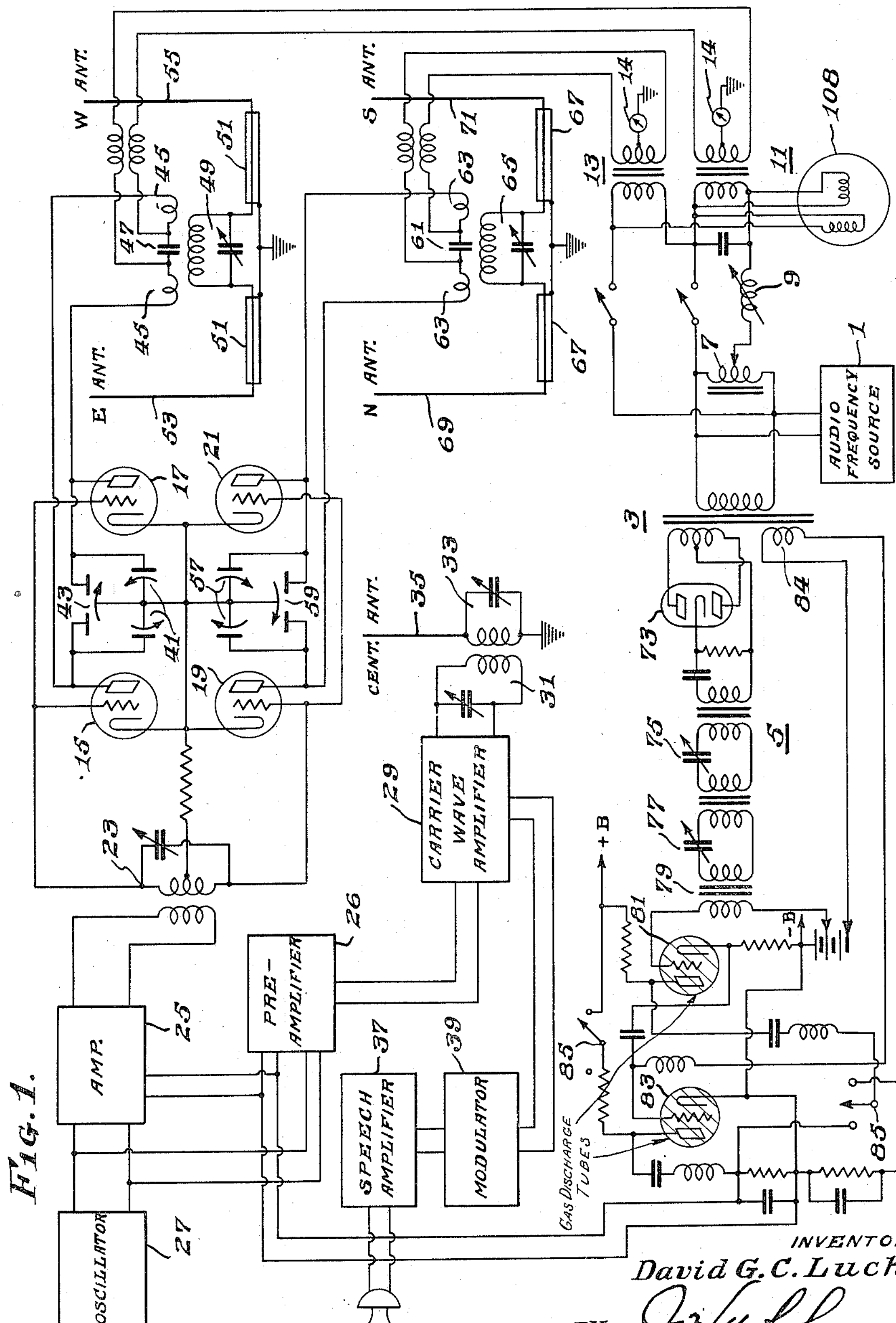
July 16, 1940. D. G. C. LUCK 2,208,376

ROTATING RADIO BEACON

Filed July 28, 1937 4 Sheets-Sheet 1



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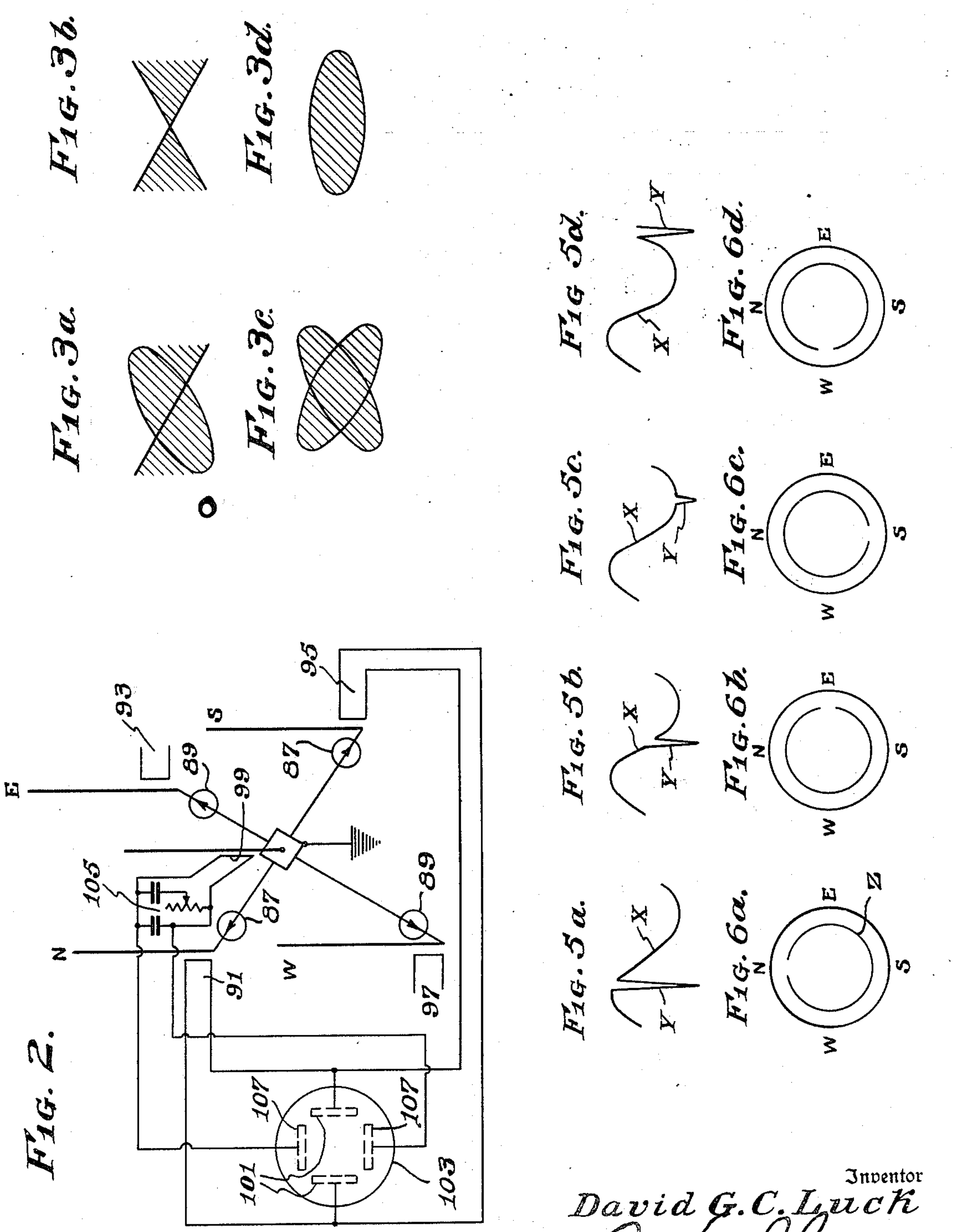
ROTATING RADIO BEACON

Filed July 28, 1937 4 Sheets-Sheet 2



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ROTATING RADIO BEACON

Filed July 28, 1937 4 Sheets-Sheet 3

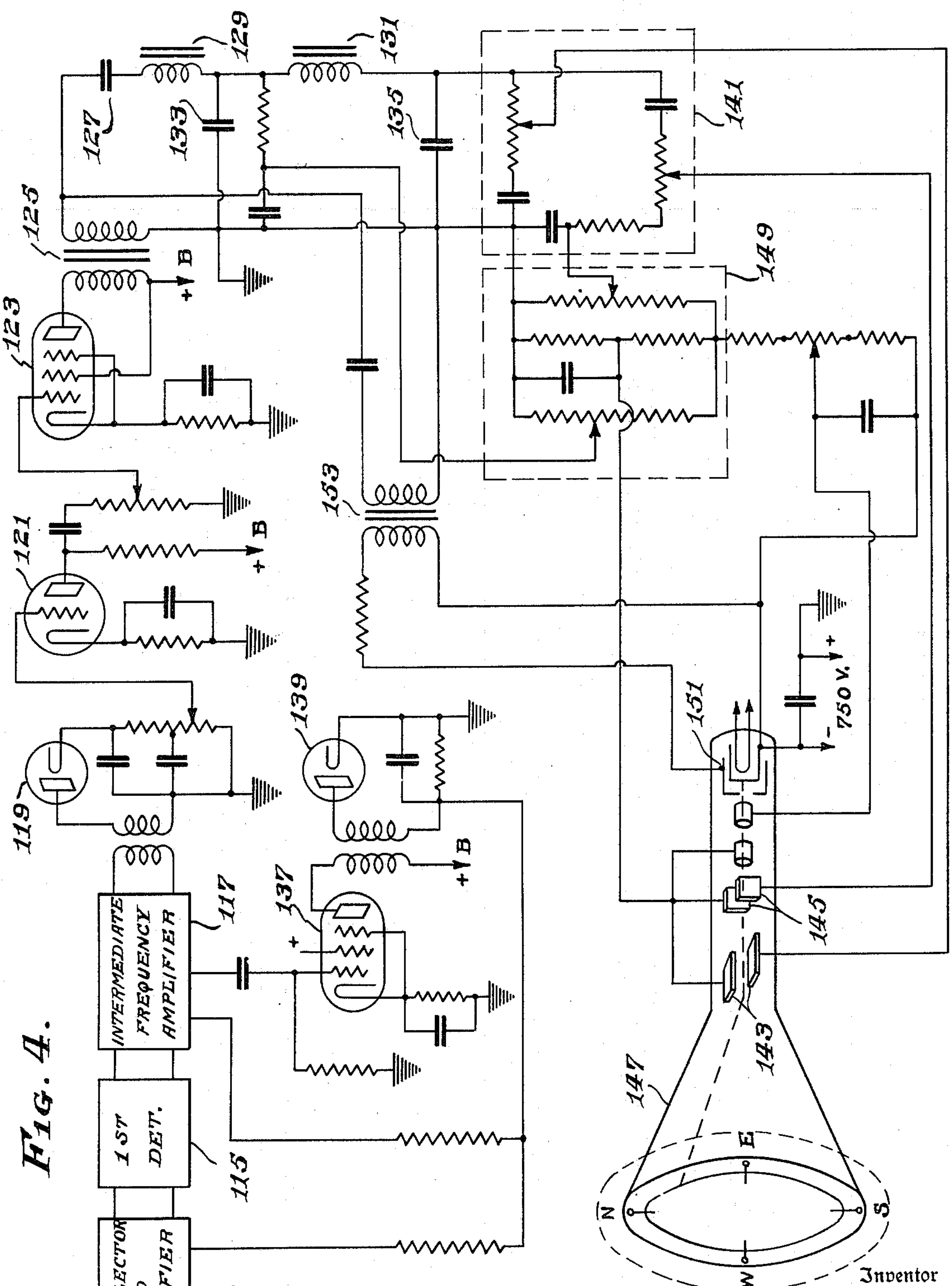

FIG. 4.

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FIG. 7.

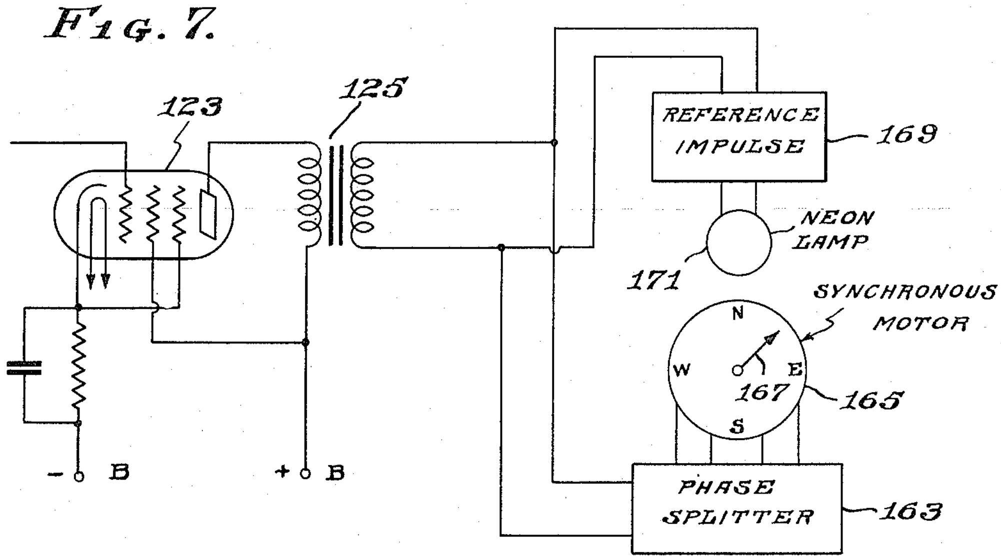
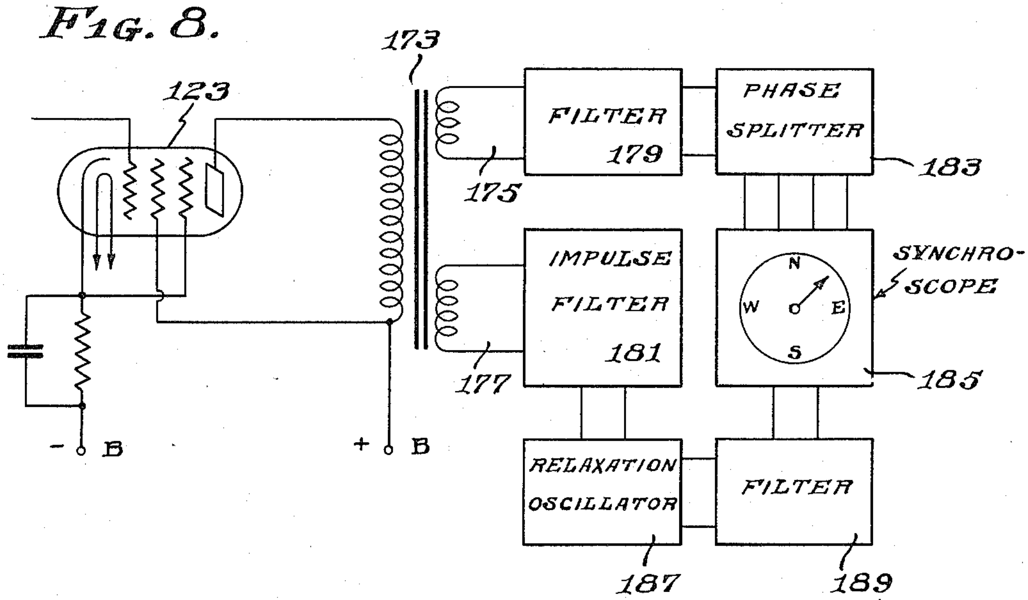


FIG. 8.



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Patented July 16, 1940 2,208,376

UNITED STATES PATENT OFFICE

2,208,376

ROTATING RADIO BEACON

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Application July 28, 1937, Serial No. 156,055

11 Claims. (Cl. 250—11)

My invention relates to rotating radio beacons. More specifically, my invention involves a radio beacon in which a rotating directive field, provided with a reference mark, determines the bearing of a receiver with respect to the beacon. My invention contemplates the use of a reference signal which is suitably timed to provide directional information in terms of the true bearing of a receiver with respect to the transmitter.

I am aware that radio direction finders employing loops have been used to indicate the line along which a transmitter lies with respect to the plane of the loop. I am also aware that it has been previously proposed to use a rotating field and a fixed field whose relative phases indicate the bearing of a receiver with respect to the transmitter. One form of the latter type of direction finder is disclosed in U. S. Patent No. 2,112,824 which issued April 5, 1938 on the application of G. H. Brown, et al, entitled Radio transmitter for direction finding, Serial No. 46,246, filed October 23, 1935 and assigned to the same assignee as the instant application. In the said patent, the two radio frequency fields are polarized, respectively, in horizontal and vertical planes and the rotating field revolves about the transmitter at radio frequency. In the present application, the radio frequency fields are polarized in the same plane, which is preferably vertical, and the rotating field omits the radio frequency carrier currents and rotates at modulation frequency. The omission of the carrier from the rotating field permits the use of balanced modulators which may be energized by alternating currents from a commercial supply line. This type of power supply simplifies the apparatus and represents a considerable saving without loss of the desired transmission characteristics. In the instant application, a uniform field is supplied by a conventional carrier, which may be suitably keyed or modulated as will be hereinafter described.

One of the difficulties in the operation of a rotating radio beacon is to maintain the proper phasal relations between the steady circular field and the rotating fields. Therefore, it is one of the objects of my invention to provide means for adjusting the elements and monitoring the operation of a rotating radio beacon.

Another object of my invention is to arrange a rotating radio beacon in which the uniform field establishes a conventional carrier and in which the rotating fields are determined by modulation currents without the accompanying carrier.

Another object of my invention is to establish a rotating field whose frequency of revolution is determined by the frequency of the alternating supply currents and in which the uniform and rotating fields may be keyed to give directional indications and which may be modulated to convey further information, such as speech.

My invention may be best understood by reference to the accompanying drawings, in which

Figure 1 is a schematic circuit diagram of the rotating radio beacon,

Figure 2 is a schematic diagram of the monitoring and phase-adjusting means,

Figures 3*a*, 3*b*, 3*c* and 3*d* are characteristic patterns representing the monitor indications,

Figure 4 is a schematic diagram of one embodiment of a radio receiver whose bearing with respect to the transmitter is indicated by means of a cathode ray tube,

Figures 5*a*, 5*b*, 5*c* and 5*d* indicate schematically the relation between the varying phase of the rotating field and the reference phase,

Figures 6*a*, 6*b*, 6*c* and 6*d* represent the indication on a cathode ray oscillograph corresponding to the phases of the currents represented in Figures 5*a*, 5*b*, 5*c* and 5*d*, and

Figures 7 and 8 represent modifications of the indicator at the receiver.

Referring to Fig. 1, a source of alternating current is represented by the reference number **1**. This alternating current source may be a conventional commercial supply having a frequency of 60 cycles per second. The power supply is impressed through a transformer **3** on a keying means **5** which will be hereinafter described and on an auto-transformer **7**. The auto-transformer is connected through a reactor **9** to a transformer **11**. The audio frequency source **1** is also connected to a second transformer **13**. The secondaries of **11** and **13** have center taps which are grounded through milliammeters **14**. The secondaries are respectively connected to anode circuits of a pair of balanced modulators **15**, **17** and **19**, **21**. The input circuits of the balanced modulators are connected to the terminals of a resonant circuit **23** which is coupled to the output of a radio frequency amplifier **25**. The input circuit of the amplifier **25** is connected to an oscillator **27**, which is a source of radio frequency currents.

The output circuit of the amplifier **25** is connected, through a pre-amplifier **26**, to the input circuit of a carrier wave amplifier **29** whose output circuit includes a resonant circuit 31. The resonant circuit 31 is suitably coupled to a second resonant circuit 33 which is included in an antenna 35. A speech amplifier 37 and a modulator 39 are connected to the carrier wave amplifier 29.

The output circuits of the balanced modulators 15, 17 include a pair of variable capacitors 41, preferably identical and ganged, and a differential capacitor 43. The capacitors form a portion of a resonant circuit which is symmetrically arranged with split inductor 45 and a blocking capacitor 47. The inductor 45 is coupled to a resonant circuit 49. The terminals of the resonent circuit 49 are connected through a pair of transmission lines 51 to two antennas 53, 55. These antennas are preferably arranged equal distances due east and due west of the antenna 35 which will be hereafter called the "central" antenna.

The modulators 19 and 21 include in their output circuits variable capacitors 57, preferably identical and ganged, and a differential capacitor 59. The capacitors form a portion of a symmetrically arranged resonant circuit which consists of a blocking capacitor 61 and a split inductor 63. The inductor 63 is coupled to a resonant circuit 65 whose terminals are connected to a pair of transmission lines 67 which terminate in antennas 69 and 71. These antennas 69, 71 are preferably arranged equally distant from the central antenna 35 and due north and due south thereof so that the east antenna 53, the west antenna 55, the north antenna 69 and the south antenna 71 form the corners of the square at the center of which is the antenna 35.

The keying means 5 is used to sharply interrupt or key the radio frequency carrier current from the oscillator 27. One suitable arrangement for keying on and off the preamplifier 26 which is located between the oscillator 27 and carrier wave amplifier 29 is illustrated in Fig. 1 of the copending application Serial No. 113,035, filed November 27, 1936, by Winfield R. Koch and entitled "Single channel two-way communication system." In the Koch drawings the impulse generator 15 is connected through an impulse amplifier 27 to the grid and cathode of an amplifier 29. While a number of different keying means may be employed, I have found the following arrangement satisfactory:

The output from the transformer 3 is impressed upon a full wave rectifier 73. The output of the rectifier includes currents which are multiples of the frequency of the source 1. A frequency equal to four times that of the source is selected by the filter circuits 75, 77 which are terminated in a peaking transformer 79. The peaking transformer is connected to the input circuit of a gaseous discharge tube 81 whose impulse output circuit may be connected to a second gaseous discharge tube 83. A suitable double throw switch 85 is connected to the circuits of the gaseous discharge tubes 81, 83.

When the switch is in the right hand contact position, both tubes are operatively connected. When the switch is in the left hand contact position, single tube operation is secured. In the latter position, four equally spaced keying impulses are obtained per revolution of the radiation pattern; in the former position, a single keying impulse per revolution is derived. The tubes 81—83 are adjusted so that the single impulse occurs once per complete cycle of the supply currents 1 and the four impulses occur within a single complete cycle of the supply currents. A voltage from the secondary 84 of the transformer 3 is impressed on the gaseous discharge tube 83 to insure that the single impulse will always occur at the same phase. This voltage is added to the impulsive control voltage obtained from tube 81. In the normal operation of the device, the keying impulses may be arranged or correlated to the rotating field to thereby correspond to the directions north, south, east and west. These four impulses enable the operator of a receiver to determine if the receiver is properly adjusted to indicate the bearing of the receiver with respect to the transmitter. These adjustments will be hereinafter described.

Operation of the beacon

In the operation of the foregoing circuit, the balanced modulators 15, 17 supply radio frequency currents modulated at the frequency of the source 1, or side band currents, to the east antenna 53 and the west antenna 55. It will be apparent that the phases of the radio frequency currents in the two antennas will be equal and opposite due to the symmetrical arrangements of the elements of the circuits. The balanced modulators 19 and 21 supply modulated radio frequency currents to the north and south antennas 69, 71, which currents are likewise of opposite phase and equal amplitude. The currents in the north antenna and, by way of example, the east antenna, will be in phase.

The radio frequency currents in the central antenna are adjusted to be in quadrature phase with the radio frequency currents in the four directional antennas. Thus the radio frequency currents in the north and south antennas are equal and opposite, the radio frequency currents in the east and west antennas are likewise equal and opposite and respectively in phase with those in the north and south antennas, and the said currents in said four antennas are in quadrature phase with respect to the currents in the central antenna. The auto-transformer 7 and the reactor 9 are so adjusted that the alternating currents, supplied to the modulators are in quadrature phase and the north-south and east-west antenna currents are equal in magnitude.

The fields established by the currents in the pairs of directional antennas are each of the conventional figure 8 type and the net effect of this pair of modulated fields is to establish a figure 8 field which rotates about the common center of the four antennas at the frequency of the alternating supply current. If the central antenna is energized by the carrier currents, a radio frequency field will be established. The radio frequency field will have a uniform or normal circular pattern. This field of circular pattern will combine with the rotating figure-of-eight field, with which it should be in phase, to establish a field which has a cardioid shape. The cardioid field rotates about the central antenna at the frequency of the supply source 1 and ceases to exist during the very brief keying intervals.

By arranging the keying or reference impulse so that the radio frequency currents are interrupted at the instant when the maximum of the cardioid pattern is due north, it will be apparent that a reference point has been established by means of which the phase of the rotating field at any point about the center of the field may be determined with respect to the reference or keying impulse. A receiver operated at any point within the fields will derive therefrom a sinusoidal current of varying phase and an impulsive current having a fixed or reference phase. A comparison of the two will indicate the bearing of the receiver from the transmitter, preferably with respect to the meridian passing through the radio beacon.

Adjusting and monitoring the beacon

One of the difficulties with rotating beacons of the foregoing type is the rigorous requirement that the phasal conditions be exactly established and maintained. One of the initial difficulties is that a certain amount of inequality exists between the two halves of each of the balanced modulators 15, 17 and 19, 21. I have found that the output of each balanced modulator may be suitably equalized in phase by adjustment of the differential capacitors 43 and 59. It is also necessary to feed the respective pairs of balanced modulators with alternating or modulation currents in phase quadrature. I have found that a suitable adjustment may be made by means of the auto transformer 7 and the variable reactor 9.

In order to determine the effect of such adjustments, I have arranged a monitoring system which is shown in Fig. 2. In this figure the meters 89 and 87 indicate respectively the modulated radio frequency currents flowing in the east, west and north, south antennas. The antennas include transformers 91, 93 and 95, 97 and 99. These transformers are preferably arranged so that they are symmetrical, dependent upon mutual inductive coupling only and relatively unaffected by electric fields about the transformers, and so that the transformers have a negligible effect on the currents flowing in the antennas. The purpose of these transformers is to supply monitoring voltages having a definite phase relation to the antenna currents.

Two of the transformers 91, 95 are connected to the deflecting electrodes 101 of the cathode ray tube 103. The transformer 99, coupled to the center antenna, is provided with a phase adjusting circuit 105 and is coupled to the deflecting electrodes 107 of the cathode ray tube 103. The transformers 93 and 97 are temporarily disconnected. If the north and south antennas and the central antenna are energized, the central antenna will induce currents of like phases in the north-south antennas; the effect of these in-phase currents may be balanced out by reversing the connections from one of the two transformers 91, 95. The remaining effect will be that of the out of phase side band currents, which are supplied to the north and south antennas, from the balanced modulator associated therewith.

The cathode ray pattern produced by the currents of opposite phases in the north and south antennas may initially resemble Fig. 3*a*. The elliptical portion of this pattern is an indication that this modulator is not properly balanced. A suitable adjustment of the differential capacitor 59 will gradually narrow the elliptical trace until a single pair of crossed lines appear as is shown in Fig. 3*b*. At this stage, the connection to the central antenna simply provides a convenient source of variable phase reference voltage. The phase adjusting circuit is varied for each differential capacitor setting to determine whether the pattern of Fig. 3*b* is attainable and thus to determine if the best condition of modulator balance has been obtained. After the currents in the north and south antennas have been properly balanced, the phase adjustment circuit is disconnected from the central antenna monitoring circuit and carrier quadrature obtained as described below. Then the transformers connected to these antennas are disconnected and a suitable connection is made to the transformers in the east and west antennas. The phase of the currents in the east and west antennas is then adjusted in accordance with the preceding method, by means of differential capacitor 43, until the cathode ray indication again shows crossed lines similar to those of Fig. 3*b*, while also showing carrier quadrature when the phase adjuster is disconnected.

It is also necessary to observe the relative phases of the radio frequency currents in the directive antennas and the central antenna. It is a well known property of unidirectional Adcock antenna systems, designed to establish cardioid field patterns, that the proper relation between the current in the central antenna and the currents in the directive antennas is that of quadrature phase. This condition is determined by disconnecting the phasing circuit 105 in the transformer 99 and applying the monitoring voltages from one of the pairs of the directive antennas and from the central antenna to the cathode ray oscillograph. These voltages will generally have the effect of producing two elliptical traces such as are shown in Fig. 3*c*. By suitably adjusting the phases, as by slightly detuning the carrier pre-amplifier 26, a single elliptical trace will be obtained such as shown in Fig. 3*d*, which indicates that the currents in these directive antennas are in phase quadrature with the currents in the central antenna. A further adjustment is made of the other pair of directive antennas, by means of the capacitor of circuit 49, to ensure that the currents in these antennas are also in phase quadrature with the currents in the central antenna.

A final adjustment is obtained by means of the auto transformer 7 and the series reactor 9. The phases of the modulation supply currents are determined or monitored by applying currents from each modulator input to one set of coils of a dynamometer 108 and regulating the currents to obtain zero torque indication on the meter. The equality of antenna currents may be determined by the meters 87 and 89. The conditions of antenna current equality and quadrature modulation phase must be simultaneously met. Although it is not necessary to this invention, the phasing of the supply currents and the equality of the antenna currents may be automatically maintained by suitable servo mechanisms.

In the event that a plurality of radio beacons are used in cooperation, it is desirable to coordinate their indications. This may be effected by insuring that each beacon is keyed at the exact instant when the maximum of its pattern passes through due north. This requirement may be fulfilled by adjusting the variable capacitors 75 or 77 so that the keying impulse occurs at the instant of zero output from the east-west antenna system. Such phasing may be monitored by connecting the oscillograph electrodes 101 to the transformers 91, 95 and electrodes 107 to the primary of transformer 11 (see Figs. 1 and 2). The resulting pattern resembles that of Fig. 3*b*. If the keying phase is incorrect, a gap will appear in the shaded portion of this figure on one side of the intersection of the crossed lines.

Receiving devices

The device for receiving may follow any number of conventional patterns because the currents whose relative phases are to be determined are audio frequency and require no special radio frequency device. It is preferable to use radio frequency amplification with automatic volume and automatic frequency control and a distortionless audio frequency amplifier. One suitable circuit arrangement is shown in Fig. 4 in which antenna 111 is connected to a preselector and amplifier 113. The output circuit of the amplifier 113 is connected to a first detector 115 which is in turn coupled to an intermediate frequency amplifier 117. The output of the intermediate frequency amplifier is impressed upon a second detector 119. The audio frequency currents from the second detector are amplified in a suitable audio frequency amplifier 121 and further amplified by a power tube 123. The automatic volume control for the amplifier 113 and intermediate frequency amplifier 117 is obtained by amplifying the intermediate frequency currents in an auxiliary amplifier 137. The output circuit of the auxiliary amplifier 137 is connected to a rectifier 139 from which biasing currents are derived which are impressed through suitable filters on the inputs of the amplifiers 113 and 117. The output currents from the power tube are impressed upon a transformer 125, which is the normal output transformer of the radio receiver.

The bearing indicator hereinafter described is connected to the secondary of the output transformer. The secondary is connected to a filter system which may comprise a serially connected capacitor 127 and inductors 129 and 131. The shunt capacitors 133 and 135 complete the output filter. If a cathode ray tube is used as an indicator, a suitable phase splitting circuit, fed from the output filter, is employed to produce a rotating field, in the indicator, which operates in synchronism with the rotating field of the transmitter. One such circuit is represented within the dash lines 141; the potentials from the phase splitting circuit 141 are impressed on the deflecting electrodes 143 and 145 of the cathode ray tube 147. The deflecting electrodes are suitably biased by connections to the network represented within the dash lines 149. The reference impulse derived from the keying, is impressed on the grid 151 of the cathode ray tube 147 by a suitable transformer 153 which is coupled through a small capacitor to the output circuit of the transformer 125.

The audio frequency currents which are derived from the second detector 119 and suitably amplified may be represented by a series of curves shown in Figs. 5*a* to 5*d*, inclusive. The sinusoidal audio frequency current is represented by the curve X and the impulse is represented by the lines Y. By way of example, it is assumed that the relative phases of the reference marks Y in the Figs. 5*a*, 5*b*, 5*c* and 5*d* correspond respectively to receiver locations north, east, south and west of the beacon station. When steady bias voltages and deflecting voltages are impressed on the deflecting electrodes and the impulse voltage on the control electrode of the cathode ray tube, the resulting traces of the currents of 5*a*, etc., will correspond respectively to the Figs. 6*a*, 6*b*, 6*c* and 6*d*. It will be observed that the audio frequency currents, after their phases have been properly adjusted by the network 141, rotate the cathode ray trace in a circular path Z, which is interrupted by the reference impulse Y.

Operation of receiver with cathode ray indicator

In the operation of the receiver it becomes highly desirable to ascertain that the circular trace corresponds uniformly with the rotating field of the transmitter and that the interruption or reference mark occurs at the correct point on the compass card, which may be arranged on the fluorescent screen of the cathode ray tube. I have found that such adjustment of the receiver may be readily effected by keying the carrier currents which establish the uniform or non-directional field at the transmitter with four impulses each spaced 90 electrical degrees from its neighbors. In addition to the keying impulses, the carrier must be modulated by currents from the source 1. The voltage from the source 1 as applied to the modulator 39 should be of the same phase as the voltage applied to the transformer 13. The currents establishing the rotating field are not needed for the receiver check, and therefore the alternating supply to the balanced modulators may be turned off.

The advantage of this method of providing signals for checking the receiver operation is that it permits calibrating receivers at any bearing from the transmitter. With the foregoing method, the operator of a receiver may, without knowledge of the receiver's position, determine the correct zero setting of the compass card without 90°, 180°, or 270° errors or uncertainty, when he receives the non-directional calibrating signal with a single reference mark.

Receivers within 45° of the meridian through the transmitter may be calibrated by applying the four mark keying to the otherwise unmodulated carrier, and energizing only the north and south directive antennas. In a similar manner, receivers east and west of the transmitter may be calibrated by energizing the central antennas as just described and the east and west directive antennas. The operator at the receiving devices adjusts the direct current biases and the alternating current phase and amplitude by means of the controls in the networks 141, 149, etc.

If the phase constant of the filter has a proper value, I have found that the following procedure aids in quickly and certainly adjusting the cathode ray trace location:

(1) Adjust the phase and relative amplitude controls until a substantially circular and centralized pattern is obtained.

(2) Adjust the horizontal centering (bias) until the spaces in the trace caused by the north and south reference impulses show equal errors or displacements at the north and south compass points.

(3) Turn the cathode ray tube or the compass scale card to remove the north and south errors. That is, line up the compass card with the north and south reference points as marked on the ray trace.

(4) Adjust the vertical centering bias to give equal errors or displacements at the east and west reference points.

(5) Adjust the phase control to remove the errors at the east and west compass points.

This alignment of the trace insures accuracy at the said points. It also limits any errors of indication between these points. After the check has been made with the four reference points, the transmitter is again keyed with a single impulse corresponding to due north, as previously described. The zero setting of the single reference impulse may always be obtained by rotating the cathode ray tube or compass card. The foregoing adjustments are for the purpose of adjusting or checking receiver operation.

Modified forms of indicator

Instead of using a cathode ray tube for the indicator at the receiver, other means for indicating the phase of the rotating field with respect to the reference phase may be used. One such arrangement is illustrated in Fig. 7. In this circuit, the receiver output currents are impressed on an output transformer 125. The sinusoidal audio currents are filtered and impressed on a phase splitter 163 to obtain currents to operate a synchronous motor 165. The indicator 167 on the motor shaft will revolve in synchronism with the rotating field about the transmitter. The reference impulse is derived by any suitable means 169 such as a gaseous discharge tube, amplifier or the like. The reference impulse is used to light a neon lamp 171 which stroboscopically illuminates the pointer 167. Thus the relative phase of the rotating field and reference point is indicated in terms of the bearing of the receiver with respect to the beacon.

In the circuit of Fig. 8 the output currents from the receiver are impressed on a transformer 173 which includes a pair of secondaries 175, 177. The secondaries are connected respectively to filters 179, 181. One of the filters 179 is connected to a phase splitter 183 which is connected to a Lincoln synchroscope 185. The impulse selecting filter 181 is connected to a relaxation oscillator 187 and to a filter 189. The filter 189 is connected to the synchroscope 185. The Lincoln synchroscope is a conventional and well known instrument, which is in this instance calibrated as a compass card.

I claim as my invention:

1. In a rotating radio beacon a source of alternating currents, a source of radio frequency current, means for modulating said radio frequency currents by said alternating currents to obtain two sources of modulated radio frequency energy, a first pair of antennas, means coupled to one of said sources of energy for energizing each of said first pair of antennas with modulated radio frequency currents of opposite phase, a second pair of antennas, means coupled to the other of said sources of energy for energizing each of said second pair of antennas with modulated radio frequency currents of opposite phase, means for adjusting the phases of the alternating currents applied to said means for modulating so that said alternating currents are in quadrature phase, means for radiating a uniform field at said radio frequency and in quadrature with the radio frequency currents in said pairs of antennas, means connected to said source of alternating currents for deriving therefrom an impulse, and means for applying said impulse to momentarily stop the radiation of said uniform field, whereby a reference impulse is established.

2. In a rotating radio beacon, a source of alternating current of two phases, a source of radio frequency current, means for modulating said radio frequency currents by said alternating current phases, a first pair of antennas, means coupled to said radio frequency current source for energizing each of said antennas with currents of opposite phase, a second pair of antennas symmetrically disposed with respect to said first pair of antennas, means coupled to said radio frequency current source for energizing each of said second pair of antennas with currents of opposite phase, means for adjusting the phases of the alternating currents modulating said radio frequency currents so that said alternating currents are in quadrature phase, means for radiating a uniform field at said radio frequency and in quadrature with the radio frequency currents in said pairs of antennas, and means for keying said radio frequency currents, said means for keying including means coupled to said source of alternating current for deriving therefrom an impulse current once per cycle of said alternating current.

3. In a rotating radio beacon a source of alternating current, means for obtaining two phases from said alternating current source, a source of radio frequency currents, means for modulating said radio frequency currents by said two phases of alternating current to thereby obtain two sources of modulated radio frequency currents, a first pair of antennas, means coupled to one of said modulated radio frequency current sources for energizing each of said first pair of antennas with modulated radio frequency currents of opposite phase, a second pair of antennas symmetrically disposed with respect to said first pair of antennas and arranged so that said first and second pairs of antennas are at the corners of a square, means coupled to the other of said modulated radio frequency current sources for energizing each of said second pair of antennas with modulated radio frequency currents of opposite phase, means for controlling the phases of the alternating currents so that said alternating currents are in quadrature phase, means for controlling the relative amplitude of said antenna currents, means for radiating a uniform field at said radio frequency and in quadrature with the radio frequency currents in said pairs of antennas, and means for keying said radio frequency currents, said keying means including a rectifier coupled to said alternating current source, filters connected to said rectifier, means for adjusting said filters to secure therefrom currents of the desired phase and frequency, means including gaseous discharge tubes connected to the output of said filter to obtain reference impulses from said alternating current source, and means connecting said keying means to said source of radio frequency currents.

4. In a radio bearing system of the character described, a source of radio frequency currents, means including said source of radio frequency currents for radiating a radio frequency field, a source of audio frequency current, means for applying said audio frequency current to said radio frequency currents so that said radio frequency currents are modulated, means for rotating said field at said audio frequency, means for radiating a non-directional radio frequency field, means for deriving from said audio current source an impulse for interrupting said nondirectional field once per revolution of said rotating field to establish a reference impulse, means for applying said impulse to said non-direction field radiation means to interrupt said radiation, means located at any point within said fields for determining the phase of the rotating field with respect to said reference impulse, a cathode ray tube including pairs of deflecting elements for adjusting and monitoring the phases of the radio frequency currents in said directional and non-directional antennas, means coupling one of said pairs of elements to said non-directional antenna, and means for differentially coupling the other of said pairs of elements to one of said pairs of directive antennas.

5. In a radio bearing system of the character described, a source of radio frequency currents, means including said source for establishing a radio frequency field, means for modulating said radio frequency currents, means for rotating said field at said modulation frequency, means for radiating a uniform radio frequency field, means for deriving from said modulation means a keying impulse, means for applying said impulse to the field radiating means to key the currents which establish said rotating field and uniform fields at a predetermined point in said rotation, means for determining the phase of said rotating field with respect to said keying at any point within said fields, a cathode ray tube including pairs of deflecting elements for adjusting and monitoring the phases of the radio frequency currents in said directional and non-directional antennas, means coupling one of said pairs of elements to said non-directional antenna, and means for differentially coupling the other of said pairs of elements to one of said pairs of directive antennas.

6. In a device of the character of claim 1, means for graphically observing an indication of the phase relationship of the modulated radio frequency currents.

7. In a device of the character of claim 1, means for graphically indicating the phase relationship of the modulated radio frequency currents with respect to currents from said radio frequency source.

8. In a rotating radio beacon, a source of radio frequency currents, a pair of balanced modulators, means for impressing currents from said source on said modulators, two pairs of directive antennas, a connection from one of said pair of directive antennas to one of said modulators, a connection from the other of said pair of directive antennas to the other of said modulators, a source of alternating current, means for deriving two phases from said alternating current source, means for maintaining quadrature relation between said two phases, means for impressing currents of one of said phases on one of said modulators and currents of said other phase on said other modulator, a non-directional antenna, means for impressing said radio frequency currents on said non-directional antenna, means for obtaining a phase quadrature between the currents in said non-directional antenna and the currents in said directional antennas, means for deriving from said alternating current source an impulse current of controllable phase, and means for applying said impulse current to momentarily interrupt the application of radio frequency currents to at least said non-directional antenna whereby a reference impulse is established which bears a chosen relation to the phase of said alternating current.

9. In a device of the character of claim 8, means for including a plurality of reference impulses in the currents impressed on said non-directional antenna, whereby a receiver responsive to said beacon signals may be calibrated at a plurality of reference points.

10. In a device of the character of claim 8, means for including four reference impulses in the currents impressed on said non-directional antenna, whereby a receiver responsive to said beacon signals may be calibrated at four reference points.

11. In a rotating radio beacon of the character described in claim 8, a cathode ray tube, including pairs of deflecting elements, for adjusting and monitoring the phases of the radio frequency currents in said directional and non-directional antennas, and means coupling one of said pairs of elements to said nondirective antenna and means for differentially coupling the other of said pairs of elements to one of said pairs of directive antennas.

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