DIRECTION FINDER

Filed Nov. 16, 1946

Fig. 1.

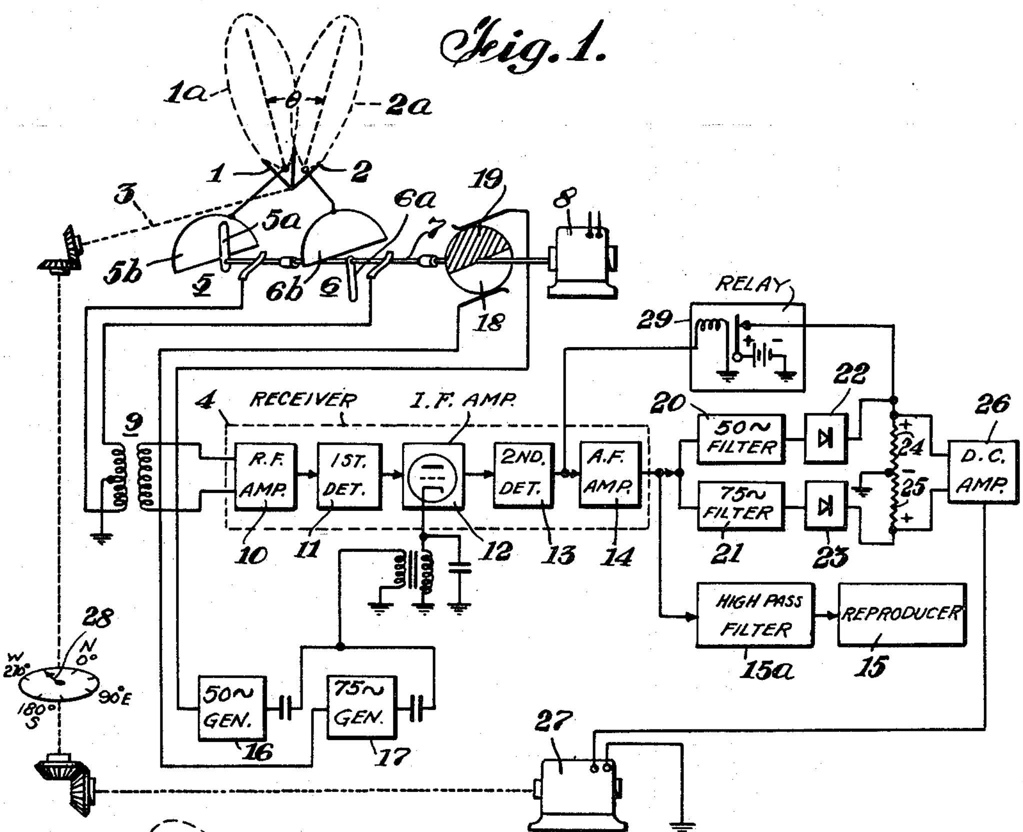
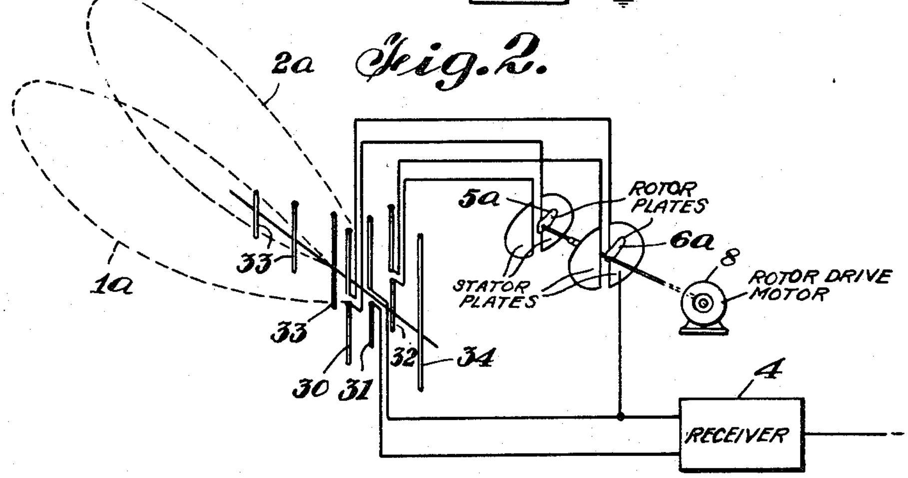


Fig. 2.



INVENTOR.
EDWARD B. MOORE

BY Percy P. Lantzy
ATTORNEY

Patented Oct. 25, 1949

2,485,627

UNITED STATES PATENT OFFICE

2,485,627

DIRECTION FINDER

Edward B. Moore, Ridgewood, N. J., assignor to Federal Telephone and Radio Corporation, New York, N. Y., a corporation of Delaware

Application November 16, 1946, Serial No. 710,322

11 Claims. (Cl. 343—117)

1

My invention relates to direction finders and is particularly directed to means for accurately indicating the direction of received radio waves.

The principal object of my invention is simple and reliable means for continuously rotating a directional radio receiving antenna until an incoming wave is found and for then bringing the antenna to rest and accurately focusing the antenna on the source of the incoming wave.

My direction finder comprises an extensive system of component parts cooperating to effect the principal object mentioned, and as the following description of one embodiment of the system proceeds, other objects will appear. The inventive features of my direction finder are defined in the appended claims, said embodiment being shown in the accompanying drawing in which:

Fig. 1 shows essential circuits, partly in block diagram, of my direction finder; and

Fig. 2 shows in some detail a preferred directional antenna array for my direction finder system.

Two directional antennas 1 and 2, for high or ultra high frequencies, are mounted side-by-side and are oriented so that the axis of the principal lobes 1*a* and 2*a* of the response patterns are disposed at a fixed angle θ. The antennas are mounted as a unit on a rotatable shaft 3. When the patterns are alike, a straight equipotential line lies between the two lobes and will, with the circuits to be described, quite sharply define the direction of an oncoming wave. The two directional antennas are alternately coupled or switched to the input of the radio receiver 4. The particular coupling means shown comprises motor driven variable condensers 5 and 6, the rotor plates 5*a* and 6*a* being mounted on insulated sections of the shaft 7 of the motor 8 so that the rotor plates alternately pass over and capacitively engage the stator plates 5*b* and 6*b*. The rotor plates are each connected through the usual brushes to the radio frequency coupling coil 9 in the input circuit of the receiver. The receiver may comprise a radio frequency amplifier 10, a first detector 11 preferably of the superheterodyne type, an intermediate frequency amplifier 12, a second detector 13, and an audio amplifier 14. The audio output of the receiver will accordingly contain the signal on any carrier picked up by the antennas, and may be fed to a speaker, or other reproducer 15. A high-pass filter 15*a* may be used ahead of the reproducer to eliminate locally generated signals, to be described hereinafter.

2

For separating and comparing the signals that are derived from the two antennas, the carrier energy is modulated with two distinct locally generated tone signals, the tone signals being applied alternately and in time phase with the antenna switching. The tones are conveniently impressed on the carrier in any of the radio frequency or intermediate frequency amplifier stages of the receiver. By way of example the two generators 16 and 17 are coupled in multiple to the intermediate frequency stage 12 in the embodiment illustrated, the frequencies of oscillation being, respectively, two distinct tones preferably in the lower extremity of the audible range such as 50 and 75 cycles per second. For convenience in the description, these two frequencies will be referred to. The generators may be started and stopped as by biasing their control grids to either side of cut-off, the grid circuits each including the conducting segment 18 and the insulating segment 19 of the commutator on the motor-condenser shaft 7. The rotational position of the commutator segments with respect to the rotor condenser plates are easily adjusted so that one generator starts when one antenna is first coupled to the receiver and continues while said one antenna is coupled, and next the other antenna and generator are simultaneously switched in.

The output current of the receiver, then, contains alternate and end-to-end trains of signals from the antennas, each signal train being distinctly characterized by 50 or 75 cycle tone modulations. The tone modulations are easily separated by filters 20 and 21 and then recombined for amplitude comparison. The inputs of the filters are connected in parallel and to the receiver output, the output currents of the filters being then rectified at 22 and 23 and passed in opposite directions through the resistors 24 and 25. It now appears that the direct current potential between the outer ends of the resistors is zero when the signals received from the two antennas are equal, corresponding to the "on-target" position of the antennas, and when the antennas point to either side of this position the currents of the rectifier become unbalanced and a direct current voltage appears across the resistors, the polarity depending on the direction of unbalance.

The direct current voltage across the resistor, when sufficiently amplified at 26, may drive a direct current motor 27, the direction of rotation of which depends on the polarity of the driving current. The motor is mechanically coupled to the antenna shaft 3 through appropriate gears and shafting. In operation, a radio signal arriving from either side of the directional antenna of sufficient strength to activate the receiving circuits and produce a voltage at the resistors 24—25 will start the motor in the correct direction to rotate the antennas toward the signal source. In case the antenna over-shoots, the voltages and motor 27 reverse. Hunting may be damped by many well known electrical or mechanical means. To indicate the azimuthal position of the antenna assembly, a simple pointer 28 may be carried on the antenna shaft. The position of the antenna shaft may be remotely indicated if desired by any of the mechanical or electrical indicators in the art.

According to a further and important feature of my invention, the antenna assembly will continue to rotate, scanning the horizon until a signal of the correct frequency is received. Means for acomplishing this function comprises a relay circuit 29 connected to one end of the resistors for unbalancing the voltage thereacross during the absence of a signal at the receiver output. It will be recognized that the voltages of the resistors are balanced when no signal is received at either antenna. If an electromechanical relay is used, the winding would be connected to the receiver output and the secondary circuit connected between a battery and one end of resistor 24. Alternatively, a grid-controlled gas tube may be used as the relay, the grid of the gas tube being coupled through a rectifier to the receiver output. The static bias on the grid would be, normally positive with no incoming signal, and the gas tube would be conducting. A signal voltage, however, would reverse the grid bias, block the gas tube, remove the unbalancing voltage from the resistors, and restore the motor driving voltage to control by the signal voltage. Accordingly, in normal operation the antenna continues to rotate in one direction until a signal is picked up, when the relay 24 deenergizes, and the antenna moves into focus on the transmitter.

One system of directional antennas particularly adapted for the lobe switching of my direction finder is shown in Fig. 2. Three dipoles 30, 31 and 32 are disposed vertically and in a substantially straight line, the center dipole 31 being connected directly to the receiver and the two outer dipoles 30 and 32 being coupled, respectively, to the receiver through the condenser switch mechanism shown so that the outer dipoles are alternately coupled in parallel with the center dipole. A plurality of vertical director rods 33 are arrayed along a line perpendicular to the plane of the dipoles, at least one reflector rod 34 being placed to the rear of the desired lobe direction. The field of either pair of dipoles, when distorted with the parasitic oscillations of these rods, will yield a response characteristic or lobe in the horizontal plane substantially as shown, with the centerline of the lobe at a small angle with the plane of the reflector rods. Switching to the other pair of dipoles moves the lobe, through an angle twice said small angle, to the other side of the reflector plane. Unlike direction finding systems which operate on a lobe null, my array responds to the intersection of two lobes the sides of which may be adjusted to be quite steep at or near the intersection for high sensitivity. In my system the sharpness of the main lobes is less important than in other systems because the sensitivity depends, as suggested, on the slope of the sides of the lobes rather than on the curvature at the peak or at the null. The lobe need not be narrower than 30 degrees between the half-power points.

The interval during which the rotor passes between the two plates or sets of plates is substantially negligible so that no errors are introduced during that time when only the central dipole is coupled to the receiver. The lobe switching time must be rapid compared with the antenna rotating speed, that is, the rotor-drive motor 8 shown must have a much greater speed than the antenna-drive motor 27.

A small, compact and mechanically simple array that is easy to mount for rotation may comprise dipoles spaced one quarter wave length apart, giving the array a width of one half wave length. Such an array may be used with frequencies down to 100 megacycles without exceeding reasonable array sizes. At frequencies higher than 600 megacycles, parabolic reflectors would become desirable. A carrier frequency range of 1.6 to 1 may be effectively received by the array of Fig. 2.

I claim:

1. A radio direction finder, comprising two directional antenna sections oriented to receive maximum signal voltages from different directions, means for moving said antenna sections as a unit, a radio receiving circuit, means alternately coupling said antenna sections to the input of said receiver, two generators of different frequencies coupled to said receiver circuits for modulating the signals passed by said receiving circuits, means for alternately applying said different frequencies to said receiving circuit, the application of the frequencies being respectively synchronized and in time phase with the coupling of said antenna sections to the receiver input, two filters selectively responsive respectively to said two frequencies, coupled to the output of said receiving circuit, means for comparing the amplitude of the output currents of the filters, and means, responsive to the output of said comparing means, for directing said antenna unit such that said sections receive equal signal voltages.

2. A radio direction finder comprising two directional antenna sections, a receiver, a demodulator, the patterns of the antenna sections being partially overlapped to a definite extent, means for alternately sampling a signal from each antenna section, means for applying said alternate samplings over a common electrical path of said receiver to said demodulator, means along said path for modulating said alternate samplings with a distinctive characteristic, means for comparing the signals strength of alternate demodulated samplings, and means, responsive to said comparing means, for directing said antenna sections to receive equal signal voltages from a certain signal.

3. A radio direction finder comprising an antenna system having at least two angularly dis-

placed directional patterns, a radio receiver coupled to said antenna system, means for alternately shifting the response of said antenna system from one pattern to another, means for locally modulating the signals received from each pattern with a characteristic wave, means for demodulating the wave-modulated signals, filters for separating said characteristic waves, means for comparing the amplitudes of the characteristic waves, and means for physically orienting said antenna system in response to the output from said comparing means.

4. In the radio direction finder defined in claim 3, said antenna system comprising two directional antennas fixedly mounted side-by-side and directed in different direction, said antennas as a unit being journalled to rotate in a desired plane.

5. In the radio direction finder defined in claim 3, said antenna system comprising two directional antennas fixedly directed in different directions, said antennas being separately coupled to the input circuit of said receiver, and means for alternately interrupting the coupling between the antennas and said input circuit.

6. In the radio direction finder defined in claim 3, said radio receiver having high frequency amplifiers and a final detector, said modulating means comprising generators of two low frequency characteristic waves, and the output of said generators being fed to at least one of said amplifiers.

7. In the radio direction finder defined in claim 3, said means for separating the characteristic waves comprising filters responsive respectively to said waves, and said comparing means comprising rectifiers connected respectively to said filters and resistors connected in series and, respectively, in the output circuits of said rectifiers.

8. In the radio direction finder defined in claim 3, said means for comparing the characteristic waves comprising rectifiers connected, respectively, to said filters, resistors connected together and to said rectifiers for algebraically adding the direct current voltages of said rectifiers, and a relay means responsive to the locally modulated signals connected to apply a certain voltage across one of said resistors.

9. In the radio direction finder defined in claim 3, said antenna system being journalled to rotate as a unit, said means for comparing the characteristic waves comprising a rectifier for each wave and resistors connected in series and, respectively, in the output circuits of said rectifiers, said orienting means comprising a reversable motor responsive to the voltage and polarity of voltage across the series resistors, said motor being coupled across said resistors and being mechanically connected with said antenna system, and means for applying a voltage to said motor when no signal is received by said antenna system.

10. A direction finder comprising a plurality of antennas having angularly displaced directional field patterns, a superheterodyne-type radio receiver, motor driven coupling condensers connected between said antennas and the input circuit of said receiver to successively couple each antenna to said receiver, a plurality of generators of different frequencies coupled to the high frequency circuits of said receiver, a motor driven switch, control circuits for said generators connected to said switch such that each generator delivers its output to said receiver in synchronism with the coupling of one antenna with said receiver, filters, responsive to said frequencies, connected in parallel and to the output circuit of said receiver, a rectifier and a resistor serially connected to each filter, a direct current amplifier connected across the resistors, a motor connected to and driven by said amplifier, said motor being mechanically coupled to said antennas.

11. A direction finder according to claim 10 wherein said antennas comprise three spaced parallel side-by-side dipole antennas disposed in a common plane, a plurality of spaced parallel parasitic antenna rods arrayed in the plane of the center one of said dipole antennas and perpendicular to said common plane, the center dipole being directly connected to said receiver and the two remaining dipoles being coupled alternately to said receiver through said coupling condensers.

EDWARD B. MOORE.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,165,800	Koch	July 11, 1939
2,176,469	Moueix	Oct. 17, 1939
2,216,708	Kolster	Oct. 1, 1940
2,360,810	Carlson et al.	Oct. 17, 1944
2,424,193	Rost et al.	July 15, 1947