PATENT SPECIFICATION

525,359

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COMPLETE SPECIFICATION

Improvements in or relating to Radio Transmitting Systems

I, FRANK GREGG KEAR, a Citizen of the United States of America, of 806 McLachlen Building, Washington, D. C., United States of America, do hereby declare the nature of this invention, and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention relates to the art of radio transmission and more particularly to the establishment of so-called equi-signal beacon courses in space which may be employed as a guide for aircraft. As is well-known, such beacon courses are established by the radiation of directional fields, each of which is identified by a characteristic tone modulation or signal, and which fields overlap or intersect in space to produce zones of equal signal intensity which provide the beacon course. Such fields have heretofore been established by the radiations from antenna arrays comprising crossed loop type or four vertical antennas, either of which products two radiated fields of figure-of-eight shape. Both of these types of transmitting systems present certain deficiencies, the chief of which is that the relative positions of the characteristic signals are reversed on opposite sides of the location of the transmitting array. It has also been proposed to provide a radio beacon having four equi-signal courses each of which is established by the overlapping areas of two figure-of-eight shaped fields, the major axes of which are at right angles to each other. In this proposed beacon system the radiated fields are established by alternately exciting two non-directional antennas, which are spaced apart by one-half of the transmitted wavelength, in-phase and 180° out of phase. The two fields are differently characterised by interrupting the in-phase excitation in a characteristic manner and by interrupting the out-of-phase excitation in a different characteristic manner.

According to my invention in a radio transmitting system having two non-directional antennas spaced K° apart for establishing cardioid-shaped characteristically modulated radiated fields which overlap in space to provide two zones of equal signal intensity which may be employed for navigational purposes, there is provided means for simultaneously energizing both said antennas with radio frequency energy upon which a characteristic signal is impressed in such a manner that the energy in one antenna leads the energy in the second antennas with radio frequency energy upon which a second characteristic signal is impressed in such a manner that the energy due to the second energising means in the aforesaid leading antennas lags the energy in the second antenna by R°, the value of K+R being approximately equal to 180°.

The invention is set forth more in detail in the following description which is accompanied by drawings in which:—

Figure 1 illustrates the field pattern resulting from the energization of two non-directional antenas in one manner:

Figure 2 illustrates the field pattern resulting from the energization of two non-directional antennas in a second manner:

Figure 3 illustrates the field pattern resulting from simultaneous or alternate energization of two non-directional antannas in the manners represented in Figures 1, and 2:

Figure 4 is a schematic drawing of an antenna arrangement for producing the field patterns of Figures 1, 2 and 3:

Figure 5 discloses a circuit arrangement for the antennas in accordance with the schematic showing of Figure 4:

Figure 6 discloses a circuit arrangement for energizing the circuit of Figure 5:

Figure 7 discloses a second circuit for energizing the circuit of Figure 5:

Figure 8 illustrates the field pattern resulting from the energizing of two non-directional antennas in a system for the production of a four-course beacon:

Figure 9 illustrates the field pattern resulting from the energization, in a different manner, of two non-directional antennas, for the production of a four-course beacon;

Figure 10 illustrates the combination of the field patterns of Figures 8 and 9:

Figure 11 is a schematic showing of the arrangement of two vertical antennas for the establishment of a four-course beacon:

Figure 12 is a schematic showing of a system for energising the antennas of Figure 11:

Figure 13 is a circuit diagram illustrating a second circuit arrangement for establishing a two-course beacon by the radiations from two non-directional antennas:

Figure 14 is a circuit diagram illustrating a second circuit arrangement for establishing a four-course beacon by the radiations from two vertical antennas:

Figure 15 shows the straight course produced by two equal fields according to the invention:

Figure 16 shows the bent course produced by two unequal fields according to the invention:

Figure 17 shows how the reversal of signal occurs in a previously known arrangement.

I have found that if two vertical antennas be so spaced and the currents in the antennas so phased that the algebraic sum of the space and time phase angles of the antenna currents is 180°, a radiated field having 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 apart by one-quarter wavelength, of 90°, and the energization of antennas W leads that of antennas E by 90°. If a current be supplied to the antennas so that the energization of antenna W lags that of antennas 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 antenna be energized either alternately or siultaneously in the manner described above, two radiated fields of cardioid shape, 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 radiated fields 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 vertical antennas be spaced K° apart and energized by currents displaced R° in time phase, when $K+R=180°$.

In Fig. 4 there is schematically illustrated a radiating array according to the present invention which is so arranged as to establish radiated 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 current 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 tower E will produce a similar voltage in tower W with a 90° time lag, while a voltage supplied to tower W will produce a similar voltage in tower 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 currents 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 vertical antennas E, W which are grounded at 13 and 14, respectively.

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 radiated field of cardioid shape will be produced by such energization and the maximum of this field will lie in a line joining the antennas E, W and extending in the direction of antenna W. It wil be apparent that current supplied to antenna W will produce in antenna E a current similar to that produced in antenna W but lagging such current by 90°. If equal currents are 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 bisection a line joining the two antennas, such line of intersection providing a course extending in two directions from the transmitting station.

The radio frequency energy supplied to the two antennas may be modulated with different characteristic signals in order to provide a zone of equal signal intensity which defines the course. The usual A and N signals for aural beacons or the different audio frequency signals for visual beacons may be employed. In the operation of a system of this type, each of the two radiated fields will be modulated by a different characteristic signal. Each signal will therefore always be greater than the other on one side of the course defined by the line of intersection of the radiated fields, and an aircraft flying along such course will not encounter any reversal of signals.

As stated above, the desired space patterns may be produced alternately if a signal of the so-called aural type is to be provided at a receiver located in the radiated fields, or continuously if a signal of the visual signal 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 currents 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 and 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 equi-signal course will lie on a line perpendicularly bisecting the line between the two antennas as shown in Figure 15. If, however, the energy is so supplied to radiators that one cardioid-shaped field is stronger than the other and therefore represented by a larger diagram the two bisectors, which are the lines of equi-signal strength, are bent through an angle away from the stronger side so that the resulting course is bent (as shown in Figure 16). 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 to be employed, the circuit for energizing the antennas of Figure 5 may be as disclosed in Figure 7. In this circuit a master oscillator 19 supplies currents 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 86.7 and 65 cycle audio frequency modulations may be impressed on the carriers and supplied continuously to the antennas E and W. As shown in Figure 15, the array will constantly produce two cardioids, one having its maximum in the direction of one antenna and being modulated with the 86.7 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 producing the course B A. As can be seen in following this course, the characteristic signals 86.7 and 65 remain on the same side of the course for its whole length, whereas with the previously known arrangement shown in Figure 17, in following the course B A the 65 signal is first on the right and then, after passing the point x, on the left Thus, as the aircraft passed over the radiated point x, it would be necessary to "turn over the reed box", or reverse the relative positions of the tuned receiving means, in order to maintain the aircraft on the same course without difficulties. Thus the invention effects a considerable simplification by avoiding this reversal. 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 vertical antennas 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 supply 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 circuit of 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 vertical antennas 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 wavelength apart. The transmission line 54 also includes 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 transformers 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 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 radio frequency energy modulated by any desired characteristic signals is 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, which, being series connected to the windings 52, 53 will cause currents to flow in opposite directions in these coils and 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 conncted 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 radiated fields of cardioid shape, resulting from the combination of the circle and figure-of-eight patterns. 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 field of figure-of-eight shape whose maximum intensity is equal to the intensity of the circular field produced, and leads 65 and 66 are so arranged 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 arm 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 axis 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 pattern 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 and 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 field of cardioid shape whose maximum will lie on a line joining the two antennas and extending in a direction opposite to that of the cardioid 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 providing equi-signal course indications.

The present invention also contemplates the provision of means for producing a four-course beacon for a system employing only two non-directional antennas. 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 antennas, 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 usually employs 86.7 cycle and 65 cycle modulations of the carrier to provide characteristic signals. According to the present invention two non-directional antennas E and W, as disclosed in Fig. 8, are provided and are spaced a half wavelength apart. These antennas are supplied with currents at radio frequency modulated by the 86.7 cycle frequency. If the 86.7 cycle antenna currents are in time phase a figure-of-eight pattern as illustrated in Fig. 8 results. The same antennas may be supplied with currents 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 pattern of Fig. 9 results. If the two antennas be excited simultaneously or alternately in this manner, the two figure-of-eight patterns combine as illustrated in Fig. 10 overlapping to produce equi-signal zones which are indicated by the four shaded areas of Fig. 10 and the intersections of the figure-of-eight patterns define four courses in space 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 wavelength 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 86.7 cycle frequencies to both of the antennas. A source of radio frequency (not shown) may supply currents 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. In-phase currents having an identifying characteristic, such as the 65 cycle modulation for example, are supplied to the two antennas from the modulating circuit 30 and produce a figure-of-eight pattern of the type illustrated in Fig. 8, due to the phasing of the currents and the spacing of the antennas. The 86.7 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 pattern of the type illustrated in Fig. 9. Simultaneous energization of the two antennas by the 86.7 cycle and 65 cycle currents, in the manner described, will produce a combined field pattern resulting from the combination of the in-phase and out-of-phase fields, which field pattern 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 currents 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 space pattern produced will also be the same, except that at any given instant only one of the space patterns of Figures 8 and 9 will exist.

A second means according to the invention for producing a four-course beacon from a circuit employing two vertical antennas is disclosed in Figure 14. In shape type as illustrated in Fig. 10. The this circuit there is provided an antenna array consisting of the two vertical antennas 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.

Referring to Figure 14, if radio frequency currents modulated by any desired characteristic signal, such as the usual A or N signal for an aural system or the 86.7 and 65 cycle signals for a visual system, are supplied to coils 82 and 84 through leads 92 and 91 which are connected to the centers of such coils, in-phase voltages will be supplied to antennas E and W since if lead 91 is positive energy flows through it and then through each half of coil 84, upwardly in both of the primary coils which transfer energy to the antennas, and through the two halves of coil 82 to lead 92. As the energy is flowing upwardly in both of the primary coils it is in phase in those coils and, therefore, in the antennas. Thus 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, out-of-phase currents will be supplied to antennas E and W, since when lead 85 is positive, energy will flow through it, coil 83 and lead 86 inducing a current in coils 82 and 84 which flows downward in the primary coil at antenna W and upwardly in the primary coil at antenna E. Thus the currents in these two primary coils are out-of-phase and the currents they induce in the antennas are also out-of-phase; whereby a radiated field pattern of figure-of-eight form will be produced, and such field pattern 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 Figure 10 and the intersections of the fields will provide four courses in space for aerial navigation.

Having now particularly described and ascertained the nature of my said invention, and in what manner the same is to be performed, I declare that what I claim is:—

1. A radio transmitting system for

establishing cardioid-shaped, characteristically modulated radiated fields which overlap in space to provide two zones of equal signal intensity which may be employed for navigational purposes, comprising two non-directional antennas spaced K° apart, being characterised by the provision of means for simultaneously energizing both said antennas with radio frequency energy, upon which a characteristic signal is impressed, in such a manner that the energy in one antenna leads the energy in the second antenna by R°, and means for simultaneously energizing both said antennas with radio frequency energy, upon which a second characteristic signal is impressed, in such a manner that the energy due to the second energizing means in the aforesaid leading antenna lags the energy in the second antenna by R°, in which K+R is approximately equal to 180°.

2. A radio transmitting system according to Claim 1 for establishing cardioid-shaped characteristically modulated radiated fields which overlap in space to provide two zones of equal signal intensity which may be employed for navigational purposes, comprising two non-directional antennas spaced K° apart, means connecting each antenna to a source of energy, and modulating means included in each of said connections, being characterised by the provision of means connecting said antennas and being R° in electrical length, whereby modulated energy supplied to each antenna will be transmitted to the other antenna with a time lag of R°, in which K+R is approximately equal to 180°.

3. A radio transmitting system according to Claim 2, in which the antennas are connected by a transmission line which is R° in electrical length and which is inductively coupled to each of said antennas.

4. A radio transmitting system according to Claim 2, in which the two antennas are alternately supplied with modulated energy by the source.

5. A radio transmitting system according to Claim 2, in which the two antennas are simultaneously supplied with energy by the source.

6. A radio transmitting system for establishing characteristically modulated radiated fields which overlap in space to provide zones of equal signal intensity, comprising an antenna array of two non-directional radiators spaced apart by a distance equal to one-quarter of the transmitted wavelength, means for supplying to said radiators energy modulated with one characteristic signal in such a manner as to produce in the radiators in-phase currents and currents which in one radiator lead the current in the other radiator by 90°, and means for supplying to said radiators energy modulated with a second characteristic signal in such a manner as to produce in the radiators in phase currents and currents which, in the aforesaid leading radiator, lag the current in the other radiator by 90°, to thereby cause the radiation of two cardioid-shaped fields the maximums of which extend in opposite directions.

7. A radio transmitting system for establishing characteristically modulated radiated fields which overlap in space to provide zones of equal signal intensity, comprising an antenna array of two non-directional radiators spaced apart by a distance equal to one-quarter of the transmitted wavelength, means for supplying to said radiators energy modulated with a characteristic signal in such phase relation as to produce in said radiators energy having such phase relation as to cause the production of a field of circular shape and a field of figure-of-eight shape, such energy combining in said radiators to cause the radiation of a field of cardioid shape modulated with said characteristic signal, and means for supplying to said radiators energy modulated with a second characteristic signal in such phase relation as to produce in said radiators energy having such phase relation as to cause the production of a field of circular shape and a field of figure-of-eight shape, such energy combining in said radiators to cause the radiation of a field of cardioid shape extending in a direction opposite to the first radiated cardioid-shaped field and modulated with the second characteristic signal.

8. An equi-signal radio beacon comprising two non-directional antennas spaced apart by K electrical degrees, means for exciting said antennas in phase by radio frequency energy on which a characteristic signal has been impressed, and means for simultaneously exciting said antennas with radio frequency energy on which a different characteristic signal has been impressed and which, in one of said antennas, is R electrical degrees out of phase with respect to the similarly characterised energy in the other antenna, K+R being equal to 360°.

9. An equi-signal beacon according to Claim 8, in which K and R are each approximately equal to 180°.

10. Radio transmitting systems for establishing cardioid-shaped fields substantially as described with reference to the accompanying drawings.

Dated the 18th day of February, 1939.

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Fig. 1.

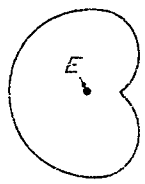


Fig. 2.

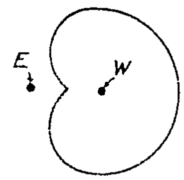


Fig. 3.

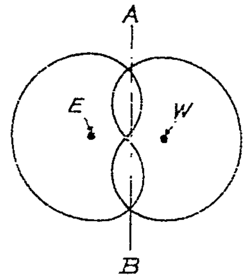


Fig. 4.

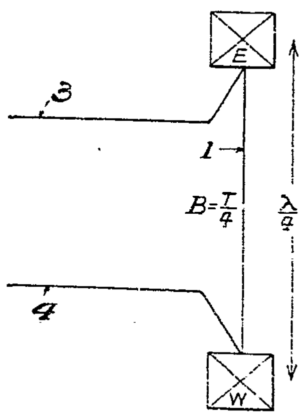
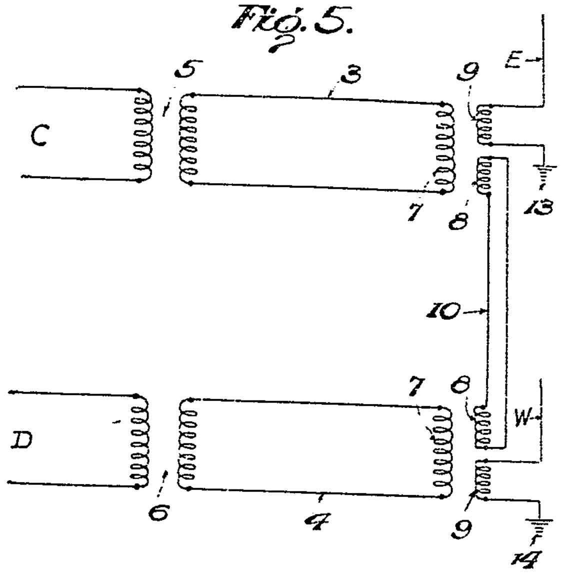


Fig. 5.



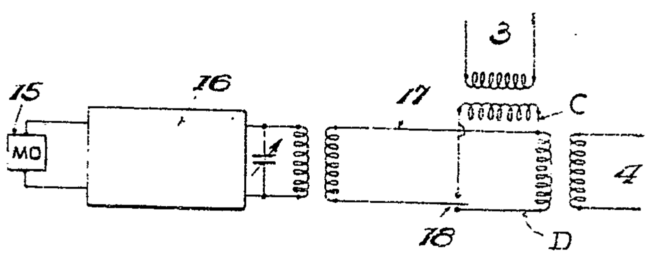


Fig. 6.

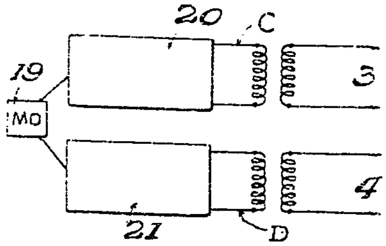


Fig. 7.

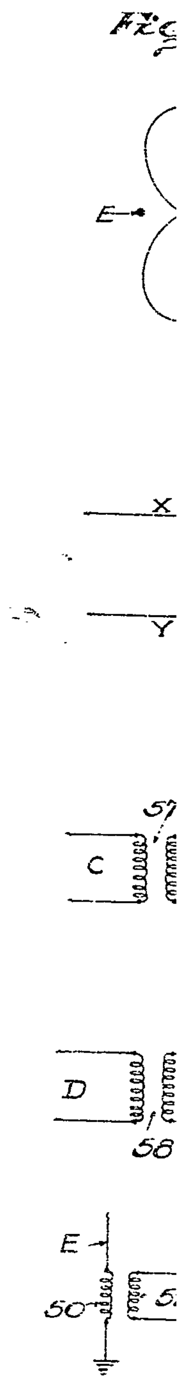


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Fig. 8.

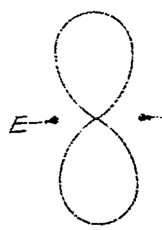


Fig. 9.

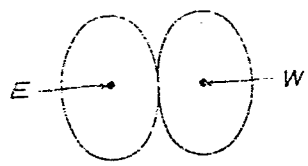
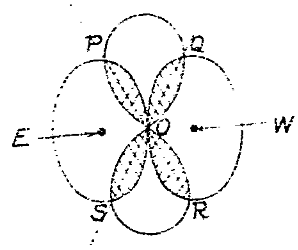


Fig. 10.



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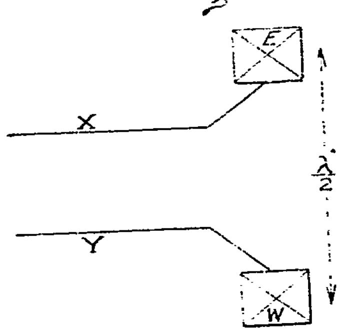

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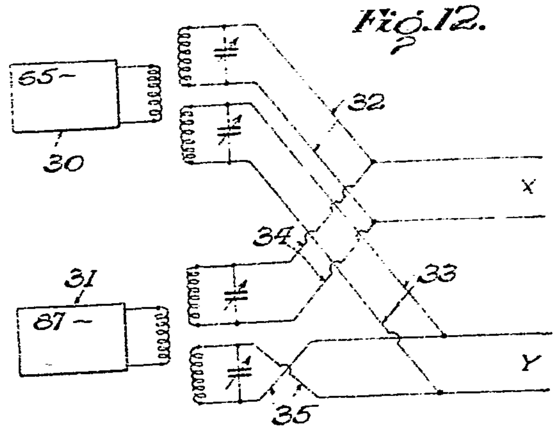

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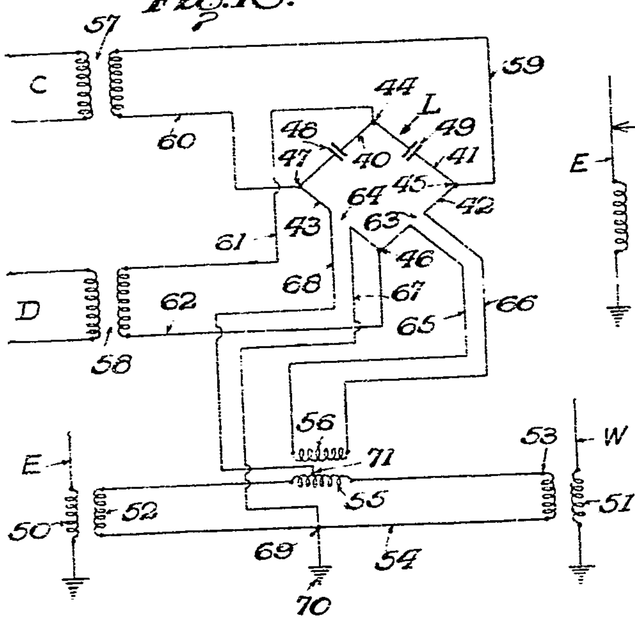

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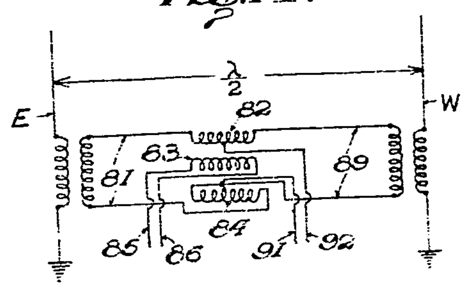
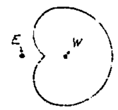


6.

[This Drawing is a reproduction of the Original on a reduced scale.]

Fig.1.

Fig.2.



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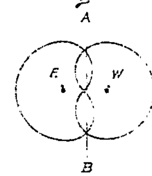

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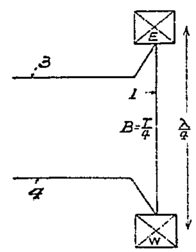

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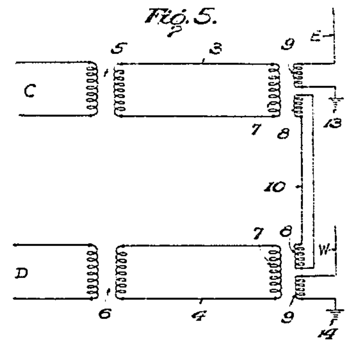

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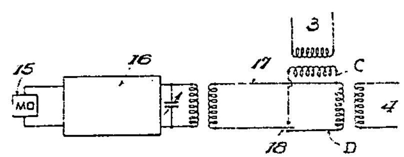

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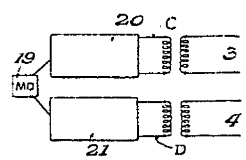

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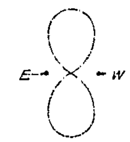

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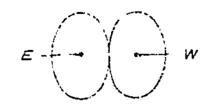

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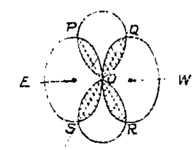

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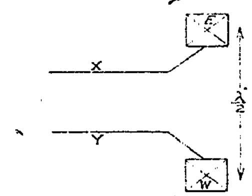

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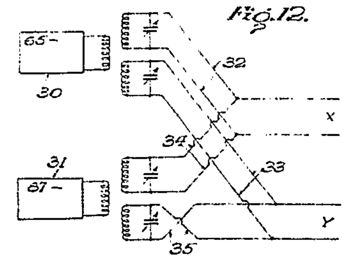

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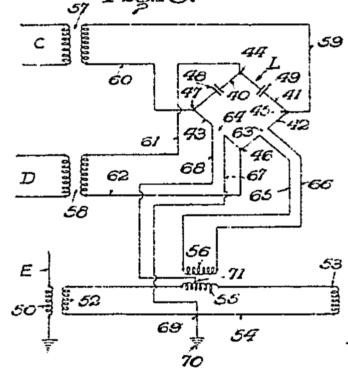

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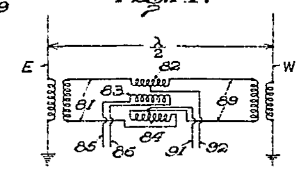

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FIG. 15

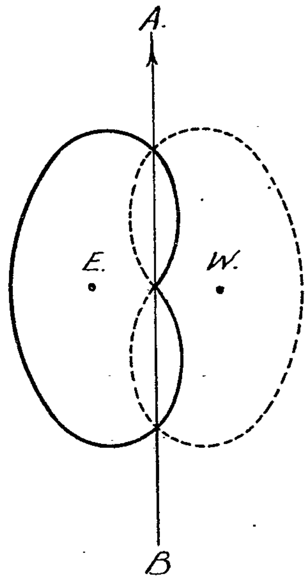

FIG. 16

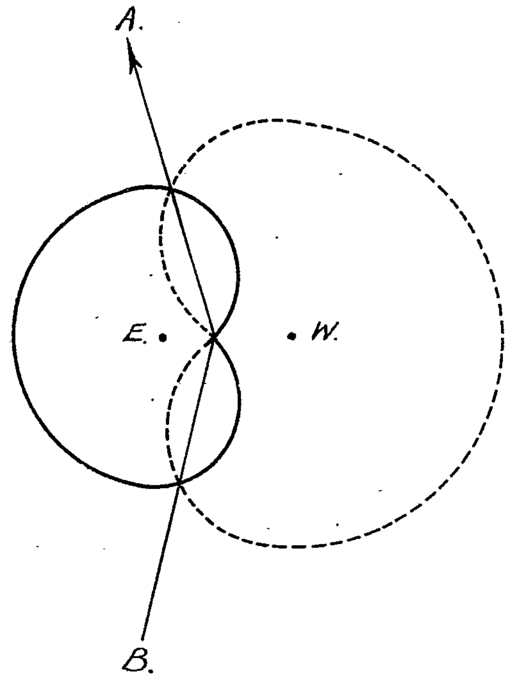

FIG. 17