May 26, 1953 N. MARCHAND 2,640,192

SHIFTABLE DIRECTIONAL ANTENNAS

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Fig. 1.

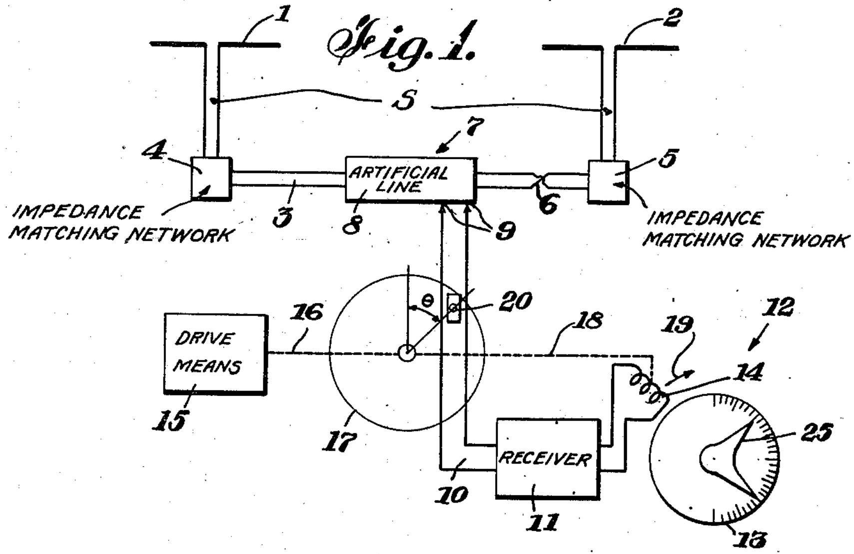

Fig. 2.

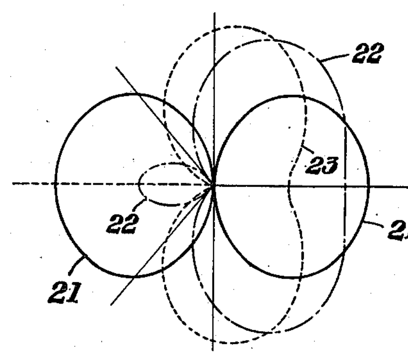

Fig. 3.

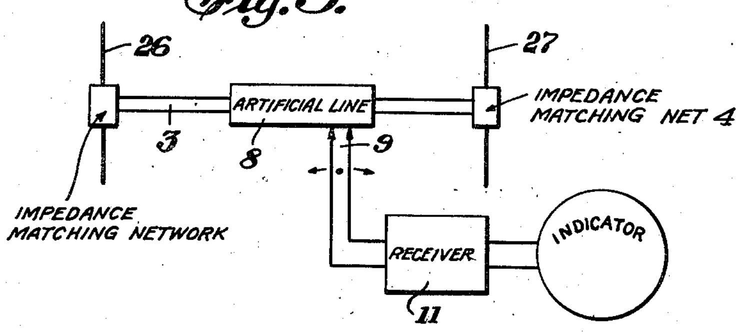

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Fig. 4.

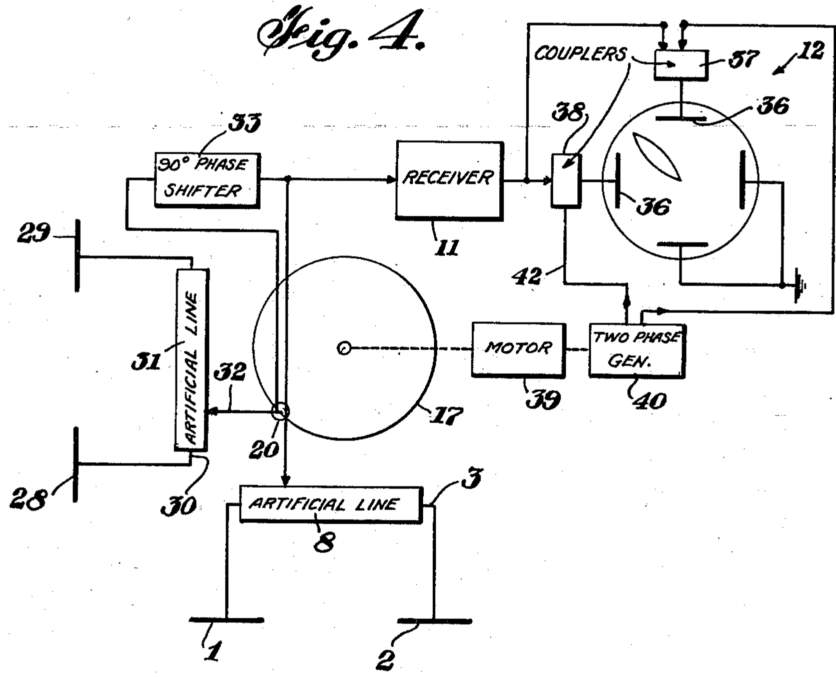
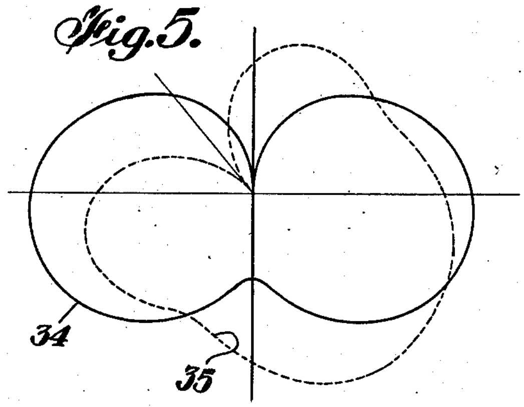


Fig. 5.



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SHIFTABLE DIRECTIONAL ANTENNA

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20 Claims. (Cl. 343—120)

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This invention relates to direction finders and more particularly to radio direction finders in which the directive action is shifted without rotation of the antennas.

In directionally shiftable radiant acting systems, used either as direction finders or as rotary beacons, systems have been proposed wherein rotation of the directive action of the system is effected without rotation of the antennas by rotatable goniometer couplings.

It is an object of my invention to provide a directionally shiftable radiant acting system in which the directive pattern is shifted through a predetermined angular relationship by means of a phase shifting network shifting the phase relationship of two or more antenna means with respect to a given receiver.

It is a further object of my invention to provide a phase shifting network in a line interconnecting two radiant acting members, which produces a phase shift as a substantially sine wave function, whereby uniform shifting of the resultant radiant action independent of frequency is obtained.

It is a further object of my invention to provide a directionally shiftable radiant acting system in which a null or a maximum directional indicating radiation may be rotated through 360° or less by means of phase shifting arrangements coupling the antennas to a translating apparatus with variable phase relationship between the energy in two or more spaced antennas.

It is a still further object of my invention to provide a transmission line means interconnecting two antenna means together with an arrangement for continuously and cyclically shifting a coupling point along this transmission line means to couple the antenna means to a translator unit in variable phase relationship.

According to a feature of my invention, I interconnect two antenna units by means of a transmission line. Each of the antenna units or groups of units is coupled to the transmission line in impedance matching relation. In the coupling line is provided a phase shiftable coupler for coupling the antenna units to a translating apparatus in variable phase relationship. In the output of the translator arrangement may be provided an indicator producing a trace line positioned in accordance with the positioning of the variable phase coupler and means for applying energy from the output of said translator to said indicator to produce deflection of the trace in accordance with the strength of the signals.

Preferably the phase shifting of the coupler is

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made to occur in the form of a sine wave so that the directional shifting is made at a uniform rate. Consequently, the indicator calibration may be made of a uniform or straight line scale, and will remain in proper calibration for all received frequencies. This universal calibration for different frequencies may also be obtained if straight line displacement of the phase shifter is used, with an indication deflection system operating as a sine wave function, or with the scale calibrated in accordance with such a function. The first expedient however is preferred as it will provide uniform receptive sensitivity in the antenna structure.

A better understanding of my invention and the objects and features thereof may be had from the particular description thereof made with reference to the accompanying drawings, in which:

Fig. 1 is a block diagram of a simple receiver unit operating in accordance with the principles of my invention;

Fig. 2 is a set of polar diagrams used in explaining the operation of the circuit in Fig. 1;

Fig. 3 is a modified arrangement of the direction finder unit illustrated in Fig. 1;

Fig. 4 is a modified direction finder system in accordance with my invention for producing a directional indication without ambiguities; and

Fig. 5 is a set of polar diagrams illustrating the operation of the circuit of Fig. 4.

Turning first to Fig. 1, two antennas 1 and 2 are shown interconnected by a transmission line 3. Antennas 1 and 2 are spaced apart a given distance S, S preferably less than 180 electrical degrees. Antennas 1 and 2 are coupled to line 3 over impedance matching networks 4 and 5, respectively. Since the sharpest indication of direction may generally be produced by a null indication, I preferably provide a transposition 6 in line 3. Thus at the mid coupling point between antennas 1 and 2, there will normally be a zero or null providing the signal is approaching at right angles to the plane defined by antenna systems. If the signal comes at some other angle so that antennas 1 and 2 are not energized in phase, the null will occur at some other point along the line. Midway of line 3 intermediate the ends thereof I provide a phase shifting network 7 which may consist of an artificial line 8 together with movable contact connections 9. Artificial line 8 is preferably made electrically equal to the spacing between antennas 1 and 2 so that a complete effective rotation of the directive action of the system may be obtained.

Contacts 9 are connected over a coupling line

10 to a receiver 11 in the output of which is provided an indicator 12. Preferably indicator 12 is some form of visual indicator arrangement such as a cathode ray tube 13 provided with deflecting means such as coil 14. Drive means 15, which may for example be a motor, is coupled over a shaft 16 to a driving wheel 17 and over a shaft 18 to a control means indicated by arrow 19 for rotating deflection coil means 14 about the cathode ray tube 13. Mounted on wheel 17 is a crank 20 which serves during rotation of wheel 17 to shift contacts 9 regularly backward and forward along artificial line 8. If drive means 15 operates continuously at a given speed, contacts 9 will travel back and forth along artificial line 8 at a speed corresponding to a simple harmonic motion. Accordingly, the phase angle of the energy transferred from antennas 1 and 2 will continuously and cyclically be varied. This operation, because of a simple harmonic motion, will provide an output substantially in the form of a sine wave so that effective regular rotation of the directive action of the pattern from antennas 1 and 2 will thus be effected. Since coil 14 rotates in synchronism with the movement of contacts 9, radial deflection of the cathode ray beam will be made in accordance with the incoming signal energy so a pattern dependent upon the direction of a transmission station will be traced on the screen of the cathode ray tube. Since the displacement is uniform about the screen a permanent calibration may be provided. With the relationship outlined, the direction indications will be uniform for all frequencies received.

Turning now to Fig. 2, the pattern 21 corresponds to the energy applied to receiver 11 from a transmitting station located at right angles to the plane of the antennas 1 and 2 and on line with the center of radiant action of this system during one complete cycle of phase shift. It will be seen that in this arrangement a null is located at a position which may be considered zero direction indicating action. If the transmitting station is located at substantially a 45° angle to the line interconnecting antennas 1 and 2, a pattern such as shown at 22 of Fig. 2 will be traced. Here it will be seen there are produced two nulls at substantially 40 and 140 degrees from zero. If a transmitting station is located at a position in line with the two antennas 1 and 2 then pattern 23 of Fig. 2 having a single null at a 90° angle will be produced. Thus, as the contacts 9 move backward and forward along artificial line 8, an effective rotation of the null direction indication will be obtained. If then on the indicator 13 the trace line is at the greatest deflection in the absence of signal, a pattern such as shown at 25 of Fig. 1 may be traced by a station located 45° from the line connecting the two antennas. It will be noted that the directional indication for zero null has a 180° ambiguity while when the null is at 90° there is no ambiguity. Intermediate these patterns there will be an ambiguity in indication varying between zero degrees and 180°. The ambiguity may be avoided if desired by some form of sensing indication.

If it is desired to use the maximum indication instead of a minimum for the directional system, two spaced antenna means 26, 27 may be interconnected by a transmission line 3 and impedance matching networks 4 and 5 as shown in line 3 and an artificial line 8 together with the movable contacts 9. However, in this case no transposition is provided in transmission line 3 so that in the plane midway between antennas 26 and 27 the energy will arrive in phase at receiver 11. Accordingly, a maximum indication rotatable similarly to the null of Fig. 1 will be obtained. Vertical dipoles have been shown instead of the horizontal dipoles of Fig. 1. It should be understood that any desired form of antenna may be used in either case.

As the contacts 9 are shifted forward and backward across artificial line 8, the phase of the energy from the two antennas as applied to the receiver is varied. Unless the antenna units are impedance matched with respect to transmission line 3, standing wave reflection will be set up on the line obscuring the null. Accordingly, impedance matching networks preferably are provided in order that a correct indication may be obtained.

Since the ambiguity present in the systems illustrated in Figs. 1 and 3 may be undesirable, a preferred type of direction finder in which ambiguity is overcome as shown in Fig. 4 may be provided. According to Fig. 4, there is provided one pair of antennas 1, 2 coupled over line 3, artificial line 8 and movable brushes 9 to receiver 11. At the same time, two other antenna units 28, 29 are coupled over line 30, artificial line 31 and movable brushes 32 through a phase shifter 33 to the output of receiver 11. Since brushes 9 and 32 are simultaneously moved by rotatable drive wheel 17 through the co-operation of crank 20, lines 8 and 31 are simultaneously scanned but in relatively opposite directions. Thus two patterns shifted 90° with respect to one another are produced. The output energy from brush 32, however, is shifted a further 90° to bring it into phase opposition with energy from brush 9 at the input of receiver 11 if a null indication is desired. In this case, when a null is produced along the zero axis of antennas 1, 2, a single null across the 90° axis will be produced in the line from antennas 28, 29. These nulls added together will produce resultant pattern 34 of Fig. 5 having a single or unidirectional null.

Similarly, if a null is produced at a direction of 40° to the plane of antennas 1, 2, the two outputs from the antenna pairs added together will produce a pattern such as shown at 35, Fig. 5, having a single null in that direction.

Returning to Fig. 4, the indicator 12 is shown as a cathode ray tube having plate deflecting electrodes 36 instead of the rotatable coil 14 shown in the arrangement of Fig. 1. Accordingly, the output of receiver 11 is coupled through coupler arrangements 37, 38 to the vertical and horizontal deflecting plates, respectively, of the indicator. A driving motor 39 serves simultaneously to drive disc 17 and a two-phase generator 40. The output of two-phase generator 40 is applied across the vertical and horizontal electrodes of indicator 12 by means of lines 41 and 42. It should be apparent that any type of deflection system may be used in any of the circuit arrangements illustrated. Likewise, any type of antenna units desired may be provided. Furthermore, the rotation of a pattern from two antennas is not the only possibility since any one or all of the antennas illustrated in the figures may be replaced by directional arrays if desired. It should further be understood that contact brushes 9 and 32 may be capacitively coupled to the receiving artificial lines if desired rather than being connected directly. Furthermore, it should be clear that the system illustrated, the contact resistance will not cause a shifting in the null even though they differ on the two pairs of antennas. The nulls are obtained by a phase comparison of the energy and are independent of the amplitudes of the signals so applied.

In the specific embodiments shown, I have illustrated a system wherein the phase shifting is made substantially in the form of a sine wave function and the deflection and scale calibration is substantially a straight line function. It should be understood that the proper indication for all frequencies may be obtained by other systems, for example, by maintaining any two of the functions as straight line functions and the other as a sine wave function.

While I have illustrated my invention in connection with certain specific embodiments thereof, it should be distinctly understood that this illustration is given merely by way of example and not as a limitation on my invention as set forth in the objects thereof and the accompanying claims.

I claim:

1. A directional, shiftable radiant acting system, comprising two spaced radiant acting means, impedance matching means for each radiant acting means, coupling means for coupling said radiant acting means together through said impedance matching means, a radiant energy translating means, and phasing means for coupling said translating means to said coupling means in variable phase relation with respect to said two spaced radiant acting means for shifting the directive characteristic of said radiant acting system.

2. A system according to claim 1, wherein said phasing means comprises a line section interposed in said coupling means, a transmission line coupled to said line section, and means for continuously shifting the coupling point of said transmission line along said line section.

3. A system according to claim 1, wherein said phasing means comprises a line section interposed in said coupling means, a transmission line coupled to said line section, and means for continuously and cyclically shifting the coupling point of said transmission line along said line section whereby rotation of said directive characteristic is effected.

4. A system according to claim 1, further comprising a second pair of spaced radiant acting means arranged at right angles to said first named radiant acting means, a second coupling means for coupling together said second pair of radiant acting means, second phasing means for coupling said translator means in variable phase relation with respect to the radiant acting means of said second pair, and means for simultaneously controlling said first named and said second named phasing means.

5. A system according to claim 1, further comprising an indicator means, means for producing a trace line on said indicator means in accordance with the phasing of said phasing means, and means for deflecting said trace line in response to energy received in said translating means.

6. A radio direction finder system comprising two spaced antenna means, a transmission line means interconnecting said spaced antenna means, impedance matching means coupling said antennas to said transmission line means, a radio receiver means, and phase shifter means, continuously variable over a range substantially equivalent to the spacing of said antennas in electrical degrees for coupling said receiver means to said transmission line means in variable phase relation with respect to said two antenna means.

7. A direction finder system according to claim 6, wherein said antenna means are spaced apart a distance not greater than 180 electrical degrees.

8. A direction finder system according to claim 6 further comprising a transposition in said transmission line, whereby a null directional indication is produced.

9. A direction finder system according to claim 6 further comprising a second pair of spaced antenna means arranged at right angles to said first named pair of antenna means, a second transmission line interconnecting said second antenna means.

10. A radio direction finder according to claim 6 further comprising means for continuously and cyclically adjusting said phase shifter over said range, indicator means coupled to the output of said receiver means, means operating synchronously with said means for continuously and cyclically adjusting said phase shifter for producing a trace indication in said indicator, and means responsive to energy applied to said receiver for producing a deflection of said trace.

11. A radio direction finder system comprising two spaced antenna means, a transmission line means interconnecting said spaced antenna means, impedance matching means coupling said antennas to the ends of said transmission line means, a radio receiver means, artificial transmission line means interposed in said transmission line means intermediate the ends thereof, means continuously variably coupling said receiver means to said artificial transmission line along different points thereof to couple said receiver in variable phase with respect to said two antenna means.

12. A direction finder system according to claim 11, wherein said antenna means are spaced apart a distance not greater than 180 electrical degrees.

13. A radio direction finder according to claim 11 further comprising means for cylically adjusting said variable coupling means, indicator means coupled to the output of said receiver means, means operating synchronously with said cyclically adjusting means for producing a trace indication on said indicator and means responsive to energy applied to said receiver for producing a deflection of said trace.

14. A direction finder system according to claim 11 wherein said antenna means are spaced apart a distance not greater than 180 electrical degrees and wherein said artificial transmission line has an electrical length substantially equal to the spacing between said antenna means.

15. A radio direction finder comprising two pairs of spaced antenna means arranged mutually at right angles to one another, separate transmission lines interconnecting the antennas of each pair, artificial transmission lines, each having an electrical length substantially equal to the spacing between corresponding antenna means, interposed intermediate the ends of said antenna means, impedance matching means coupling each antenna means to the corresponding end of its associated transmission line, a receiver means, variable coupling means for variably coupling said receiver means to variable points along said artificial transmission lines, means for adjusting said coupling means simultaneously in different senses to provide for energy transfer from said different antenna means pairs to said receiver means in different phase relationship, and means for producing a further relative phase

shift between energy in said coupling means applied to said receiver means to produce a substantially unidirectional received radiation effect.

16. A direction finder system according to claim 15, wherein said antenna means are spaced apart a distance not greater than 180 electrical degrees, and wherein said artificial transmission line has an electrical length substantially equal to the spacing between said antenna means.

17. A directional shiftable radiant acting system, comprising two spaced radiant acting means, coupling means for coupling said radiant acting means together, a radiant energy translating means, phasing means for coupling said translating means to said coupling means in variable phase relation with respect to said two spaced radiant acting means for shifting the directive characteristic of said radiant acting system and means for cyclically controlling said phase shifter means in accordance with a sine wave function.

18. A radio finder system comprising two spaced antenna means, a transmission line means interconnecting said spaced antenna means, a radio receiver means, artificial transmission line means interposed in said transmission line means intermediate the ends thereof, means continuously variably coupling said receiver means to said artificial transmission line along different points thereof to couple said receiver in variable phase with respect to said two antenna means, first driver means for cyclically adjusting said variable coupling means, indicator means coupled to the output of said receiver means, second driver means operating synchronously with said cyclically adjusting means for producing a trace indication on said indicator and means responsive to energy applied to said receiver for producing a deflection of said trace one of said driver means operating to produce a sine wave function.

19. A direction finder system according to claim 18, wherein said antenna means are spaced apart a distance not greater than 180 electrical degrees, and wherein said artificial transmission line has an electrical length substantially equal to the spacing between said antenna means.

20. A radio direction finder comprising two pairs of spaced antenna means arranged mutually at right angles to one another, separate transmission lines interconnecting the antennas of each pair, artificial transmission lines, each having an electrical length substantially equal to the spacing between corresponding antenna means, interposed intermediate the ends of said antenna means, a receiver means, variable coupling means for variably coupling said receiver means to variable points along said artificial transmission lines, means for adjusting said coupling means simultaneously in different senses to provide for energy transfer from said different antenna means pairs to said receiver means in different phase relationship, means for producing a further relative phase shift between energy in said coupling means applied to said receiver means to produce a substantially unidirectional received radiation effect and means for cyclically adjusting said variable coupling means according to a sine wave function.

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