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J. R. HOOVER

3,231,890

RADIO DIRECTION FINDER

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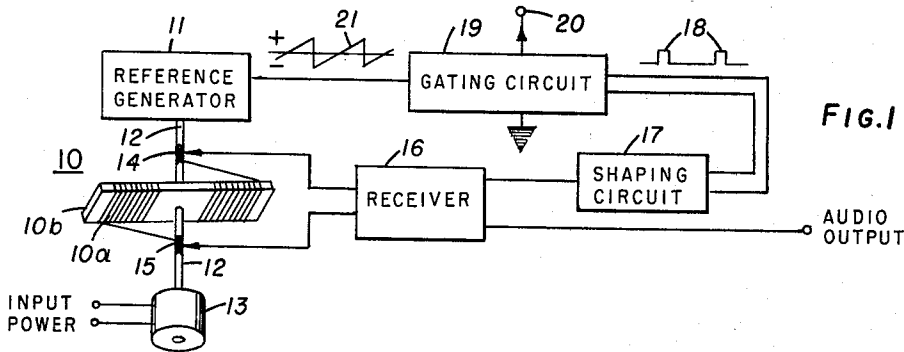


FIG. 1

FIG. 2

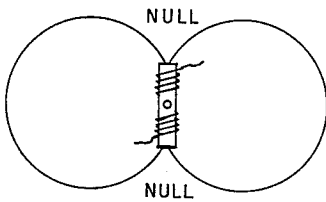


FIG. 3A

FIG. 3B

FIG. 3C

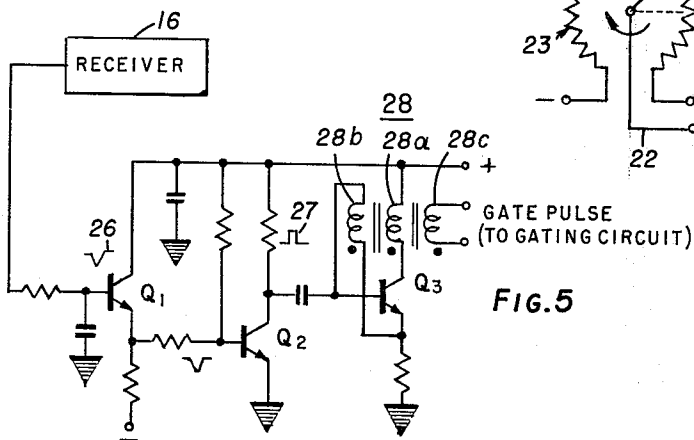
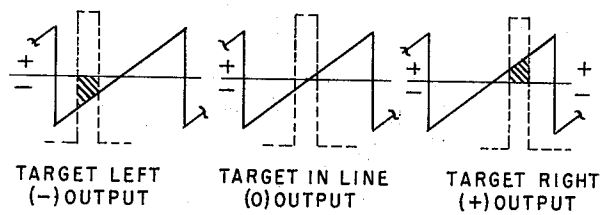


FIG. 5

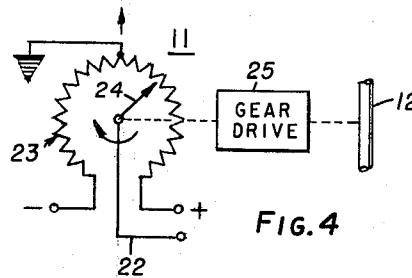


FIG. 4

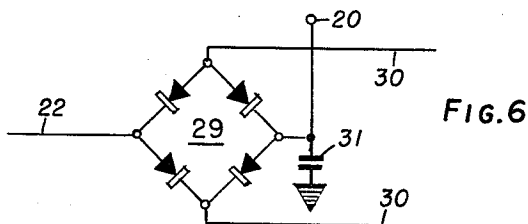


FIG. 6

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RADIO DIRECTION FINDER

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3 Claims. (Cl. 343-118)

This invention relates to radio receiving devices for producing an indication of the direction of approach of a received signal, and more specifically to the type of device employing a continuously rotatable directional antenna.

Objects of the invention are to provide a radio direction finder having the advantages of: low cost; low power requirements; high reliability; light weight; adaptable to portable (hand held) operation; and adaptable for autopilot control.

Directional radio finders employing continuously rotatable directional antennas have hitherto been used in various ways. For instance it is old to apply signals from a rotating directional antenna to a cathode ray tube having a sweep rotating in synchronism with the antenna. It is also old to phase-compare signals from a rotating antenna with two quadrature sine waves generated in synchronism with the antenna rotation.

The present system differs from prior systems in that a sawtooth reference wave is generated in synchronism with the antenna rotation, and a sample of the wave is periodically taken in response to a predetermined output from the directional antenna, such as a null (minimum) or a maximum signal. If the sawtooth wave varies from a negative value through zero to a positive value of the same magnitude, and the sawtooth wave generator is properly phased with respect to the antenna rotation, the sample will be taken from the center of the sawtooth wave and will be zero when the directional radius of the finder coincides with the direction of the received radio signal. If the directional radius does not coincide with the direction of the received signal the sample will be of a magnitude proportional to the departure from coincidence and of polarity depending upon the direction of departure from coincidence.

A full understanding of the invention and its advantages may be had from the following description with reference to the drawing in which:

FIG. 1 is a schematic diagram of a system incorporating the invention.

FIG. 2 is a diagram showing the reception pattern of an antenna that may be employed in FIG. 1.

FIGS. 3A, 3B and 3C are graphs illustrating the operation of the system.

FIG. 4 is a schematic diagram of a reference generator that may be employed in the system of FIG. 1.

FIG. 5 is a circuit diagram of a shaping circuit that may be employed in FIG. 1.

FIG. 6 is a schematic diagram of a gating circuit that may be employed in FIG. 1.

Referring to FIG. 1, a directional antenna 10 and a reference generator 11 are mounted on a common vertical shaft 12 which is continuously rotated by a motor 13 when the system is in operation. The antenna 10 may be of many known types, but is shown as a loop 10a on a ferrite core 10b. The terminals of the loop are shown connected through slip rings 14 and 15 to the input of a radio receiver 16, the output of which is delivered to a shaping circuit 17. The function of the receiver 16 is, in addition to selecting a desired signal, to indicate the magnitude of the current generated in the antenna by a received signal, and it is common practice to take as the output from the receiver the AGC voltage, which varies directly with the magnitude of the signal input to the receiver.

This AGC voltage nulls and peaks at a frequency equal to or harmonically related to the speed of rotation of the antenna 10.

The purpose of the shaping circuit 17 is to produce a pulse of constant duration and amplitude in response to variations in antenna output through a predetermined level. For the present let it be assumed that each time the antenna 10 moves into a predetermined position with respect to the direction of a received radio signal, a positive pulse 18 is delivered to a gating circuit 19 which enables the passage, through the gate to an output terminal 20, of the output potential of the reference generator 11. If the directional radius of the antenna 10 (in this instance the axis of the core 10b) is aligned with the received signal at the time of occurrence of the midpoint of the ramp wave 21, zero output potential (FIG. 3B) will pass through the gate 19 to the output terminal 20. If the system is mounted on a moving craft aiming at the transmitting station from which the radio signal is received, the apparatus would be adjusted (as to orientation with respect to the craft) so that the output of the ramp wave 21 has its median value (zero under the condition described) when the directional radius of the rotating antenna is aligned with the longitudinal axis of the craft. The direction (right or left) of deviation from "on course" would then be shown by the polarity of the output signal on terminal 20, and the magnitude of the deviation by the magnitude of the output signal. "Off course" conditions are illustrated in FIGS. 3A and 3C. Obviously the output signal can be applied to an indicator, such as a D.C. voltmeter, having a zero-center scale to read either positive or negative values, or to an automatic pilot or steering mechanism selectively responsive to positive and negative control signals.

FIG. 2 shows a simple directional antenna having a figure-8 pattern producing two null signals and two maximum signals during each revolution. With such an antenna the reference generator 11 or its coupling to the antenna can be designed to produce a ramp wave 21 either once during each antenna rotation, utilizing only one of the two null positions, or twice during each antenna rotation, utilizing both of the two positions. Obviously antennas such as those having a cardioid pattern and producing only one null or maximum signal per rotation may be used if desired.

FIG. 4 shows one type of reference current generator that can be employed. It consists of a potentiometer winding 23 having a rotatable contact 24 which is coupled to the shaft 12 for rotation thereby. The connection can be direct for rotation at the same speed as the shaft 12 as previously described, or, as shown in FIG. 4, the contact may be driven through a gear drive 25 at twice the speed of the shaft 12. As shown, one end of the winding 23 is connected to a negative terminal of a D.C. source, the other end of the winding is connected to the positive terminal of a D.C. source, and the center point of the winding is connected to ground. If the positive and negative D.C. sources are of equal potential and the potentiometer winding 23 is linear, rotation of the contact 24 will apply to the output line 22 a linear ramp wave as indicated at 21 in FIG. 1.

Many known circuits may be employed for the shaping circuit 17 in FIG. 1, one of which is shown in FIG. 5 and is a transistorized version of a type of vacuum tube pulse generator described in Chapter 6 of Volume 19 of "Radiation Laboratory Series," to which reference is made for detailed theory of operation.

Briefly, in FIG. 5 each negative null pulse 26 from the receiver 16 is amplified without inversion by a transistor Q₁, and applied to a transistor Q₂ for amplification with inversion, to produce a positive pulse 27 which triggers a blocking oscillator circuit comprising a transistor Q₃ and

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a transformer 28 having a primary winding 28a in the collector circuit of Q₃, a secondary feedback winding 28b connected to the base circuit of the transistor, and a secondary output winding 28c connected to the gating circuit 19 (FIG. 1). In response to each trigger pulse 27, the blocking oscillator circuit oscillates through one-half cycle to produce the uniform gating pulses 18 of FIG. 1.

FIG. 6 shows a well known gating circuit that may be employed in the block 19 of FIG. 1. It comprises a four-diode circuit 29, one pair of terminals of which are connected between the reference generator lead 22 and the output terminal 20, and the other pair of terminals of which are connected to the output leads 30 of the shaping circuit 17. In the absence of a pulse 18 (FIG. 1) on the leads 30, the bridge circuit is nonconductive between the lead 22 and the output terminal 20, but becomes conductive in the presence of a pulse 18. A storage capacitor 31 retains the potential of the previous gated sample which is applied to output terminal 20.

Obviously the synchronized movements of the antenna and reference generator are not limited to continuous rotation; but can be oscillations back and forth through any desired angle.

Although it is usually preferable to utilize the null portion of the signal from the antenna rather than some other portion, the present system is not dependent on use of any particular portion so long as it is a changing function of the antenna position.

Although for the purpose of explaining the invention a particular embodiment thereof has been shown and described, obvious modifications will occur to a person skilled in the art, and I do not desire to be limited to the exact details shown and described.

I claim:

1. A radio direction-indicating system comprising: angularly movable directional antenna means having a directional radius, and means for angularly moving said antenna means whereby incoming radio signals generate an antenna current varying toward and away

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from a limit value in response to angular movement of the antenna means such as to sweep said directional radius across the path of the incoming signal; movable reference current means delivering a reference current varying in magnitude through a range having a median value in an intermediate point in said range;

means moving said reference current means in fixed phase relation with respect to movement of said antenna means whereby said directional radius has a predetermined orientation at the time of passage of said reference current through its said median value; an output terminal;

means actuated by said antenna current for generating a gating pulse in response to variation of said antenna current through said limit value;

gating means responsive to each successive gating pulse for momentarily connecting said reference current means to said output terminal to apply to the latter a potential which is a function of the orientation of said antenna means with respect to the said incoming signal path.

2. Apparatus according to claim 1 in which:

said movable reference current means comprises a ramp wave generator producing a succession of ramp waves each varying from a maximum value of one polarity through a median value of zero to a maximum value of opposite polarity.

3. Apparatus according to claim 1 in which the shape and magnitude of said gating pulse is independent of said antenna current.

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CHESTER L. JUSTUS, *Primary Examiner.*