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VISUAL TYPE RADIO BEACON

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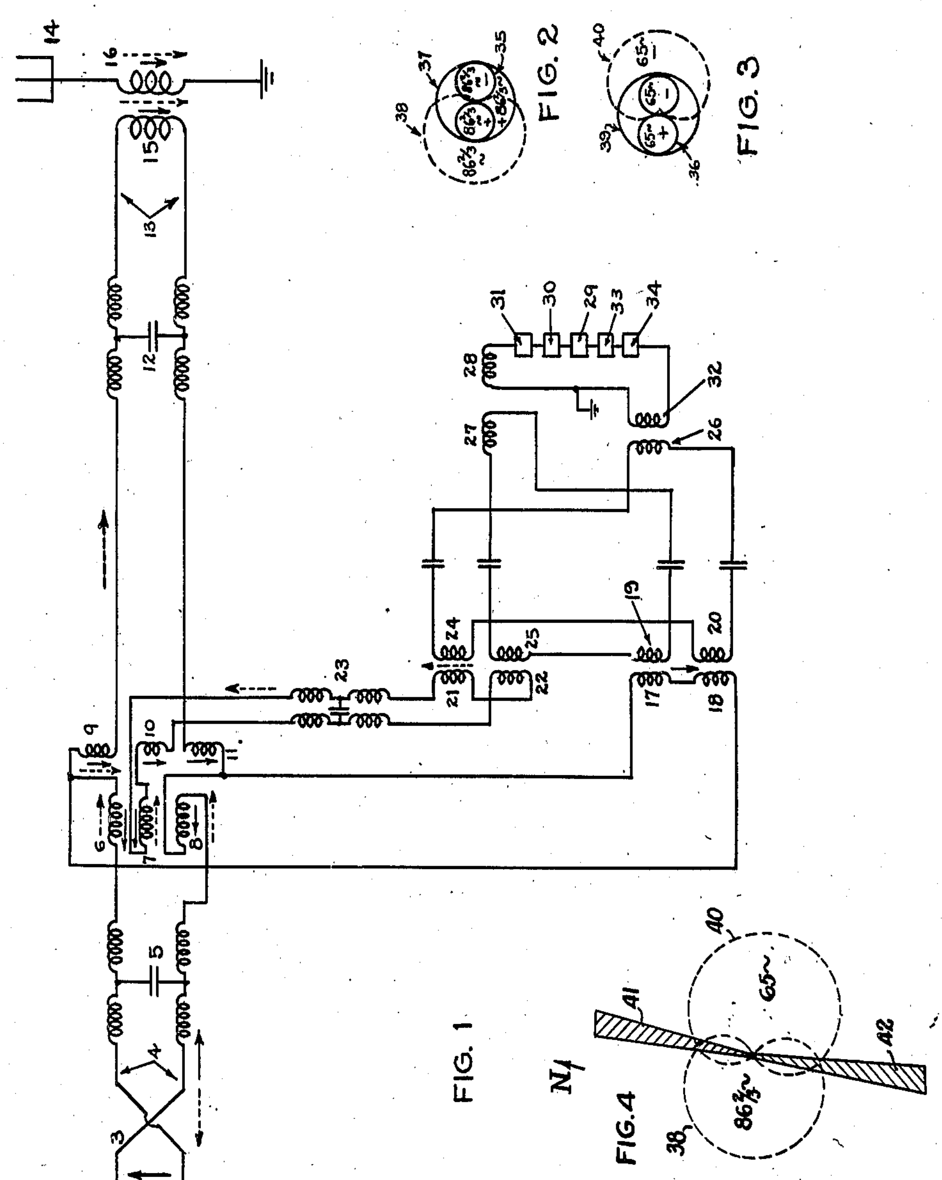

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VISUAL TYPE RADIO BEACON

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The invention described herein may be manufactured and used by or for the Government of the United States for governmental purposes only, without the payment of any royalty thereon.

Our invention relates to a new type of radio beacon of the visual type in which unidirectional signals are used in place of the usual bidirectional signals, the two unidirectional signals being sent simultaneously with major radiation in opposite directions, each on the same carrier but modulated at a different audio frequency. Each directional signal has the general shape of a cardioid with phase stabilization which gives stability to the directional transmission.

In our invention the two modulated frequencies are coupled in through suitable hybrid coils in the transmission line to the two Bureau of Standards "TL" type antennas described in the "Air Commerce Bulletin," U. S, Department of Commerce for July 15, 1932, giving two figure-of-eight transmissions separated in time phase by approximately 90 degrees, one of 65 cycles modulation, the other of 86⅔ cycles modulation. These figure-of-eight transmissions are made independent of minor changes in the constants of the antenna circuits by making the line from the hybrid coils to the antenna of proper electrical length, as described in the July 1932 issue of the Bureau of Standards Journal of Research under the title of "Phase synchronization in directional antennas with particular application to the radio range beacon" by F. G. Kear and further described in a companion patent application by F. G. Kear for giving phase stabilization between the currents in the two antennas. Superimposed on these figure-of-eight transmissions are two non-directional or circular radiations, one of 65 cycles modulation, and the other of 86⅔ cycles modulation, the carrier waves of which are 270 degrees out of phase with each other. As a result, when the circular radiation of 65 cycles modulation combines with the 65 cycles figure-of-eight radiation, a cardioid signal is sent in the direction of one vertical antenna, and when the circular radiation of 86⅔ cycle modulation combines with the 86⅔ cycle figure-of-eight radiation, a cardioid signal is sent in the direction of the opposite vertical antenna. This invention provides a method of simultaneously radiating from a "TL" antenna system two cardioid directional transmissions of different audio modulation on the same carrier frequency, but sent in opposite directions, in which the currents in the antennas had phase stabilization so that appreciable changes in the antenna constants would not alter the position of the equi-signal zones produced by the intersection of these two field patterns.

Other objects and advantages of our invention will be more clearly understood by reference to the following description and diagrammatic drawing.

Fig. 1 shows a circuit embodying the principles of our invention.

Figs. 2 and 3 show diagrammatically the principle of operation.

Figure 4 is a digrammatical view showing the cardioid 38 in Figure 2 and the cardioid 40 in Figure 3 combined which forms the courses 41 and 42.

Referring to Fig. 1: 1 is a vertical antenna grounded through a secondary coil 2; 3 is a primary coil connected at its opposite ends to two transmission lines 4. 5 designates an artificial line section introduced to make the transmission line of correct electrical length to give phase stabilization. 6, 7 and 8 are three coils, all wound in the same direction and closely coupled, coil 8 being connected in reverse polarity to that of 6 and 7. 9, 10 and 11 are a similar set of coils at right angles to the coils 6, 7 and 8, the coil 11 being connected in reverse polarity to that of 9 and 10. 12 is a second section like 5 introduced into the transmission lines 13 for controlling the electrical length of the same. The transmission lines 13 after being properly adjusted by means of the building out section 5 feed a vertical antenna 14 through a primary coil 15 and a secondary coil 16. The common connection between the coils 6 and 9 and that between the coils 8 and 11 are connected to coils 17 and 18 which are in series and inductively coupled to coils 19 and 20, respectively, all being wound in the same direction. The coils 7 and 10 are connected in series, the free ends being connected to coils 21 and 22, respectively, which are also connected in series, 21 and 22 being wound in the same direction, but the connections to 22 are reversed to those of 21. 23 is a 90 degree phasing section between the coils 7 and 10 and the coils 21 and 22. Coil 21 is inductively coupled to a coil 24 wound in the same direction and coil 22 is inductively coupled to a coil 25 also wound in the same direction. The coils 24 and 20 are connected in series to a secondary coil 26, and the coils 25 and 19 are connected in series to a secondary coil 27. A coil 28 is inductively coupled to the coil 27 and is excited with radio frequency from a master oscillator 29 through a minus 45 degree phasing section 30 and modulated at 65 cycles by a modulating amplifier

31. A coil 32 is inductively coupled to the coil 26 and is excited with radio frequency from the master oscillator 29 through a plus 45 degree phasing section 33 and modulated at 86⅔ cycles by a modulating amplifier 34.

The principle of operation is as follows: Considering the power supplied at the coils 19 and 20, the 65 cycles and 86⅔ cycles modulated currents induced in the coils 17 and 18 flow down in the coils 17 and 18 to the left in the coil 6, down in the coil 9, up in the coil 3, up in the coil 2 by induction, down in the coil 15, down in the coil 16 by induction, down in the coil 11 and to the left in the coil 8. The currents in the coils 8 and 6 induce a voltage to the left in the coil 7, and the currents in the coils 9 and 11 induce a voltage down in the coil 10. Since the coils 7 and 10 are in series and the induced voltages are in opposite directions, no current will flow in the coils 21 and 22 as a result of the currents in the coils 17 and 18. The result of these circulating currents will be a 65-cycles and 86⅔ cycles-modulated current flowing up in the antenna 1 and down in the antenna 14. The resulting signal in space will be two figure-of-eight transmissions separated in time phase by 90 degrees and with maximum signal sent in the directions of the antennas 14 and 1. These figure-of-eight transmissions are diagrammatically shown at 35, Fig. 2, and 36, Fig. 3.

Referring again to Fig. 1 and considering the power supplied by the coils 24 and 25: A current of 86⅔ cycles modulation will be induced in the coil 21 and flow up. This current will flow to the right in the coil 7 and down in the coil 10. The current in the coil 7 will induce a voltage to the right in the coil 6 and to the right in the coil 8. The current in the coil 10 will induce a voltage down in both the coils 9 and 11. The result of these induced voltages will produce a clockwise circulating current through the transmission lines 4 and 13 in series, producing a current down in the coil 3 and down in the coil 15, and by induction will also produce a current down in the coil 2 and down in the coil 16. No voltages will be applied to the terminals of the coils 17 and 18 due to these currents, as these coils 17 and 18 are connected at nodal points. The net result is an 86⅔-cycles current flowing down in both antennas, producing a plus non-directional in phase 86⅔-cycles radiation in each antenna as diagrammatically indicated by the full line 37, Fig. 2. Due to the 90 degree phase shift introduced by the section 23, the resultant signal in space when the figure-of-eight transmission 35 combined with the plus circular radiation 37 will be a directional signal indicated by the dash line 38 modulated at 86⅔-cycles, cardioidal in shape and sent in the direction of the antenna 1, Fig. 1, with a carrier frequency that of the master oscillator 29, Fig. 1.

Next, considering the 65-cycles modulated current induced in the coil 22 by the coil 25: Since the coil 22 is connected in reverse polarity to the coil 21, the 65-cycles circulating currents in the system will be 180 degrees out of phase with the 86⅔ cycles. The result will be non-directional radiation, produced by currents flowing up in the antennas 1 and 14, as indicated by the circular line 39, Fig. 3. The result of the combination of this minus 65-cycles non-directional radiation with the 65-cycles figure radiation will be a directional signal indicated by the dash line 40, modulated at 65 cycles, cardioidal in shape and sent in the direction of the antenna 14 (Fig. 1) with a carrier frequency that of the master oscillator 29, Fig. 1. Since the phasing sections 5 and 12 give the proper phasing in the transmission line, a phase stability between currents in the two antennas will be maintained. The cardioid 38 shown in Figure 2 and the cardioid 40 shown in Figure 3 when combined, as shown in Figure 4, forms the courses 41 and 42 at the intersections of these cardioids. The showing in the drawing is such as will produce two courses, but should more than two courses be desired these can be obtained by a duplication of the apparatus with the line or plane between the antennas of the duplicated set crossing the plane or line between the antennas 1 and 14 at substantially 90 degrees.

While the circuit arrangement shown in Fig. 1 illustrates one method of transmitting these two directional synchronized signals, other arrangements of circuits may also be used to transmit said signals by our novel method, and therefore our claims are not intended as restricted to the specific details of our invention as disclosed herein.

What we claim is:

1. A method for producing two radio beam carriers of the double-modulation type, and which includes the steps of radiating into space two radio signals in the same direction of the same carrier frequency and each of a figure-of-eight characteristic, modulating each radio signal at a different audio-frequency, superimposed on each radiated figure-of-eight characteristic, a non-directional radiation characteristic of the same carrier frequency, modulating said non-directional characteristic to correspond with said audio-frequency modulations of the figure-of-eight characteristics, respectively, and maintaining said non-directional radiated characteristics of such phase and amplitude that the resultant patterns radiated into space will be cardioidal in shape and each on the same carrier frequency, but modulated at a different audio-frequency, whereby the intersecting cardioidal space pattern provides two radio beacon courses of double modulation type and which may be substantially fixed in space.

2. In a visual type radio beacon, the combination with a source of radio frequency, of means modulating said source of radio frequency at two different audio frequencies, a hybrid coil, a set of two coupling means for each modulated frequency and connecting said hybrid coil with one of said modulating means, one of each set of said coupling means being inductively associated with one coupling means in the other set and in reversed polarity with respect thereto, each set of coupling means feeding one input of the hybrid coil, respectively, phasing means interposed in series between one of each set of coupling means and one input of said hybrid coil, two radiating means separated in space, non-radiating transmission lines between the outputs of said hybrid coil and each radiating means, and substantially ninety degrees in electrical length, and a coupling means between each transmission line and its associated radiating means, one of said last mentioned coupling means being reversed in polarity with respect of the other.

3. In a visual type radio beacon, the combination with a source of radio frequency, of means for modulating the output of said source of radio frequency at a plurality of audio frequencies, hybrid coil means, a set of two coupling means for each modulated frequency and connecting said hybrid coil means with one of said modulating means, one of each set of said coupling means

being inductively associated with one coupling means in another set and in reversed polarity with respect thereto, each set of coupling means feeding inputs of the hybrid coil, respectively, phasing means interposed in series between one of each set of coupling means and one input of said hybrid coil, a plurality of radiating means separated in space, non-radiating transmission lines between the outputs of said hybrid coil means and each radiating means and ninety degrees in electrical length, and coupling means between each transmission line and its radiating means, the coupling means in certain of said transmission lines being reversing in polarity with respect to other coupling means.

4. In a visual type of radio beacon, the combination with a source of radio frequency and two vertical antennas, of means for modulating a portion of said radio frequency at an audio frequency, means for modulating a second portion of said radio frequency at a second audio frequency, means for transmitting from said two antennas a portion of said first modulated radio frequency accompanied by a portion of said second modulated radio frequency in two figures-of-eight each of said modulated frequencies and separated by ninety degrees in time phase, and additional means for transmitting from said two antennas a portion of said first modulated radio frequency accompanied by a portion of said second modulated radio frequency in circular space patterns each of said modulated radio frequencies and spaced 180 degrees in time phase with respect to each other, and spaced in time phase ninety degrees from said figures-of-eight space patterns.

5. In a visual type radio beacon, the combination with a source of radio frequency and two vertical antennas separated in space, of means for modulating a portion of the radio frequency output of said source at an audio frequency, means for modulating a second portion of said radio frequency at a second audio frequency, means for transferring to said antennas a portion of said first modulated radio frequency accompanied by a portion of said second modulated radio frequency in proper phase relation to produce two radiant figures-of-eight space patterns each of different modulated frequencies, additional means for transferring to said antennas a portion of said first modulated radio frequency accompanied by a portion of said second modulated radio frequency each producing a space pattern circular in shape and of different modulated radio frequencies, and phasing means incorporated in one of said transferring means and of such time constant that the combined figure-of-eight patterns and circular space patterns form two cardioidal space patterns with maximum energy of transmission in opposite directions, whereby one of said cardioidal space patterns is sent on said radio frequency and modulated at said first audio modulation and the second cardioidal space pattern being sent on said radio frequency and modulated at said second audio frequency, while said first and second cardioidal space patterns intersect in space to form two equi-signal zones remaining fixed in their angular positions in space.

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