side of the course defined by the line of intersection of the radiating fields of the antennas and an aircraft flying along such course will not encounter any reversal of indication.

As stated above, the desired space patterns may be produced alternately if a so-called aural beacon is to be provided at a receiver located in the radiated fields, or continuously if a so-called visual beacon is desired. A circuit for supplying voltages alternately to the circuits C, D of Fig. 5 is disclosed in Fig. 6. In this circuit a master oscillator 15 supplies voltages at radio frequency to a beacon amplifier 16, the output of which is connected to a link circuit 17 containing a keying relay 18 which may be operated to alternately energize the circuits C and D to supply power to lines 3 and 4. When line 3 is excited the array will produce a cardioid whose

maximum is on the line joining the antennas and in the direction of antenna W. When line 4 is excited a cardioid whose maximum is in the direction of antenna E will be produced. With equal power supplied to the two antennas, the course indication will lie on a line perpendicularly bisecting the line between the two antennas. The course may be bent by adjusting the relative amplitudes of the voltages supplied to the antennas. Any desired coding, such as the A and N signals in this case, may be impressed on the carrier at the keying relay 18.

If a visual system is being employed, the circuit for energizing the antennas of Fig. 5 may be as disclosed in Fig. 7. In this circuit a master oscillator 19 supplies voltages at radio frequency to the two amplifier branches 20, 21, these branches being coupled respectively to the circuits C and D for supplying the lines 3 and 4. Any desired coding, such as the 87 and 65 cycle audio frequency modulations, may be impressed on the carriers and supplied continuously to the antennas E and W. It will therefore be seen that the array will constantly produce two cardioids, one having its maximum in the direction of one antenna and being modulated with the 87 cycle frequency, and the other having its maximum in the direction of the other antenna and being modulated with the 65 cycle frequency. The line of intersection of the two cardioids will perpendicularly bisect the line joining the two antennas and it will be seen that the 87 cycle frequency and the 65 cycle frequency will each always be of greatest intensity on one side of the course on both sides of the line joining the antennas. Consequently, it will not be necessary for the pilot of an aircraft flying on the course to turn over the reed box or, if a reed converter is used, switch over the converter when crossing over the beacon station. The course may be bent as desired by varying the relative amplitudes of the voltages supplied to the lines. The beacon sidebands, being of different frequency, will not combine in space but will produce a pair of cardioid patterns, as described, with a course in the same line as in the case of the aural beacon. The carriers will combine in space but the resultant carrier from each antenna is in time phase with the other and the pattern is an ellipse of slight eccentricity which will not disturb the courses.

The invention also provides other means for providing a two-course beacon by the radiation of energy from two non-directional radiators in such a manner as to establish two intersecting radiated fields each of which will have a cardioid transmission characteristic and which will be reversed in phase. By this means according to the invention, there is provided a circuit for supplying to two non-directional radiators voltages which would cause the establishment of a radiated field having a circle pattern, a circuit for supplying to the non-directional radiators currents which would cause the establishment of a radiated field having a figure-of-eight pattern, and a circuit for combining these currents and supplying such combined currents to the non-directional radiators. The combined currents will cause the radiation from the antennas of energy so phased as to produce two reversed phase radiation fields each of which will have a cardioid transmission characteristic. The intersections of these radiated fields will define two courses in space extending on opposite sides of the line joining the two antennas. Such means are disclosed in Fig. 13 of the drawings.

The system disclosed in Fig. 13 comprises a bridge circuit L having the arms 40, 41, 42 and 43, which arms are connected at terminals 44, 45, 46 and 47. Fixed condensers 48 and 49 are inserted in arms 40 and 41. Two non-directional radiators E and W are provided and are coupled to ground through inductance coils 50, 51 which form the secondaries of input transformers, the primaries 52 and 53 of which are included in the circuit of a transmission line 54 having an electrical length of 90° in the present case. The antennas E and W are spaced, in the case under discussion, a quarter wave-length apart. The transmission line 54 also includes a coil 55, the same being in inductive relation to a primary coil 56, the purpose of which arrangement will appear more fully hereinafter. Voltages at radio frequencies and modulated to provide any characteristic signals desired are supplied through input circuits C, D to input transformer 57, 58. One terminal of the secondary of input transformer 57 is connected by lead 59 to terminal 45 of the bridge L, while the other terminal of the said output transformer is connected to terminal 47 of the bridge through lead 60. The output terminals of the transformer 58 are connected to bridge terminals 44 and 46 through leads 61 and 62 respectively. The circuit across terminals 45, 46 of the bridge is completed by leads 65, 66 which are connected at their one ends to the terminals 45, 46 and at their other ends to the terminals of primary coil 56. The circuit across terminals 46 and 47 of the bridge is completed by leads 67, 68, one of which, lead 67, is connected at its one end to bridge terminal 46 and at its other end to the midpoint 69 of transmission line 54, which point is also connected to ground at 70. The other lead 68 is connected at its one end to bridge terminal 47 and at its other end to the secondary coil 55 in the transmission line 54 by a center-tap 71.

Assuming that voltages at radio frequency and modulated by any desired characteristic signals are being supplied to input circuits C and D, current will flow from the secondary of transformer 57 through lead 59 to bridge terminal 45 where it divides, part flowing through arms 41 and 40 of the bridge and lead 60 to the other terminal of transformer 57. The rest of the current flows through bridge arm 42, lead 66, winding 56, lead 65, bridge arm 42, bridge arm 43, lead 67, terminal 69, transmission line 54, windings 52 and 53, winding 55, center-tap 71 of winding 55, lead 68, bridge arm 43 and lead 60 to the secondary of transformer 57, thereby completing the circuit. It will be seen, first, that the completion of this circuit energizes winding 56 causing a current to flow therein. Current in winding 56 will induce a current in winding 55, whch, being series connected to the windings 52, 53 will cause currents to flow in opposite directions in these coils. The voltages across coils 52, 53 will thus be displaced 180° in phase. Such excitation of windings 52, 53 will induce voltages having a phase displacement of 180° across antenna coils 50, 51 and a radiated field having a figure-of-eight form will be produced.

The above-described circuit being completed between terminal 69 and center-tap 71, in-phase voltages will be impressed across windings 52, 53, these windings being connected in parallel with the terminal 69 and center-tap 71. Such excitation of windings 52 and 53 will cause in-phase

currents to be induced in the antenna coils 50, 51 and a radiated field having substantially a circle form will be produced.

The in-phase and reversed-phase voltages across antenna coils 50, 51 will not cause separate fields to be produced, but the combined currents in the antenna coils will produce a radiated field of cardioid shape, resulting from the combination of the circle and figure-of-eight fields. In order to secure the correct combination of the two fields with respect to phase and magnitude, winding 56 may be provided with taps so that the voltage across winding 55 will produce a figure-of-eight field whose maximum intensity is equal to the intensity of the circular field produced, and leads 65 and 66 are so constructed in any convenient manner as to provide a phase shift of such magnitude as to bring the circular field into phase with the figure-of-eight field. In the case under discussion, the leads 65, 66 compose a transmission line or time delay circuit whose total delay is of the order of an odd multiple of ninety degrees, plus or minus.

Current from circuit D will flow through lead 62 to bridge terminal 46 where it divides, establishing two circuits. One of these is completed through bridge arm 42, lead 65, coil 56, lead 66, bridge arms 42 and 41 and lead 61 to the second terminal of the input circuit. The other circuit is completed through bridge arm 43, lead 67, terminal 69, transmission line 54, windings 52 and 53, winding 55, center-tap 71, lead 68, bridge arms 43 and 40 and lead 61 to the second terminal of the input circuit D. It is evident, from the principles of Wheatstone bridge circuits, that the result of this flow of current is to produce across the arm 42 the sum of the two voltages at a given instant, and across arm 43 the difference of these voltages, or vice-versa. This effect is independent of the phase relation of the voltages applied at C and D, although for convenience this is customarily 90°. It is understood that should carrier suppressed transmission be employed this phase angle has reference to the angles between the axes of projection of the sideband frequencies considered as rotating vectors. The voltages across windings 52 and 53 will be 180° displaced in phase due to the series connection of the elements and reversed-phase voltages will therefore be induced in antenna coils 50, 51 thereby producing a radiated field of figure-of-eight form.

The terminal 69 and center-tap 71 being connected in parallel across windings 52, 53, voltages applied across these two points will cause in-phase currents to flow in windings 52, 53 which will induce in-phase currents in antenna coils 50, 51. A radiated field having circle form will therefore be produced. As discussed above, the circle and figure-of-eight fields will combine in space to produce a cardioid field whose maximum will lie on a line joining the two antennas and extending in a direction opposite to that of the cardioid field produced by currents from input circuit C. This action is caused by the operation of the bridge circuit as previously described.

It will therefore be seen that two radiated fields of cardioid shape and having their maximums extending in opposite directions will be produced. These fields may be produced alternately in the case of an aural system by alternate energization of input circuits C and D, or may be simultaneously produced by continuous energization of the two circuits, if a visual system is desired. In either case the carriers supplied to the two exciting circuits may be modulated by any desired characteristic signal for giving differentiated course indications. The intersecting portions of the two fields determine a two-way course for aerial navigation.

The present invention also contemplates the provision of means for producing a four-course beacon from a system employing only two non-directional radiators. As stated hereinbefore, it has heretofore been proposed to provide a four-course beacon by energizing four vertical antennas in pairs to produce two intersecting figure-of-eight patterns, the points of intersection of which determine four courses in space. Such systems have been substituted for the prior crossed loop systems in order to eliminate the effects due to reflection from the Kennelly-Heaviside layer, known as night effects. By reason of the present invention it is possible to produce a four-course beacon by the use of only two non-directional radiators, thereby materially reducing the installation costs of the transmitting system, and eliminating errors due to night effect.

It may be desirable to establish a four-course beacon of either the aural or visual type and while the following discussion specifically relates to a visual system, it will be applicable to an aural system as well. The visual system employs usually the 87 cycle and 65 cycle modulations of the carrier to provide characteristic signals. According to the present invention two non-directional radiators E and W, as disclosed in Fig. 8, are provided and are spaced a half wave-length apart. These antennas are supplied with voltages at radio frequency modulated by the 87 cycle frequency. If the 87 cycle antenna currents are in time phase a figure-of-eight field as illustrated in Fig. 8 results. The same antennas are supplied with voltages at radio frequency modulated by the 65 cycle frequency. If the 65 cycle antenna currents are separated 180° in time phase, the figure-of-eight field of Fig. 9 results. If the two antennas be excited simultaneously or alternately in this manner, the two figure-of-eight fields combine as illustrated in Fig. 10, the overlapping portions thereof providing four equi-signal courses OP, OQ, OR and OS. The angular relation of the four courses may be varied by varying relatively the amplitudes of the supplied voltages.

A schematic showing of an antenna array for the production of the fields described is illustrated in Fig. 11. The antennas E, W are spaced a half wave-length apart and are separately excited through transmission lines X and Y. An exciting circuit for the antennas E and W is illustrated in Fig. 12 and it will be seen that this circuit provides for the supplying of both the 65 cycle and 87 cycle frequencies to both of the antennas. A source of radio frequency (not shown) may supply voltages at radio frequency to modulating circuits for impressing the signal frequencies. The output of the modulating circuit 30 is supplied through leads 32 to the line X which supplies antenna E, and through leads 33 to the line Y which supplies antenna W, these voltages being in phase. The output of modulating circuit 31 is supplied to line X through leads 34 and in out-of-phase relation to line Y through leads 35. Voltages having an identifying characteristic, such as the 65 cycle modulation for example, are supplied to the two antennas in in-time phase from the modulating circuit 30 and produces a figure-of-eight field of the type illustrated in Fig. 8, due to the phasing

of the currents and the spacing of the antennas. The 87 cycle currents supplied to one of the antennas from the modulating circuit 31 are 180° out of time phase with the currents of the same frequency supplied to the other of the antennas, thereby producing a figure-of-eight field of the type illustrated in Fig. 9. Simultaneous energization of the two antennas by the 87 cycle and 65 cycle frequencies, in the manner described, will produce a combined field resulting from the combination of the in-phase and out-of-phase frequencies, which field will be of the double figure-of-eight type as illustrated in Fig. 10. The two figure-of-eight fields overlap in space and the points of intersection of the fields determine four courses for aerial navigation.

It will be apparent that if an aural system is desired the lines may be energized by alternate in-phase and out-of-phase voltages modulated by the usual A and N or other desired signals. The spacing of the antennas, and the phasing of the exciting currents will remain the same and the field produced will also be the same, except that at any given instant only one of the fields of Figs. 8 and 9 will exist.

A second means according to the invention for producing a four-course beacon from a circuit employing two non-directional radiators is disclosed in Fig. 14. In this circuit there is provided an antenna array consisting of the two non-directional radiators E and W which are spaced half a wave-length apart and are connected by transmission lines 81, 89 at the junction of which are connected two coils 82, 84 of a three-winding transformer, the terminals of coil 84 being connected in reverse relation to those of coil 82. The terminals of a third coil 83 of the three-winding transformer are connected by leads 85, 86 to a source of radio frequency current which may be modulated by any desired characteristic signal. A second source of radio frequency current modulated by any desired characteristic signal is connected by leads 91, 92 to coils 82 and 84 through center-taps.

If radio frequency currents modulated by any desired characteristic signal, such as the usual A or N signal for an aural system or the 87 cycle and 65 cycle signals for a visual system, are supplied to coils 82 and 84 through leads 91, 92 which are connected to the centers of such coils, in-phase voltages will be supplied to antennas E and W and a radiated field of figure-of-eight form having its major axis at an angle of 90° to the line joining the antennas will be produced. If carrier frequency currents modulated by any desired characteristic signal are now supplied to coil 83 through leads 85, 86, similar voltages will be induced in coil 82 and 84 and out-of-phase voltages will be supplied to antennas E and W, whereby a radiated field of figure-of-eight form will be produced, and such field will have its major axis on the line joining the antennas. The two fields so produced will combine in space to produce a field of the type shown in Fig. 10 and the intersections of the fields will provide four courses in space for aerial navigation.

The foregoing description and the annexed drawings disclose certain forms of the invention, but it will be apparent to those skilled in the art that modifications and improvements of the invention may be made without departing in any way from the spirit or scope of the invention, for the limits of which reference must be had to the appended claims.

I claim:

1. A radio beacon system comprising two spaced non-directional antennas, means connecting said antennas and having a known electrical length, two sources of differently modulated radio frequency current for exciting said antennas, and means for dividing the current from each source to supply to said antennas from each source in-phase and out-of-phase currents.

2. A radio beacon system comprising two spaced non-directional antennas, a transmission line connecting said antennas, means for inducing series currents in said transmission line to produce out-of-phase currents in said antennas, and means for inducing parallel currents in said transmission line for producing in-phase currents in said antennas, whereby a radiated space pattern resulting from the combination of said in-phase and out-of-phase antenna currents is produced.

3. In the production of a radio beacon through the agency of a pair of spaced radiators connected to the opposite sides of a phase-shifting network, the steps of amplitude modulating a carrier with two different audio frequency signals to thereby produce two separate waves each resulting from a different one of such modulations; continuously supplying one of said waves to one of said sides of said network and continuously supplying the other of said waves to the other of said sides of said network; and radiating the resultant waves from said radiators.

4. In a radio beacon, the combination which comprises: a phase-shifting network having first and second sides; means for continuously supplying a wave resulting from amplitude modulation of a carrier of given frequency with one modulation frequency to the first side of said network; means for continuously supplying a wave resulting from amplitude modulation of a carrier of the same given frequency with another modulation frequency to the second side of said network; and a pair of spaced radiators respectively connected to the first and second sides of said network.

5. A radio beacon system comprising two spaced non-directional antennas, an exciting circuit inductively coupled to one of said antennas for energizing said antennas with one of a pair of signals, a second exciting circuit inductively coupled to the other of said antennas for energizing said antennas with the other of said pair of signals, and a transmission line having a predetermined electrical length inductively coupled to both said exciting circuits.

6. In a radio beacon, the combination of a source of radio frequency, means for modulating a portion of the radio frequency produced by said source at an audio frequency, phasing means and antenna radiating means for radiating in a definite direction said modulated radio frequency with a space pattern cardiodal in shape, additional means for modulating a portion of said radio frequency at a second audio frequency different from said first audio frequency, a second phasing means associated with said second modulated radio frequency and producing a second space pattern in space cardioidal in shape from said radiating means and in a direction opposite to said first pattern, said first and said second cardioidal space patterns intersecting in space to form two zones where said first modulated radio fre-

quency is equal in intensity to said second modulated radio frequency.

7. A radio beacon system for establishing a plurality of zones of equal signal intensity comprising two spaced non-directional antennas, means for producing in said antennas voltages causing a radiation having a cardioid field pattern whose major axis is in the direction of one of the antennas, and means for simultaneously producing in said antennas voltages causing a radiation having a cardioid field pattern whose major axis is in the direction of the other of said antennas, and means for differently modulating the energy in said antennas in order to produce differently modulated cardioid radiation fields.

8. A radio beacon system for establishing a plurality of zones of equal signal intensity comprising two spaced non-directional antennas, means for periodically producing in said antennas voltages causing a radiation having a cardioid field pattern whose major axis is in the direction of one of the antennas, and means operating alternately with said first means for producing in said antennas voltages causing a radiation having a cardioid field pattern whose major axis is in the direction of the other of said antennas, and means for differently modulating the energy in said antennas in order to produce differently modulated cardioid radiation fields.

9. A radio beacon system comprising two non-directional antennas spaced K degrees apart, a transmission line having an electrical length of R degrees connecting said antennas, two sources of modulated radio frequency energy supplying said antennas, a bridge circuit connected to said sources and to said transmission line for dividing the currents from said sources and supplying a plurality of in-phase and a plurality of out-of-phase currents to said transmission line whereby two intersecting field patterns are radiated from said antennas, and in which $K+R\cong 180°$.

10. A radio beacon system for producing two intersecting cardioid-shaped radiated fields, comprising two non-directional radiators spaced K° apart, means for supplying directly to one of said radiators radio frequency energy characterized by one of two different signals, means for supplying directly to the other of said radiators radio frequency energy characterized by the second of said signals, and means having an electrical length of R° connecting said radiators whereby modulated energy directly supplied to each radiator will appear in the other with a phase displacement of R°, the sum of K° and R° being approximately 180°.

11. A radio beacon system according to claim 10, in which a transmission line having an electrical length of R° connects the two radiators.

12. A method of producing a radio beacon with a pair of spaced radiators connected to the opposite sides of a phase-shifting network, which includes the steps of continuously supplying to one of said sides of said phase-shifting network a wave resulting from amplitude modulation of a carrier of given frequency with a modulation frequency, continuously supplying to the other of said sides of said phase-shifting network a wave resulting from amplitude modulation of a carrier of said given frequency with a different modulation frequency, whereby during some instants of time one of said waves has a greater amplitude at said phase-shifting network than the other of said waves and during other instants of time the said one wave has less amplitude at said phase-shifting network than said other wave, thereby causing the resultant waves received at said radiators to have different phase relations at different instants of time, and radiating the resultant waves received at said radiators.

13. In the production of a radio beacon through the agency of a pair of spaced radiators connected to the opposite sides of a phase shifting network, the steps of continuously supplying a wave resulting from amplitude modulation of a carrier of given frequency with one audio frequency signal to one of said sides of said network, continuously supplying a wave resulting from amplitude modulation of a carrier of said given frequency with another audio frequency signal to the other of said sides of said network, whereby during some instants of time one of said waves has less amplitude at said phase-shifting network than the other and during other instants of time said one wave has a greater amplitude at said phase-shifting network than said other wave, thereby causing the resultant waves received at said radiators to have different phase relations at different instants of time, and radiating the resultant waves received at said radiators.

14. In a radio beacon, the combination which comprises a phase-shifting network having first and second sides, a source of carrier waves connected to said first and second sides of said network, means continuously connected between said source and said first side of said network for modulating said carrier with an audio frequency signal, means continuously connected between said source and said second side of said network for modulating said carrier with a different audio frequency signal, and a pair of spaced radiators connected respectively to the first and second sides of said network.

15. A radio beacon system comprising two non-directional antennas spaced a half wave-length apart, means for producing in said antennas voltages having a figure-of-eight field pattern whose major axis is in a line joining the two antennas, and means for simultaneously producing in said antennas voltages having a figure-of-eight field pattern whose major axis is in a line at right angles to the line joining the antennas.

16. An equi-signal radio beacon system comprising two non-directional antennas spaced apart by a distance approximately equal to one-half of the radiated wavelength, means for exciting said antennas in in-phase relation with one of a pair of different signals and means for exciting said antennas in 180° out-of-phase relation with the other of said signals to thereby produce two figure-of-eight shaped fields each of which is respectively characterized by one of said signals and which overlap in space to provide zones within which said signals are of equal intensity.

17. An equi-signal radio beacon system comprising two non-directional antennas spaced apart by a distance approximately equal to one-half of the radiated wavelength, means for exciting said antennas in in-phase relation with one of a pair of different signals and means for simultaneously exciting said antennas in 180° out-of-phase relation with the other of said signals to thereby simultaneously produce two figure-of-eight shaped fields each of which is characterized by one of said signals which over-

lap in space to provide zones within which said signals are of equal intensity.

18. An equi-signal radio beacon system comprising two spaced non-directional antennas, a transmission line having inductive coupling to both of said antennas, a three winding transformer two of the coils of which are respectively connected in opposite branches of said transmission line, means connecting the mid-points of said coils to a source of radio frequency energy on which is impressed one of a pair of different signals whereby energy characterized by such signal is supplied in in-phase relation to said antennas, means connecting the ends of the third coil of the transformer to a source of radio frequency energy on which is impressed the second of said signals whereby energy characterized by said second signal is supplied in 180° out-of-phase relation to said antennas, whereby there are produced two figure-of-eight shaped fields each of which is characterized by one of said signals and which overlap in space to provide zones within which said signals are of equal intensity.

19. An equi-signal radio beacon according to claim 18, in which energy is alternately supplied to the first-named two coils of the transformer and then to the third coil thereof.

20. An equi-signal radio beacon according to claim 18, in which energy is simultaneously supplied to the first-named two coils of the transformer and to the third coil thereof.

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