

March 29, 1949.

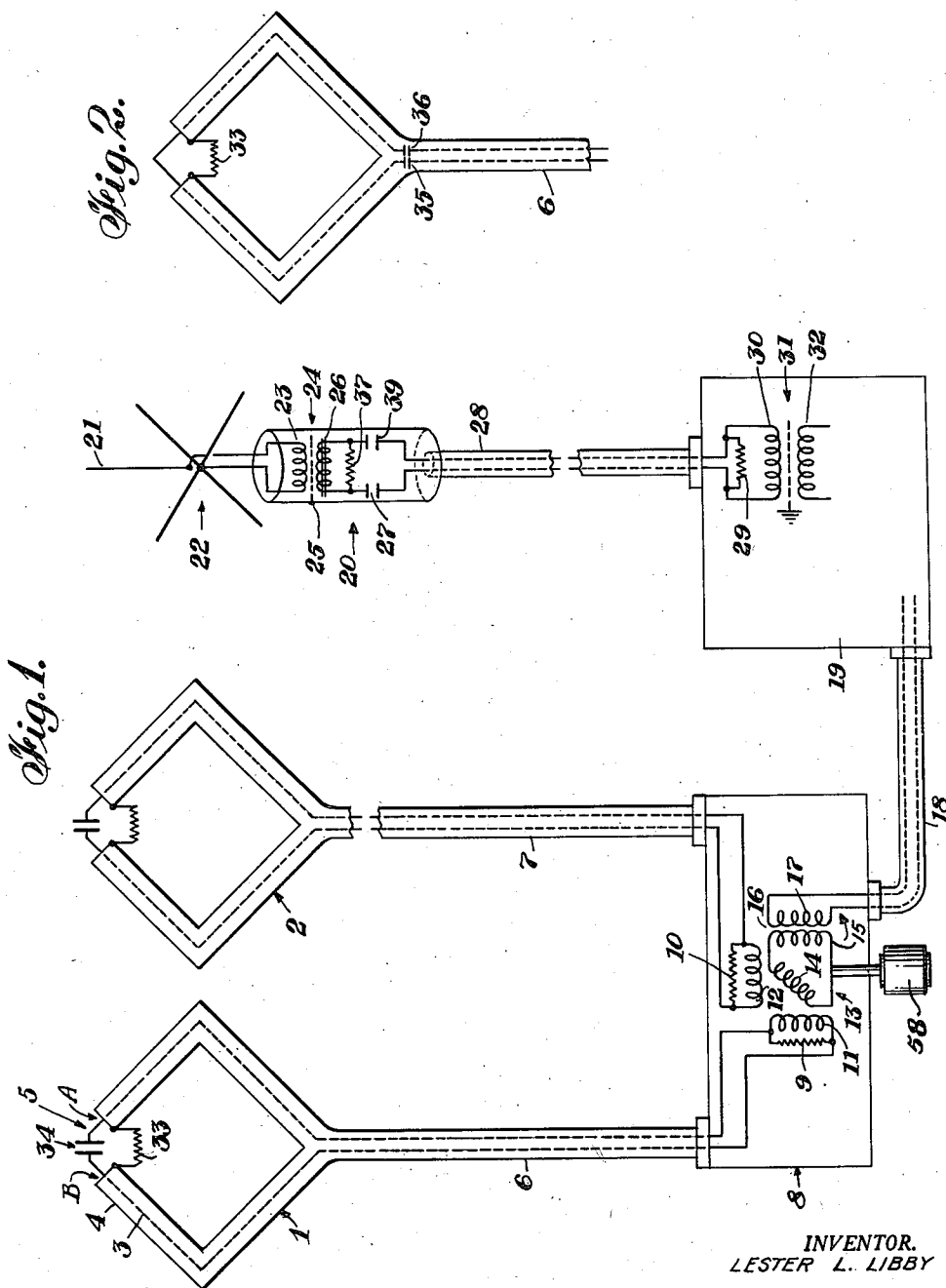
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2,465,381

LOOP ANTENNA SYSTEM

Filed March 12, 1945

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

Fig. 3.

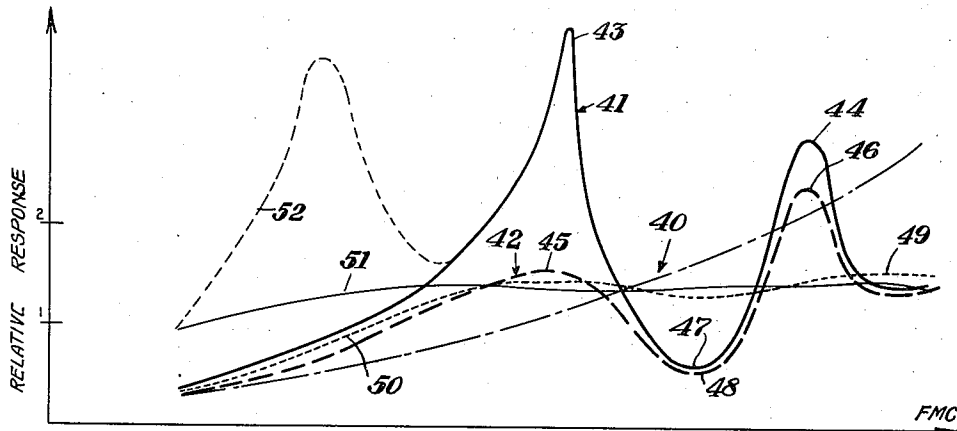


Fig. 4.

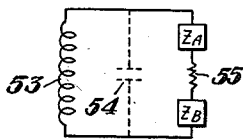


Fig. 5.

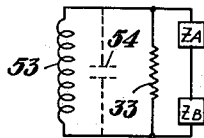


Fig. 6.

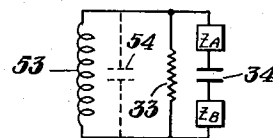
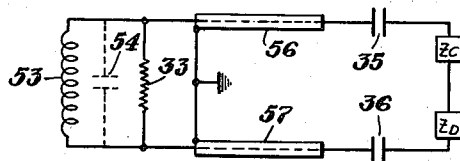


Fig. 7.



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LOOP ANTENNA SYSTEM

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Application March 12, 1945, Serial No. 582,207

19 Claims. (Cl. 343-118)

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The present invention relates to loop antenna systems including the loop antennas, their transmission line and terminations, and particularly to shielded loop antenna systems which are adapted to operate over a broad band of the higher frequencies.

In shielded loop antenna systems, resonances occur at various frequencies which materially affect the response and phase of the system. These resonances interfere with normal operation and are especially undesirable in certain systems, such as direction finding systems.

In the absence of these resonance effects, the theoretical response curve of such systems is considerably lower at the lower end of the band of frequencies than at the higher frequencies. The shape of this response curve is primarily caused by the change in effective height of the loop antennas over the band of frequencies involved. The response at the lower end of the frequency band is usually unsatisfactory. Furthermore, in view of the shape of the curve, it becomes necessary, in order to provide for uniform operation over the entire frequency band, to provide some compensation such as for example, in the transmitter or receiver associated with said antenna system.

An object of the present invention is the provision of an improved antenna system, particularly of the shielded loop type.

Another object of the present invention is the provision of a shielded loop antenna system in which the response is approximately flat over a wide band of frequencies.

Another object of the present invention is the provision of a shielded loop antenna system in which the effects of resonances are substantially minimized.

Still another object of the present invention is the provision of a shielded loop antenna system whose response at the lower frequency is increased whereby the entire response curve over a broad band becomes flatter.

A further object of the present invention is the provision of an improved direction finding antenna system including shielded loop antennas and a sensing antenna.

Other and further objects of the present invention will become apparent and the foregoing will be best understood from the following description of embodiments thereof, reference being had to the drawings, in which:

Fig. 1 is a grammatical illustration of a collector system for a direction finder incorporating an embodiment of my invention;

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Fig. 2 is a view of the portion of the system illustrated in Fig. 1, illustrating a modification thereof;

Fig. 3 is a set of curves used in describing my invention; and

Figs. 4-7 are equivalent circuits used in describing my invention.

Referring now to Fig. 1 the collector system there illustrated includes two shielded loop antennas 1 and 2 which are preferably arranged at right angles to each other. Each of said loops is preferably in the form of a coaxial line having an inner loop antenna 3 and an outer shield 4 with a gap 5 at the top thereof, or otherwise symmetrically disposed in relation to the two halves of the shielded loop antennas.

Shielded loop antennas 1 and 2 are coupled by means of dual transmission lines 6 and 7 respectively to a goniometer arrangement 8. Said dual transmission lines 6 and 7 are terminated in resistances 9 and 10 respectively and primaries 11 and 12 respectively of a goniometer 13, the rotating coil 14 of which is coupled to the rotating primary 15 of a transformer 16 whose stationary secondary 17 is coupled by means of a transmission line 18 to a direction finding receiver 19. The rotating primary 15 and the rotating coil 14 are driven by motor 58.

In Fig. 1 there is also illustrated a sensing arrangement 20 comprising a monopole 21 arranged above a counterpoise 22, the monopole and counterpoise being connected respectively to opposite ends of the primary 23 of a transformer 24 which may be provided with an electrostatic shield 25 arranged between its primary 23 and its secondary 26. The secondary 26 serves as a dummy loop and has the same constants as such a loop as nearly as they can be approximated. The secondary 26 is in turn coupled through a circuit 27 hereinafter to be described, to a balanced dual transmission line 28 terminating in the direction finding receiver 19 in a terminating resistance 29 and the primary 30 of a transformer 31, the secondary 32 of which is connected in the usual manner in the direction finding receiver.

The physical arrangements of the two shielded loops 1 and 2 and the sensing monopole 21 and counterpoise 22 may be such as is described in the copending application of H. G. Busignies-P. J. VanderWoude, for "Loop antennas," Serial No. 478,083, filed March 5, 1943, Patent No. 2,419,673 issued April 29, 1947, and T. H. Clark-P. J. VanderWoude for "Loop antenna construction," Serial No. 478,082, filed March 5, 1943, Patent No. 2,419,539 issued April 29, 1947.

In operating systems of the type hereinabove described over a broad band of frequencies, resonances appear at various points and the response at the lower frequencies is relatively poor. The response curve of these systems is therefore undesirably irregular. In accordance with my invention, I provide reactive and resistive means for producing a relatively flat response curve over the entire band of frequencies at which said systems are designed to be operated.

In order to attenuate the effect of resonances in this system, I provide at the gap of each loop a resistor 33 connecting together the ends of the shield at said gap. While the value of the resistor 33 will vary depending upon the particular parameters of the system involved and the frequencies at which it is operated, the value of such resistor is preferably of the order of four to ten times the surge impedance of the line forming the shielded loop antenna.

In order to compensate for the poor low frequency response of the system, I provide in each of said shielded loop antennas a condenser 34 positioned at the gap and in series with the inner conductor of loop antenna 3. The capacitor 34 preferably has such a value that at the higher frequencies it merely serves as a by-pass condenser having little if any substantial reactance, while at the lower frequencies, said capacitor has a substantial reactance and serves to tune the system toward the lower end of the frequency band.

While in Fig. 1, I have shown a single capacitor disposed at the gap and therefore symmetrically arranged in regard to both halves of the shielded loop antenna, it is also possible to utilize two condensers 35 and 36 (see Fig. 2) in place thereof and symmetrically dispose these two condensers in the entire shielded loop antenna system, that is, the two condensers may be arranged at symmetrical points within the shielded loop itself or may be arranged as illustrated in Fig. 2 at the point of connection between the transmission line 6 and the shielded loop or may be arranged inside the transmission line. Wherever said condensers 35 and 36 are placed, they must be placed in a similar position, or symmetrically arranged, otherwise the balance of the system would be upset. Condensers 35 and 36 will each have a value equal to twice the value of condenser 34 if they are arranged close to the gap, but this value will vary the farther they are from said gap.

In order that the sensing system 20 should suitably track with the shielded loop antenna system, the circuit 27 is made similar electrically to the shielded loop antenna arrangement by providing therein a shunt resistor 37 equivalent to resistor 33 and series capacitors 27 and 39 similar to condensers 35 and 36 of Fig. 2 or equivalent to condenser 34 of Fig. 1. Condensers 27 and 39 will have the same values as condensers 35 and 36 and twice the value of condenser 34.

Referring now to Fig. 3 in which relative response is linearly plotted along the Y axis while the frequency in megacycles is logarithmically plotted along the X axis, curve 40 is a theoretical curve indicating roughly what the response of a system, similar to the one heretofore described, would be if my invention were not incorporated therein and furthermore if there were no resonances in the system. Curve 41 indicates what might be the response in such system due to the resonances. Curve 42 indicates the effects on the peaks and troughs of curve 41 produced by using damping resistors in the loop antenna system

in series with the loops of the antennas, such as for example is described in the copending application of E. Daubaras for "Loop antenna systems," Serial No. 478,079, filed March 5, 1943 Patent No. 2,423,083 issued July 1, 1947. It will be seen that while the peaks 43 and 44 are substantially reduced, as indicated at points 45 and 46 of curve 42, the trough 47 of curve 41 is quite similar to the trough 48 of curve 42. Consequently it will be seen that while the response is improved, it is still quite irregular. By using resistor 33 as arranged in accordance with my invention, a response curve 49 may be obtained. It will be noted that this curve is substantially flat at the higher frequencies but dips downward at the lower frequencies indicated by the numeral 50. By using a capacitor such as condenser 34 of Fig. 1, or condensers 35 and 36 of Fig. 2, a curve such as 51 will be obtained. It will be noted that curve 51 is substantially flat over the entire frequency band covered. In the absence of shunt resistor 33, a peak such as 52 would be introduced by condenser 34.

The manner in which the results described hereinabove in connection with the curves of Fig. 3 are produced, will be more readily understood from a study of the equivalent circuits of Figs. 4-7 in which the inductance 53 is the equivalent of the inductance of the shield of the loops, the inherent capacity 54 is the capacity between the ends of the shield across the gap, and the impedances Z_A and Z_B are the impedances of this system looking inwardly into the gap in the directions indicated by the arrows A and B in Fig. 1. Referring now to Fig. 4, the resistance 55 is the equivalent resistance of the series resistor described in my co-pending application, L. Libby-2, for "Antenna systems," Serial No. 582,206, filed March 12, 1945, Patent No. 2,419,577, issued April 29, 1947. It will be seen that in the arrangement of Fig. 4, the voltage drop across Z_A , Z_B and resistor 55 will vary with frequency and since Z_A and Z_B will become relatively very high in value in comparison with resistor 55 at certain resonance points, these will primarily determine the response and will therefore vary this response according to the frequencies involved.

Referring now to Fig. 5, it will be seen that resistor 33, as arranged in accordance with my invention, is in shunt with impedances Z_A and Z_B and when said impedances become greater than resistor 33, resistor 33 will primarily control the voltage built up across inductance 53 and therefore determine the response of the system. Consequently resistor 33 will greatly damp the peaks and troughs due to the resonances.

In Fig. 6 it will be seen that the condenser 34 appears between Z_A and Z_B . This condenser is the equivalent of the condenser 34, Fig. 1, and due to its value will cause the circuit to resonate towards the lower end of the frequency band and consequently will produce a greater response at that end of the band.

Fig. 7 is the equivalent circuit of the modification of Fig. 2. Because of the position of the condensers 35 and 36, the sides of the shielded loop will appear as coaxial transmission lines 56 and 57 separating condensers 35 and 36 from the inductance 53 of the shield and the impedances then will be the impedances Z_C and Z_D of each half of the dual transmission line 6 looking into said transmission line towards the termination thereof. It will be seen that the circuit of Fig. 7 will function in the same manner as the circuit of Fig. 6 but that the exact position of the con-

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condensers 35 and 36 will change the various values and in actual construction it becomes necessary to change the value of these condensers, and sometimes other parameters of the system, in accordance with the position of said condensers.

While I have described my invention in detail in connection with the embodiments of Figs. 1 and 2, it will be apparent that numerous changes may be made in the details of my invention as well as the system in which it is employed. For example, my invention may be used with other than direction finding systems. The shielded loops could be made rotatable and the goniometer dispensed with. Furthermore, while I have shown the loops as shielded loops, it will be apparent that by using a capacity in an unshielded loop in the manner hereinabove described, a substantial improvement would be obtained in the operating characteristics thereof particularly at the lower frequencies of the operating band. Furthermore while I have shown the sensing arrangement as a balanced arrangement (having mirror symmetry) including a dual transmission line, a balanced termination, a pair of symmetrically arranged condensers, and a balanced secondary acting as a dummy loop, it will be apparent to those versed in the art that an unbalanced arrangement, using a coaxial line, a single-ended termination, etc., and acting as a half of the symmetrical arrangement, might be employed in place thereof, the operation thereof depending on the mirror symmetry equivalence of balanced and unbalanced circuits. Other variations will readily occur to those versed in the art from the teachings of my invention.

Accordingly while I have described above the principles of my invention in connection with specific apparatus, and particular modifications thereof, it is to be clearly understood that this description is made only by way of example and not as a limitation on the scope of my invention as set forth in the objects of my invention and the accompanying claims.

I claim:

1. In an antenna system including a shielded loop antenna comprising a conductive loop and a shield surrounding said loop and having a gap therein, a transmission line coupled at one end to said shielded loop antenna, and terminating means coupled to the other end of said transmission line; means for producing a relatively flat response over a broad band of frequencies comprising reactive means and resistive means mounted in series and in shunt respectively with said transmission line.

2. The antenna system according to claim 1 wherein said reactive means is capacitive.

3. The antenna system according to claim 1 wherein said reactive means is capacitive and is arranged in series in the loop.

4. The antenna system according to claim 1 wherein said reactive means is capacitive and is in series with the loop and is arranged symmetrically in relation to both sides of the loop.

5. The antenna system according to claim 1 wherein said reactive means is a condenser in series with the loop and positioned at said gap.

6. The antenna system according to claim 1 wherein said reactive means is a condenser arranged in series in the loop and of such a value as to have relatively large reactance at the lower frequencies of the band of frequencies at which said system is operated compared to its reactance at the upper frequencies of said band.

7. The antenna system according to claim 1

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wherein said reactive means is a condenser arranged in series in the loop and of such a value as to have negligible reactance at the higher frequencies of the band of frequencies at which said system is designed to operate and to have a substantial reactance at the lower frequencies of said band.

8. The antenna system according to claim 1 wherein said reactive means comprises a pair of condensers each arranged in series with the loop and positioned symmetrically with respect to the gap.

9. The antenna system according to claim 1 wherein said resistive means consists of a resistor positioned at the gap and connecting the ends of the shield at said gap.

10. The antenna system according to claim 1 wherein said resistive means is comprised of a resistor positioned at the gap and connecting the ends of the shield at said gap, the value of such resistor being of the order of four to ten times the surge impedance of the line formed by the loop and its shield.

11. In an antenna system, a shielded loop antenna comprising a conductive loop and a shield surrounding said loop and having a gap therein, a transmission line coupled at one end to said shielded loop antenna and terminating means coupled to the other end of said transmission line; means for attenuating the effects of resonances in said system comprising a resistor positioned at the gap and connecting the ends of the shield at said gap.

12. The antenna system according to claim 11 wherein said resistor has a value of the order of four to ten times the surge impedance of the line formed by the loop and its shield.

13. In an antenna system including a loop antenna in the form of a coaxial line comprising a conductive loop and a shield surrounding said loop and having a gap therein, a transmission line coupled at one end to said loop antenna, and terminating means coupled to the other end of said transmission line; means for increasing the response of said system at one end of the band of frequencies over which the system is designed to operate comprising reactive means arranged in series with said transmission line.

14. The antenna system according to claim 13 wherein said reactive means is capacitive.

15. The antenna system according to claim 13 wherein said reactive means is capacitive and is symmetrically disposed in said system.

16. In an antenna system including a shielded loop antenna comprising a conductive loop and a shield surrounding said loop and having a gap therein, a transmission line coupled at one end to said shielded loop antenna and terminating means coupled to the other end of said transmission line; means for increasing the response of said system at the lower end of the band of frequencies over which the system is designed to operate comprising a condenser positioned at the gap and in series with the loop.

17. In an antenna system including a shielded loop antenna comprising a conductive loop and a shield surrounding said loop and having a gap therein, a transmission line coupled at one end to said shielded loop antenna, and terminating means coupled to the other end of said transmission line; means for increasing the response of said system at the lower end of the band of frequencies over which the system is designed to operate comprising a pair of condensers each

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arranged in series with the loop and positioned symmetrically with respect to the gap.

18. In a direction finding system comprising a pair of shielded loop antennas arranged at an angle to each other and each including a conductive loop, a shield surrounding said loop and having a gap therein, a pair of transmission lines each coupled at one end to one of said shielded loop antennas, a pair of resistive terminating means each coupled to the other end of each of said transmission lines, a goniometer having a pair of stationary coils each coupled to one of said other ends of said transmission lines and a rotary coil, a direction finding receiver, and means coupling said rotary coil to said direction finding receiver; means for producing a relatively flat response over a broad band of frequencies comprising reactive means and resistive means coupled in series with the loop and connecting the ends of the shield at said gap respectively.

19. In a direction finding system comprising a pair of shielded loop antennas each including a conductive loop, a shield surrounding said loop and having a gap therein, a pair of transmission lines each coupled at one end to one of said shielded loop antennas, and a pair of terminating means each coupled to the other end of each

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of said transmission lines, a sensing antenna arrangement including a dummy loop, a transmission line coupled at one end to said sensing antenna and terminating means coupled to the other end of said last mentioned transmission line, a direction finding receiver, and means coupling the other end of each of said transmission lines to said receiver; means for producing a relatively flat response over a broad band of frequencies comprising separate reactive means and separate resistive means positioned at each of said gaps and means for coupling each reactive and resistive means in series and in shunt respectively with its corresponding transmission line, and additional resistive and reactive means coupled in shunt and series respectively with said sensing antenna transmission line.

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