United States Patent

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[73] Assignee **Warwick Electronics Inc.**

[54] **CROSSED LOOP ANTENNAS WITH SEPARATING SHIELD**
11 Claims, 5 Drawing Figs.

[52] **U.S. Cl.** **343/841,** 343/788, 343/855
[51] **Int. Cl.** **H01q 7/08,** H01q 1/52
[50] **Field of Search** 343/742, 788, 797, 829, 841, 855

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ABSTRACT: An omnidirectional antenna system having two loop antennas disposed at right angles to each other and electrically and magnetically decoupled by a shield between the antennas.

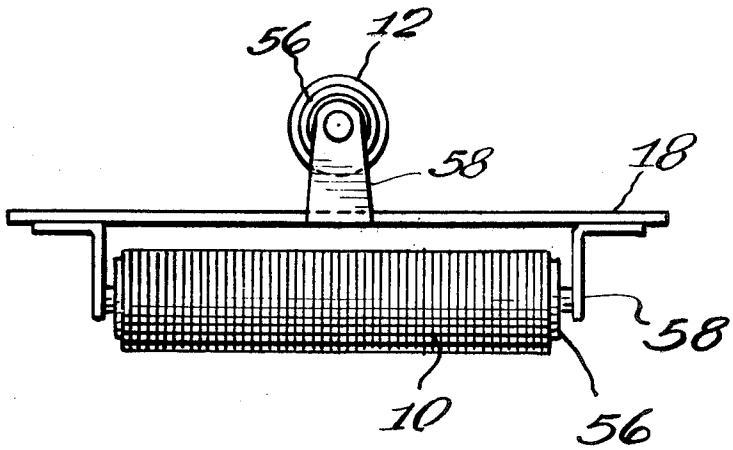


Fig. 1

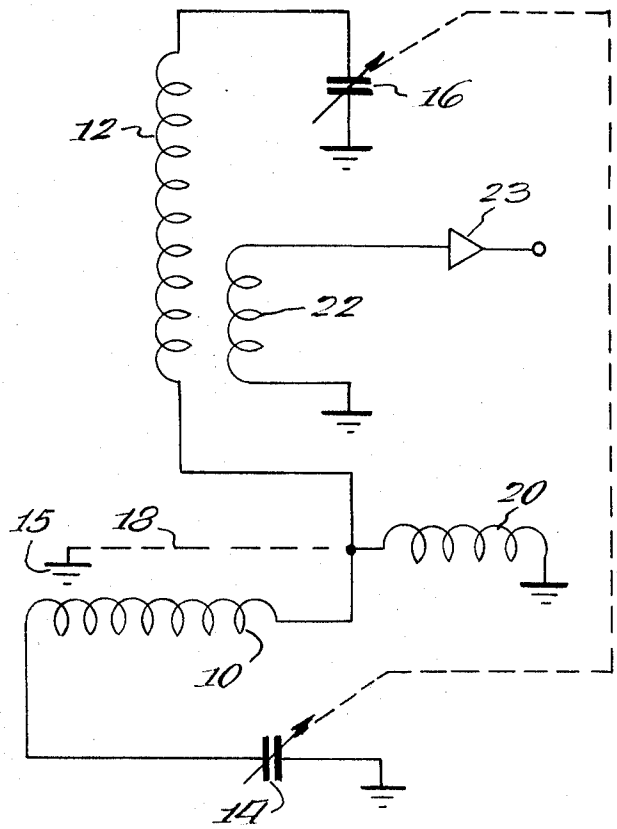


Fig. 3

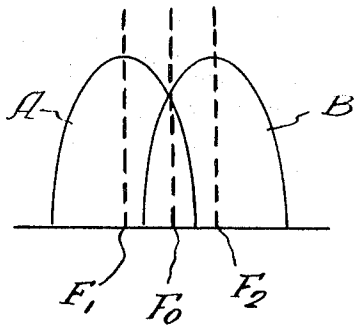


Fig. 4

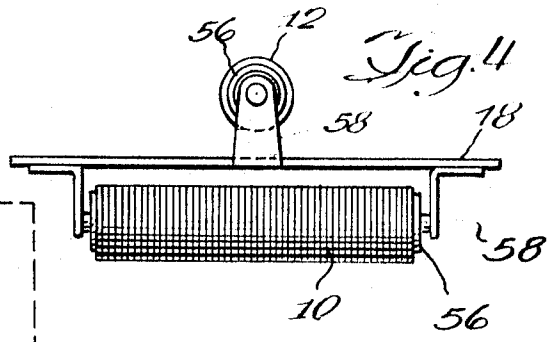


Fig. 2

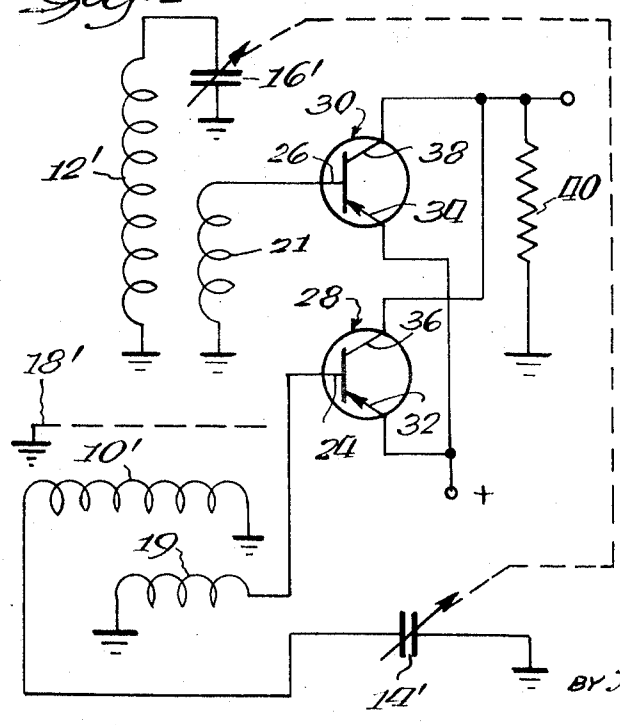
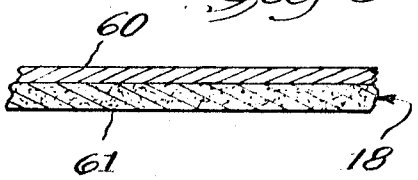


Fig. 5



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CROSSED LOOP ANTENNAS WITH SEPARATING SHIELD

This invention is concerned with an omnidirectional antenna system. More particularly, two loop antennas, bidirectional in nature and disposed at right angles to each other, are decoupled by conductive shielding located between the two antennas.

Known antenna systems have utilized two turnable loop antennas to provide nondirective antenna patterns. In order to achieve an omnidirectional pattern the antennas must be disposed at right angles to each other and the signals generated thereby must be shifted in phase to produce signals in phase quadrature in order that the signals will not cancel each other. Various methods of phase shifting the signals from the antennas have been suggested in the prior art including, among others, critically coupling the antennas which inherently produces a 90° phase shift; and stagger tuning the antennas an equal amount above and below the center frequency.

In all known systems of this type, however, it has been found that between the antennas themselves, there is a degree of coupling with is frequency dependent. This coupling produces a phase shift over the band of frequencies to be received with a resulting degradation in the omnidirectivity of the system. This coupling, as a practical matter, may be minimized by precise 90° orientation of the antennas, however, even with accurate alignment, it is impossible to eliminate all couplings between the antennas. Additionally, it should be pointed out that accurate orientation of the antennas is very difficult and also costly from a manufacturing standpoint.

The present invention provides an omnidirectional antenna system in which the coupling between the 90° displaced loop antennas is effectively eliminated whereby substantial omnidirectivity is achieved over an extremely wide band of frequencies while at the same time the cost of the system is reduced by eliminating the extreme accuracy required in the 90° displacement of the antenna.

In accordance with the present invention, two loop antennas are disposed at substantially right angles to one another on opposite sides of a grounded conductive shield which substantially eliminates all coupling therebetween. The physical separation and 90° orientation of the antennas is also effective to enhance the decoupling thereof.

Since the conductive shield effectively decouples the antennas, the system may be rendered omnidirectional over a wide band of frequencies by employing critical remote coupling, stagger tuning the antennas or any other suitable method of obtaining the necessary quadrature relation between the signals in the two antennas.

While achieving the improved wide band omnidirectivity the present invention also reduces the cost of such system by virtue of the fact that the conductive shield effectively decouples the antennas to eliminate the critical 90° displacement factor which is required in the absence of the shield to obtain maximum decoupling.

The present invention may be more fully understood by reference to the following detailed specification and the drawings, in which:

FIG. 1 is a schematic diagram a preferred embodiment of the antenna system of the present invention.

FIG. 2 is a schematic diagram of another embodiment of the antenna system of this invention.

FIG. 3 illustrates the frequency response of the individual loop antennas shown in FIG. 2.

FIG. 4 depicts the physical relationship of the two antennas.

FIG. 5 illustrates the shield used in isolating the antennas.

The invention is illustrated herein as it is used in an amplitude modulated (AM) radio receiver circuit. However, the invention can be used in a transmitter circuit and with coupling circuits other than those specifically shown and described.

Each loop antenna in this system is similarly constructed so that the gain and other characteristics of the antennas are identical. An omnidirectional antenna pattern is achieved by the superposition of two equal gain patterns upon one another. Two bidirectional, i.e. figure eight, patterns having a common center point and displaced at right angles to each other provide a circular, omnidirectional pattern upon the vector addition of the patterns.

FIG. illustrates a preferred embodiment of the present invention wherein the loop antennas **10** and **12** are remotely critically coupled to produce signals in phase quadrature relation. Each of the antennas **10** and **12** are shunted by a variable ganged capacitor **14** and **16** respectively and have their low impedance ends coupled to ground through a common inductor **20**. The antennas are physically separated and oriented at 90° to each other, as shown in FIG. 4. An electrically conductive shield **18** (shown in dotted line in FIG. 1) is located between the antennas and is grounded at **15**. A coil **22** forms a transformer secondary for antenna **12**. One end of coil **22** is grounded and the other end is coupled to the input of RF amplifier **23**. Coil **22** picks up the signals in antenna **12** which are then amplified in RF amplifier **23** from which the signals are coupled to conventional receiving apparatus (not shown).

Each antenna of the omnidirectional system comprises a number of turns of wire would on a rod or cylindrical core member **56** of a magnetic ferrite material so that the combined inductance of the antenna is approximately 490 microhenries. The ferrite rod provides a low reluctance path for the magnetic field, minimizing stray fields outside the ferrite and forming a high Q inductance. A ferrite rod antenna by itself is very directional. The antenna coil extends over substantially the entire length of the core **56** and is tightly wound thereon. Each antenna has a circular cross section and is supported on grounded shield **18** by L-shaped brackets **58**, as shown in FIG. 4. The antennas are placed at 90° to each other, such that centerlines, through, and perpendicular to, the respective circular cross sections, are skewed and substantially at 90° to one another. Shield **18** is composed of laminated parallel layers of a conductor, as a metal **60**, and paper **61**, as shown in FIG. 5.

A pair of single loop antennas, if disposed perpendicularly to each other are effectively decoupled only if they are disposed symmetrically about a common center point. Since it is impossible to so dispose the ferrite rod antennas shown in FIG. 4, the 90° orientation cannot completely decouple the antennas. Additionally, the plural elongated loops of such antennas produced even further coupling problems. By disposing a grounded conductive shield such as shield **18** between the antennas, however, complete decoupling is achieved and the attendant problems of coupling are eliminated.

In order to derive the necessary phase quadrature relationship between the signals received by each antenna, the inductor **20** is provided. Inductor **20** is selected with regard to the Q of the antenna circuits such that critical coupling is achieved. This critical coupling, by definition, causes a phase quadrature component of the signal from one antenna to appear in the other. Thus, secondary or takeoff winding **22** couples to the RF amplifier both the signal received by antenna **12** and the signal received by antenna **10** shifted 90° i.e., the signals are in the required phase quadrature relationship, and a completely omnidirectional system is achieved. This system is essentially free of any frequency dependent coupling between the antennas, and the 90° orientation of the antennas is rendered less critical since the effect thereof on directivity is less than the degradation caused by coupling between the antennas in nonisolated systems wherein slight variations in the 90° orientation causes a substantial increase in the coupling.

Although a single, common inductor **20** is shown in FIG. 1, it is to be understood that separate critically coupled inductors connected in series with each antenna could also be used.

FIG. 2 illustrates another embodiment of the present invention wherein the phase quadrature relationship between the antenna signals is achieved by stagger tuning the antennas.

Antennas 10' and 12' are the same as in FIG. 1, and are shunted by variable ganged capacitors 14' and 16' respectively. The antennas are physically separated, again as in FIG. 4. The conductive shield 18' is located between the antennas as in FIG. 1. Output coils 19 and 21 are coupled to the antennas 10' and 12' respectively and have one end connected to ground. Coils 19 and 21 form transformer secondaries for antennas 10' and 12' and couple the signals received thereby to the input bases 24 and 26 of RF transistor amplifiers 28 and 30. The emitters 32 and 34 of the PNP transistors are connected together as are the respective collectors 36 and 38. A combined output signal is developed across load resistor 40 connected form ground to the common collector junction.

In order that the system be omnidirectional, the signals at the base inputs 24 and 26 must be in phase quadrature. In this embodiment of the invention the phase quadrature relation is achieved by stagger tuning the resonant circuits of each antenna in the manner shown in the frequency response curves of FIG. 3. The resonant circuit comprised of capacitor 14' and the inductance of antenna 10' is tuned to a frequency f_1 below the center frequency f_o as indicated by curve A. The resonant circuit comprised of capacitor 16' and the inductance of antenna 12' is tuned to a frequency f_2 which is above f_o by an amount equal to the difference between f_o and f_1. See curve B.

By appropriately tuning the resonant circuits in this manner the signals appearing in takeoff coils 19 and 21 will have the requisite phase quadrature relationship and the system will be omnidirectional. As in the system shown in FIG. 1, the complete decoupling of the antennas by the use of the shield 18 eliminates the degradation caused by phase variations due to coupling between antennas and thus better omnidirectivity is achieved.

We claim:

1. An omnidirectional antenna system comprising:

conductive shield means;

first and second loop antennas having a plurality of turns, said antennas having bidirectional signal receiving patterns; said first and second loop antennas being disposed on opposite sides of said conductive shield means and positioned at right angles to each other such that the center turn of each antenna forms a crosslike projection in the plane of said conductive shield means, said conductive shield means functioning to decouple said loop antennas from each other; and

circuit means for combining signals received by said two antennas.

2. The omnidirectional antenna system of claim 1 wherein the antennas are substantially equal distances from the conductive shield.

3. The omnidirectional antenna system of claim 1 including means for tuning each antenna to resonance.

4. The omnidirectional antenna system of claim 3 wherein the first antenna is tuned to a frequency above the resonant frequency of the system and the second antenna is tuned to a frequency below said system resonant frequency, the stagger tuned antenna having frequencies of tuning equally separated above and below the system resonant frequency.

5. The omnidirectional antenna system of claim 4 including means for physically connecting each antenna to the conductive shield.

6. The omnidirectional antenna system of claim 4 wherein the loops are symmetrical providing similar frequency response curves when the antennas are tuned to their resonant frequency.

7. The omnidirectional antenna system of claim 1 wherein each bidirectional antenna has an equal gain.

8. The apparatus of claim 1 wherein said circuit means comprises, means for establishing a phase quadrature relation between the signals received by said antennas and means for combining the phase-quadrature related signals.

9. The apparatus of claim 8 wherein said means for establishing said phase quadrature relation comprises means for remotely, critically coupling said antennas.

10. The apparatus of claim 9 wherein said means for critically coupling said antennas comprises a common inductor connected in series with both of said antennas.

11. The apparatus of claim 9 wherein said means for combining said phase-quadrature related signals comprises a secondary winding coupled to one of said antennas and amplifier means coupled to said secondary winding.