

July 16, 1940.

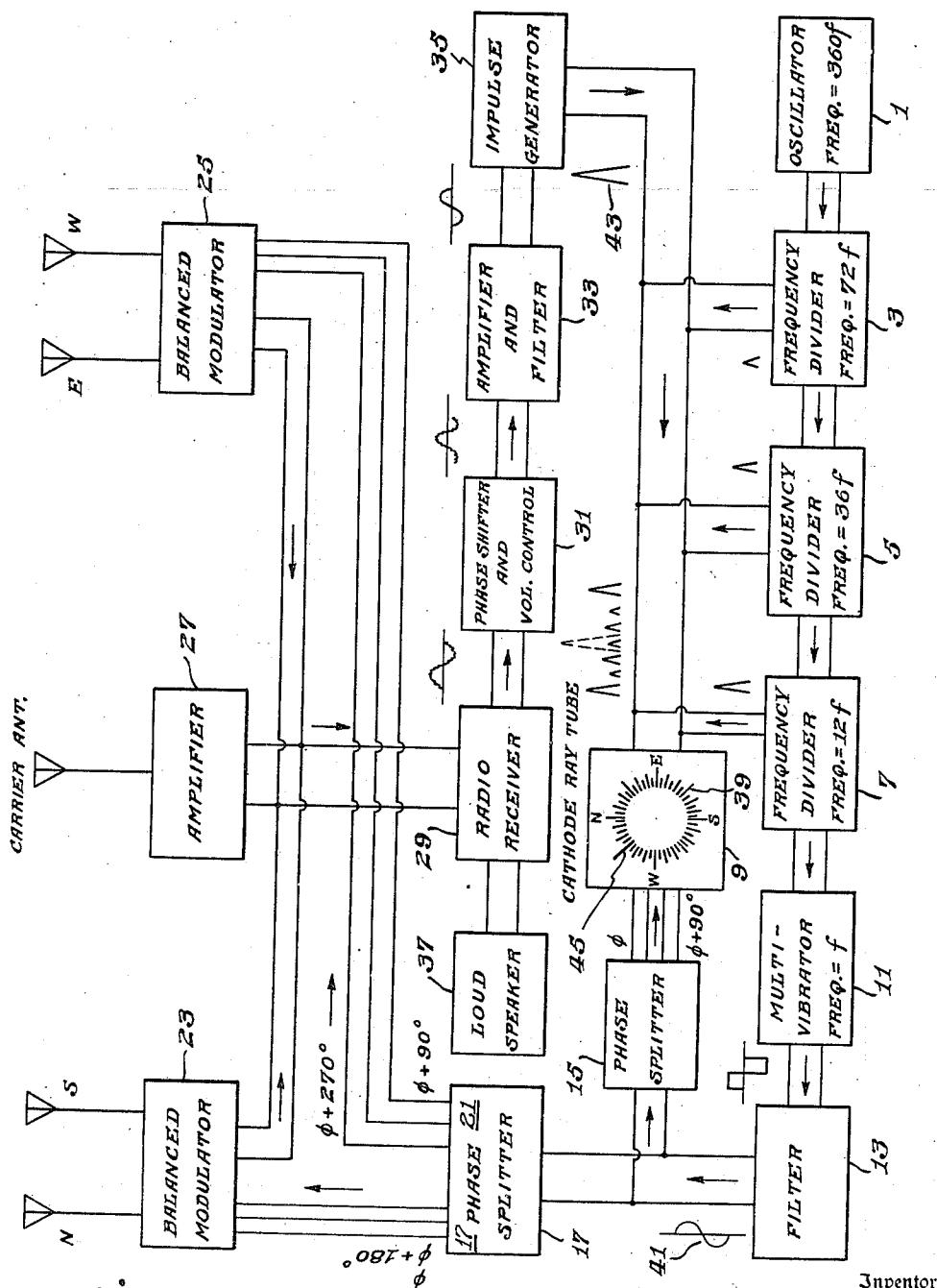
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2,208,378

CONTINUOUSLY INDICATING RADIO COMPASS

Filed June 30, 1938

3 Sheets-Sheet 1



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FIG. 2.

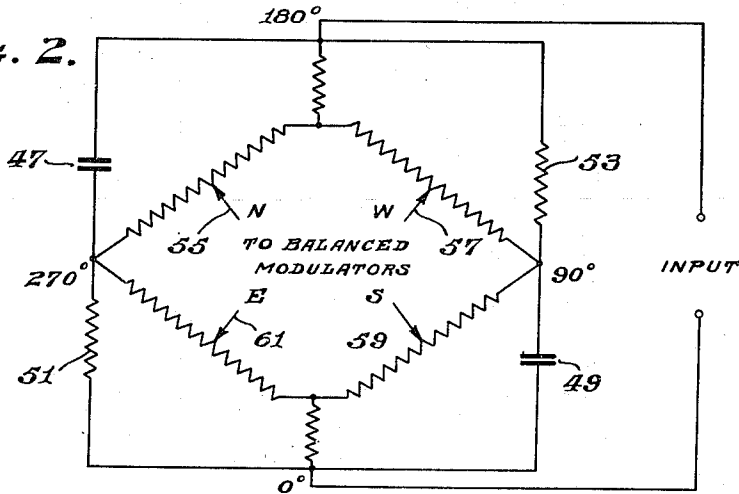
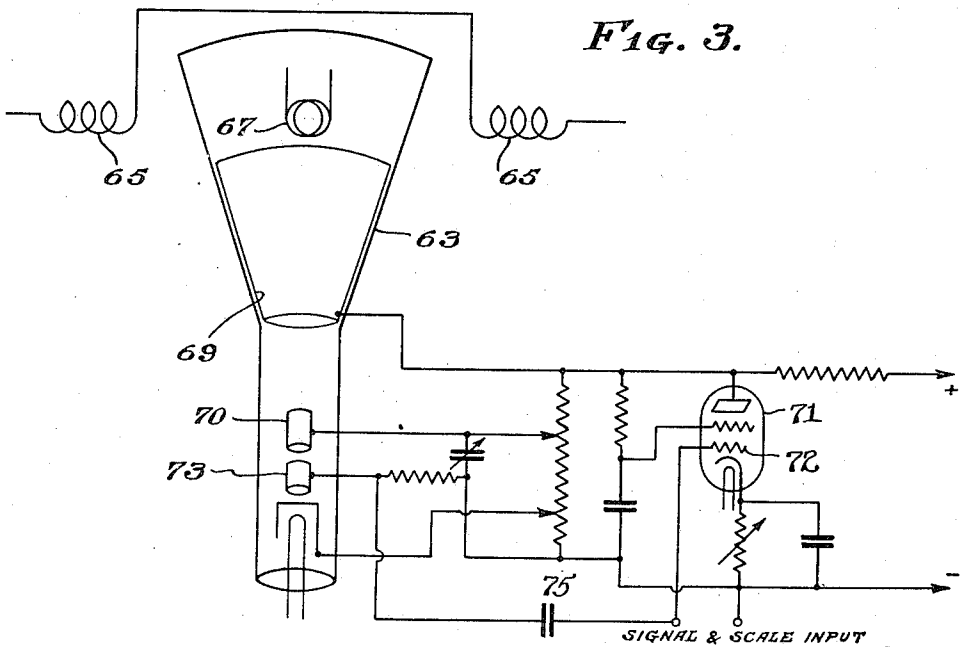


FIG. 3.



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FIG. 4.

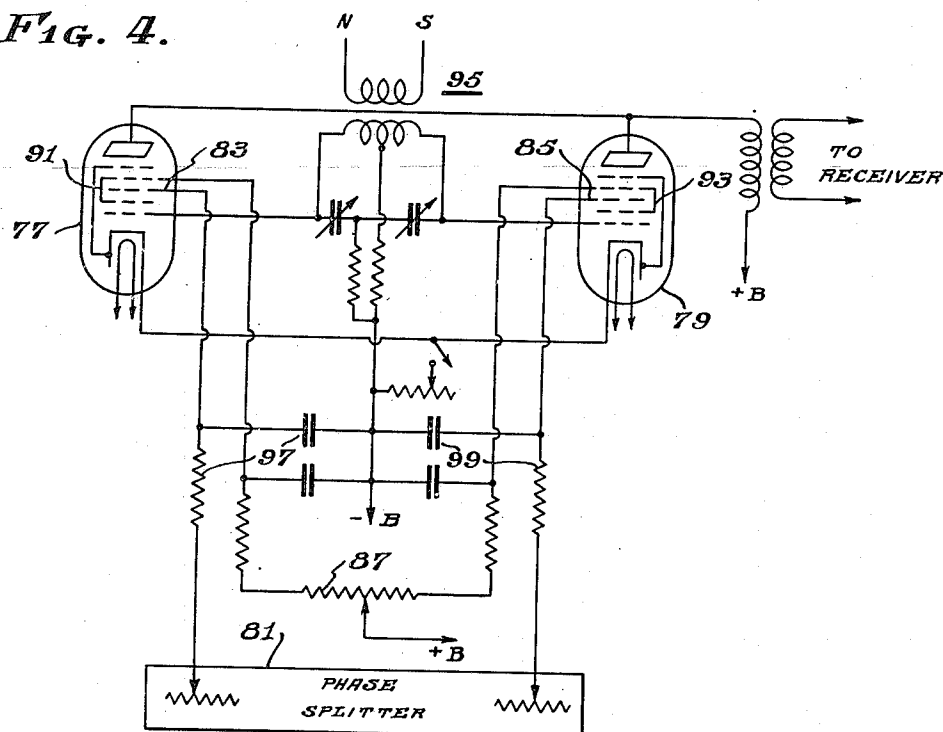
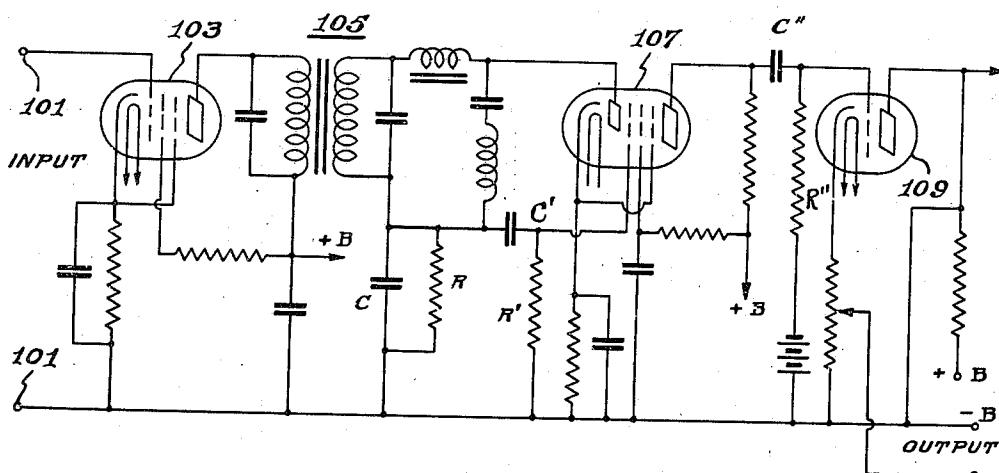


FIG. 5.



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UNITED STATES PATENT OFFICE

2,208,378

CONTINUOUSLY INDICATING RADIO
COMPASS

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poration of Delaware

Application June 30, 1938, Serial No. 216,825

8 Claims. (Cl. 250—11)

My invention relates to radio direction finders and more particularly to a radio direction finder which affords continuous indication throughout its azimuth.

5 Numerous types of radio compasses have been disclosed in the prior art. One radio compass is the so-called "left-right" type. Such radio compasses indicate departures to the left or right of a line toward a radio transmitter. It has
10 also been proposed in a copending application of Alexandre Sev, entitled "Direct reading goniometer," Serial No. 115,899, filed December 15, 1936, to continuously indicate the bearing of a radio transmitter with respect to a radio re-
15 ceiver. The system proposed by Sev includes a pair of cross loop antennas of the balanced type and a non-directive antenna. In this arrangement the currents from the several loop sections are successively applied through pairs of diode
20 detectors to a common circuit which is also energized by currents from the non-directive antenna. My invention improves the Sev system as will hereinafter appear.

It is an object of this invention to provide
25 means for operating a continuously indicating radio compass employing a cathode ray indicator. It is a further object of this invention to provide means in a radio compass for deriving electrically scale indications to avoid errors which
30 might occur in the use of fixed scales. It is a further object of this invention to provide improved means for deriving side band currents from pairs of directive antennas and carrier currents from the non-directive antenna. It is an-
35 other object to provide means for applying modulation currents of suitable phase to successively modulate currents derived from pairs of directive antennas.

The invention may be better understood by referring to the accompanying drawings in which
40 Figure 1 is a schematic diagram of one embodiment of the invention;

Figure 2 is a circuit diagram of a phase splitting circuit embodied in the invention;

45 Figure 3 is a circuit diagram showing the circuit for applying signal and scale impulses to the cathode ray tube;

Figure 4 is a schematic circuit diagram of the balanced modulator; and

50 Figure 5 illustrates one suitable circuit for the impulse generator which is embodied in the invention.

Referring to Fig. 1, a stable oscillator 1, preferably of the magnetostrictive type, is connected
55 to three frequency dividers indicated by reference

numerals 3, 5, 7, respectively. The outputs from the frequency dividers are impressed upon the control circuit of a cathode ray tube 9, as will be hereinafter described. The output from the last stage of the frequency divider 7 is impressed
5 upon the input of a multi-vibrator 11, which is connected to a filter 13.

The filter output is connected to a pair of phase splitters 15, 17. One of the phase splitters 15 is connected to the deflecting coils, or deflecting
10 electrodes, of the cathode ray tube 9. The outputs 19, 21 of the second phase splitter 17 are connected respectively to a pair of balanced modulators 23, 25.

The first balanced modulator is connected to a
15 north antenna and a south antenna. The second balanced modulator 25 is connected to an east antenna and a west antenna. The several antennas N, E, S, W are preferably arranged at the corners of a square, as in the well known
20 Adcock type direction finders. A non-directive or carrier current antenna is positioned at the intersection of the diagonals of the square and is coupled through an amplifier 27 to a radio
25 receiver 29. The outputs of the balanced modulators 23, 25 are likewise coupled to the input of the radio receiver.

Although the invention is not limited to a particular type of receiver, a superheterodyne with a suitable automatic sensitivity control is preferred. The output of the radio receiver 29 is
30 applied to a phase shifter and volume control 31, which is connected to an amplifier and filter 33. The output of the amplifier and filter 33 is applied to an impulse generator 35 which is con-
35 nected to the input circuit of the cathode ray tube 9. The radio receiver may also include a loudspeaker 37.

The operation of the circuit is essentially as follows: Currents having a frequency of the order of $360n$ cycles per second are derived from the oscillator 1 and frequency divided to provide
40 impulses at the respective rates of $72n$, $36n$ and $12n$ cycles per second. These impulses are preferably of different amplitudes to provide the
45 scale marking impulses 39 for the cathode ray tube 9.

The details and operation of the oscillator and frequency divider circuits are more completely described in U. S. Patent No. 2,121,359, issued
50 June 21, 1938 to David G. C. Luck and Lowell E. Norton and assigned to Radio Corporation of America, or as described in Norton application Serial No. 210,574, filed May 28, 1938 and assigned
55 to the aforementioned assignee.

The currents from the last stage of the frequency divider 7 are impressed on the multi-vibrator to derive therefrom a frequency of 1 $\frac{1}{2}$, or 42 $\frac{1}{2}$ cycles per second. The output currents from the multi-vibrator, after filtering, are sine wave currents as indicated at 41. The sine wave currents are applied to the first phase splitter 15 and through the phase splitter to the cathode ray deflecting elements. The potentials thus applied to the deflecting elements rotate the cathode ray beam in synchronism with the oscillator and thereby correctly apply the various scale marking impulses at intervals of 5, 10 and 30 electrical degrees.

The currents from the second phase splitter operate in synchronism with the cathode ray beam and modulate, at phase intervals of 90°, currents induced in the several directive antennas N, E, S and W. The output currents from the balanced modulators are substantially deprived of their carrier which is supplied by currents from the carrier antenna after amplification.

The effect of thus successively modulating the several antennas and supplying carrier currents from the central antenna is that of a rotating cardioid response pattern. Thus, the receiver output will be modulated as a result of the rotation of the cardioid pattern. The phase of this modulation will depend on the direction from which the receiver signal arrives. This phase may be shifted so that the north point of the cathode ray scale can be made to correspond to a signal derived from a transmitter due north of the carrier antenna, by use of the phase shifter 31.

The receiver output currents may be further amplified and filtered to attenuate all the currents of undesired frequencies and to apply currents of modulation frequency to the impulse generator 35. The impulse generator establishes a single impulse 43 whose phase is determined with respect to the modulation phase of the receiver output. Thus, the incoming signal establishing the impulse 43 is applied to the cathode ray tube as shown by the marker signal 45.

One satisfactory form of phase splitter for applying the modulation currents to the balanced modulator is shown in Fig. 2. In this circuit, capacitors 47, 49 and resistor 51, 53 are connected in series. The input currents are applied to the junction of capacitor 47 and resistance 53 and to the junction of capacitor 49 and resistance 51. The resistive bridge is connected between these same junctions and the remaining junctions of the serially connected capacitors and resistors. The bridge arms are provided with adjustable contacts 55, 57, 59, 61, which are respectively connected to control grids in the balanced modulators which are coupled to the N, W, S, E antennas in the order named. This phase splitting and adjusting circuit has been found to provide a very satisfactory means of impressing modulation voltages having the required phase progression on the four modulator tubes.

One suitable method of applying the deflecting potentials and the signal and scale input potentials to the cathode ray tube is illustrated in Fig. 3. The deflecting elements for the cathode ray tube 63 are represented as coils 65, 67. It should be understood that the coils are arranged in pairs and are separated substantially 90°. The first and second anodes 69, 70 are connected to a potentiometer in the output circuit of the ray velocity modulator tube 71. The control grid

73 of the cathode ray tube is connected through a capacitor 75 to the signal and scale input which is also connected to the ray velocity modulator tube 71. The operation of these circuits is more fully described in the above mentioned Norton application.

Referring to Fig. 4, the thermionic tubes 77, 79 are connected as a balanced modulator. The modulator currents from the phase splitter 81 which corresponds to the phase splitter 17 of Fig. 1 are impressed on grid electrodes 83, 85. The potentiometer 87, which is connected to screen grid electrodes 91, 93, forms a suitable means of balancing the modulator tubes, which are of the two control grid mixer type. The input to the modulator tubes is applied through the transformer 95, the secondary of which is symmetrically connected to control grids of the modulator tubes. Filter circuits 97, 99 are preferably included in the connections between the grid electrodes 83, 85 and the phase splitter circuit 81.

One suitable form of impulse generator circuit is shown in Fig. 5. The input terminals 101 are connected to an amplifier 103. The output circuit of the amplifier includes a filter circuit 105. The output of the filter is connected to a diode rectifier which is part of thermionic tube 107. The rectifier is connected to the amplifier section of tube 107. The amplifier output is impressed on the input of tube 109 which is preferably a gas discharge type of tube. The output terminals are indicated by the reference numeral 111. The foregoing circuit is arranged so that the input sine wave currents are used to derive the sharply defined impulse marking current. In actual practice, this circuit arrangement has proven very satisfactory, but it should be understood that the invention is not necessarily limited to the precise impulse generator shown.

The operation of the impulse generator is essentially as follows: The signal currents applied to the input 101 are amplified and filtered. The filtered signals are applied to the diode rectifier which produces unidirectional currents. The unidirectional currents are made asymmetrical in form by properly choosing the ratio of capacity C and resistance R in the rectifier circuit. The currents of asymmetrical wave form are differentiated by a filter C'R' including capacity and resistance. The differentiated currents are amplified and further differentiated by another filter C'R''. The last mentioned differentiated currents establish, across the resistor R'', potentials which are applied to the gaseous tube 109. The gaseous tube is biased negatively and is only triggered by the positive peak of the applied potential. The final impulses are obtained from the potentiometer in the discharge circuit of the gaseous tube 109. The impulse generator per se is described and claimed in the copending application entitled "Impulse generators," Serial No. 214,473, filed June 18, 1938, Patent No. 2,188,611, January 30, 1940 by Lowell E. Norton and assigned to the same assignee as the instant application.

Inasmuch as the remaining elements of the circuits are known to those skilled in the art, further description is unnecessary. Thus, I have described a continuously indicating radio compass. The scale markings for the compass are applied electrically and synchronously with the rotation of a cathode ray. Signals from a transmitter whose bearing is to be determined are

modulated in synchronism with the rotation of the cathode ray whereby a signal is derived having a phase dependent upon the bearing of the transmitter. The phase determining this bearing is indicated by applying the received signal to the cathode ray tube.

It should be understood that the non-directive antenna may be omitted and that the carrier frequency currents may be derived from the directive antennas. It should also be understood that the system may be operated by employing a symmetrical rotating field and obtaining two indications of bearing spaced 180°. In such installations there will be a 180° ambiguity. A cathode ray tube 63 having deflecting electrodes or coils disposed as to produce a radial deflection directly may be used, in which case the beam velocity modulator tube 71 is not required.

I claim as my invention:

1. A directive radio receiver including a pair of directive antennas, said antennas having response patterns differently oriented, a non-directive antenna, a radio receiver, a pair of balanced modulators, one of said balanced modulators being connected between each of said pair of antennas and said radio receiver, a local source of modulation currents, means for applying said modulation currents in quadrature phase to said balanced modulators to successively transfer energy from said directive antennas to said radio receiver so that the resultant response pattern of said directive antennas is effectively rotated, means for applying energy from said non-directive antenna to said radio receiver, a cathode ray tube, means for obtaining from said modulation current source quadrature phase currents for rotating the cathode ray beam of said cathode ray tube, and means for applying a signal to deflect said cathode ray as a function of the phase of the output signals from said receiver.

2. In the device of the character of claim 1 means including said quadrature phase currents for electrically applying a compass scale to said cathode ray tube.

3. A continuously indicating radio compass including, in combination, a pair of directive antennas, a non-directive antenna, a radio receiver, a pair of balanced modulators respectively connected between said pairs of directive antennas and the input of said radio receiver, a local source of modulation currents, means for obtaining currents of quadrature phase relation from said modulation currents, means for applying said currents of quadrature phase to said balanced modulators, means for connecting the non-directive antenna to said receiver, a cathode ray tube, means including quadrature phase currents derived from said source of modulation currents for rotating said cathode ray, and means for applying a signal impulse derived from the output

of said radio receiver to deflect said cathode ray in a radial direction.

4. In a device of the character of claim 3 means operatively related to the next to the last mentioned means for applying scale marking impulses to said cathode ray tube.

5. The method of continuously indicating the bearing of a radio transmitter with respect to a radio receiver including a pair of directive antennas, a non-directive antenna and a cathode ray tube which includes impressing radio waves from said transmitter on said antennas, successively modulating energy from each of said directive antennas, combining said modulated energy with carrier frequency energy from said non-directive antenna so that the resultant response pattern of said directive antennas is effectively rotated, rotating the cathode ray beam of said cathode ray tube in synchronism with the rotation of the resultant response pattern of said directive antennas, and applying an impulse derived from said combined energy to deflect and visibly indicate said cathode ray.

6. A directive radio receiver including a pair of directive antennas, said antennas having response patterns differently oriented, a radio receiver, a source of modulation currents, means for obtaining currents in quadrature phase relation from said modulation currents, means for applying said quadrature phase currents to successively transfer energy from said directive antennas to said radio receiver whereby a rotating response pattern is obtained, a cathode ray tube, means including said quadrature phase currents for rotating the cathode ray beam of said cathode ray tube in synchronism with the rotation of said response pattern, and means for deflecting said cathode ray to provide marks as a function of the phase of the output signals from said receiver.

7. In a device of the character of claim 6, means including said quadrature phase currents for electrically applying in synchronism with the rotation of said beam a compass scale to said cathode ray tube.

8. A continuously indicating radio compass including, in combination, a pair of directive antennas, a radio receiver, a pair of balanced modulators for connecting said directive antennas to the input of said radio receiver, a source of modulation current, means for deriving two phases from said modulation current source, means for applying said phases to said pair of modulators whereby a rotating response pattern is obtained, a cathode ray tube, means for applying said phases to rotate the cathode ray of said tube in synchronism with the rotation of said pattern, and means for applying signal impulses derived from the output of said radio receiver to deflect said cathode ray.

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