

June 30, 1953

S. R. THRIFT
DIRECTIVE ANTENNA SYSTEM

2,644,158

Filed Nov. 6, 1946

2 Sheets-Sheet 1

FIG. 1

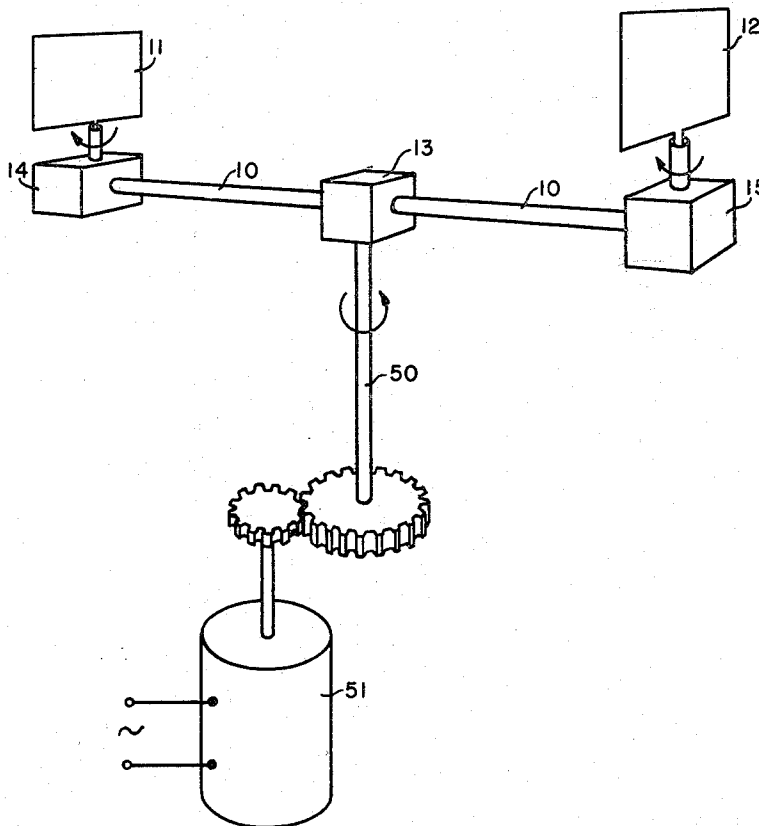
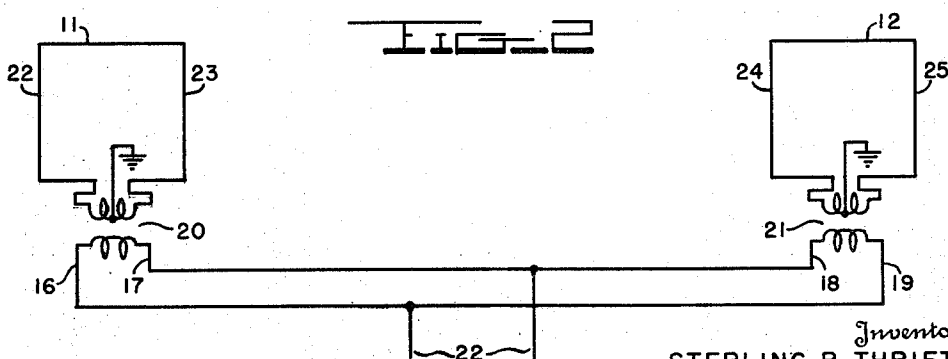


FIG. 2



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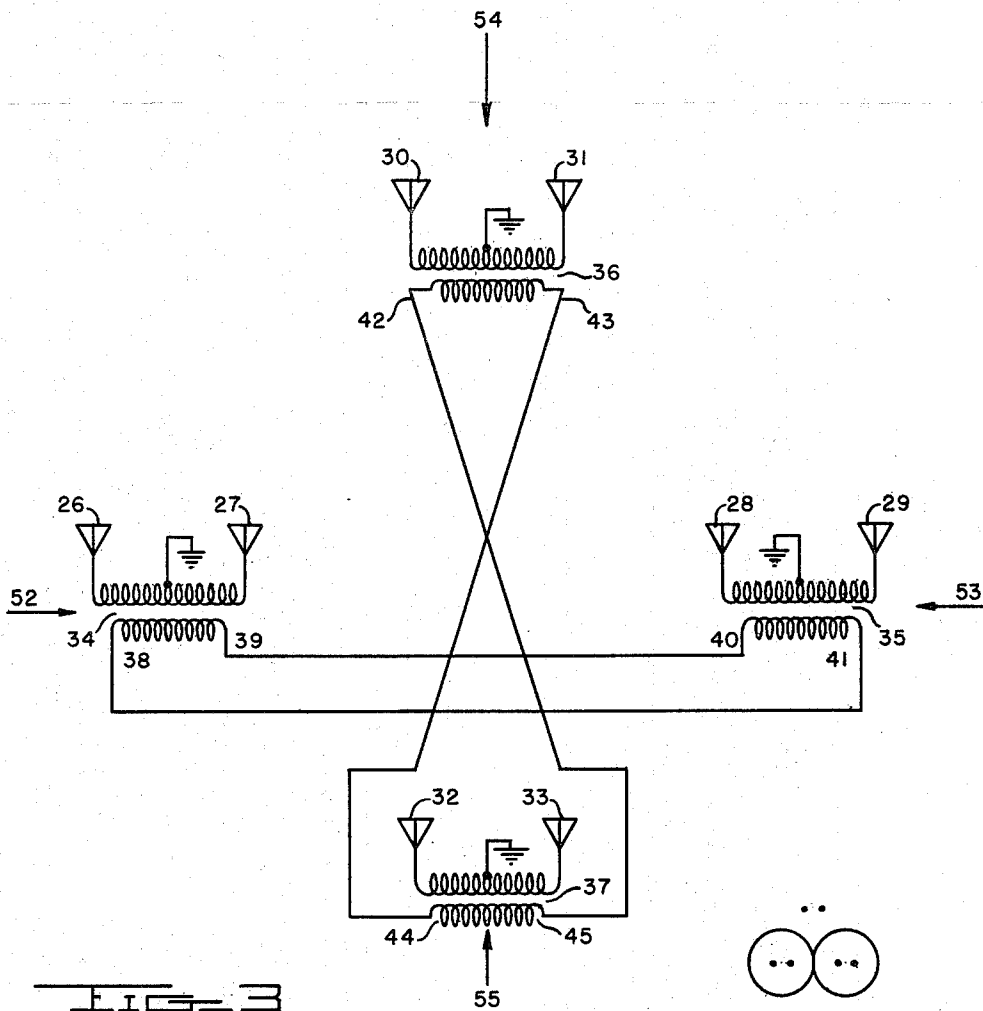
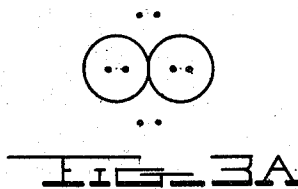


FIG-3



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DIRECTIVE ANTENNA SYSTEM

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4 Claims. (Cl. 343—118)

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sec. 266)

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This invention relates to a directive antenna system and more particularly to an improvement in the system disclosed in the application Serial No. 701,857, filed October 8, 1946, now Patent No. 2,576,150 granted to Clifford N. Simpson.

As disclosed in the aforementioned application, it is frequently desirable to provide a direction finding system which will exclude signals from an unwanted direction, and yet possess the direction finding properties of a conventional direction finding system with respect to signals from any other direction. While the aforementioned application illustrates a variety of antenna arrangements for accomplishing this purpose, I have found that a rotatable loop antenna, constructed as herein taught, provides a measure of compactness and portability heretofore unknown to the art.

Other objects and advantages of the invention will be apparent from the following detailed description when taken in conjunction with the accompanying drawings which illustrate preferred embodiments of the invention and in which:

Fig. 1 is an embodiment of the mechanical features of the invention;

Fig. 2 is an embodiment showing the electrical components of the invention, and

Fig. 3 shows an antenna arrangement electrically equivalent to the arrangement of Fig. 1.

Figure 3A is a diagram showing the response pattern of the antenna arrangements of Figures 2 and 3.

In accordance with the present invention, discrimination against signals from a particular direction is accomplished by synchronously rotating a loop antenna at each end of a shaft. The shaft itself is simultaneously rotated about its mid-point at the same rate as the antennas but in the opposite direction thereto. In this manner the azimuthal orientation of the loops remain fixed throughout each revolution of the shaft, and as hereinafter described, the unwanted signal is excluded by choosing the orientation of the loops to coincide with the direction of the unwanted signal.

In Fig. 1, to which reference is now had, there is shown an assembly consisting of a rotatable shaft 10 having identical loop antennas 11 and 12 rotatably mounted at each end thereof. The shaft is free to rotate about its center point by means of the pivotal joint 13 while antennas 11 and 12 are free to rotate about the pivotal joints 14 and 15, respectively. The subject system con-

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templates that the complete assembly will rotate about the pivotal joint 13, while each of the loops 11 and 12 will follow at the same speed as the complete assembly, but in a reverse direction thereto. The rotation will take place such that the planes at the two loop antennas are always parallel to each other and maintain the same orientation. This action may be obtained by means of any suitable well known mechanical linkage between the drive motor 51 and loop antennas 11 and 12. Included in this linkage are the shafts 10 and 50, and pivotal points 13, 14 and 15. Such linkages are well known to the art therefore the details as to a specific linkage are believed to be unnecessary to an understanding of the invention.

Fig. 2 shows the electrical components of the system. These comprise the loop antennas 11 and 12 and associated transformers 20 and 21, the primaries of which are connected to the outputs of the loop antennas 11 and 12, respectively. The secondaries of the transformers 20 and 21 are cross-connected such that terminals 16 and 17 of transformer 20 connect to terminals 19 and 18, respectively, of transformer 21. The output 22 of the system is taken from the cross-connections between the transformers.

It will be seen that as the assembly rotates, at one instant, such as shown in Fig. 2, the planes of the loops will be so aligned that the extension of the plane through one of the loops will also include the other loop and also the shaft 10 holding the loops. When the shaft 10 has rotated 90° to the position of Fig. 1, the loops will have rotated 90° with respect to the shaft and now the loops, although still being parallel to each other will be perpendicular to the shaft 10. Since a loop is closely similar in its pickup properties to two non-directional antennas located at the same position as the vertical arms of the loop, an antenna system similar to that shown in Fig. 3 and described in detail in the aforementioned application will result. The positions of the antennas 26 and 27 and the antennas 28 and 29 correspond to the positions of the vertical arms 22 and 23, and the arms 24 and 25 of the loops 11 and 12, respectively, as depicted in Fig. 2. When a rotation of 90° has occurred, the position of the antenna 30 corresponds to that of the vertical arm 22; likewise, the antennas 31, 32 and 33 correspond in position to the vertical arms 23, 24 and 25, respectively, of the loop antennas 11 and 12. Additionally, the connections between the antennas of Fig. 3 correspond to the connections made in the loop antenna system shown in Fig. 2. Thus, since the vertical arms of each

loop are connected through the primary windings of a transformer, the antennas 26 and 27, 28 and 29, 30 and 31, and 32 and 33 may be connected to each other through the primary windings of the transformers 34, 35, 36 and 37. The secondaries of diagonal pairs of antennas are cross-connected to correspond to the cross-connection shown in Fig. 2. Thus, terminals 38 and 39 of transformer 34 are connected to the terminals 41 and 40, respectively, of transformer 35. Likewise, the terminal 42 is connected to the terminal 45 and the terminal 43 to the terminal 44 in the secondaries of the transformer 36 and 37. As in Fig. 2, the output from the cross-connected transformers may be combined into a resultant output.

Because the action of the loop antenna system of Fig. 2 is similar to that of the vertical antenna system of Fig. 3 and the system of Fig. 3 can be more easily understood than that of Fig. 2, the operation of Fig. 3 will be described. It should be understood, at the beginning, however, that the system of Fig. 3 results from the interacting rotations of the loop assembly and the loops themselves of the system described in connection with Fig. 2.

Referring, then, to Fig. 3, consider now the signal 54 which is coming from such a direction that its wavefront is parallel to the planes containing the antenna sets. Since the wavefront will reach the antennas 30 and 31 at the same time, voltages of equal amplitude and the same phase will be induced in these antennas and these voltages will appear at the ends of the primary winding of transformer 36. Thus, because of the fact that no voltage difference exists across the primary winding, no voltage will be induced in the secondary winding of the transformer 36. Likewise, no voltage will be induced in the secondary winding of the transformer 37 because of equal voltages on the antennas 32 and 33. Thus, no resultant voltage can be taken from the cross-connections of the transformers 35 and 37. In like manner, antennas 26, 27, 38 and 29 will receive equal voltages and thus the secondary windings of the transformers 34 and 35 will receive no electromotive force to be transmitted to the cross-connections to the transformer and to be taken therefrom. Thus, no resultant output will be derived from the antenna system for a signal having the direction of the signal 54. In like manner, no response will be obtained for a signal coming from an exactly opposite direction, such as the signal 55.

Consider, however, the signal 52 whose wavefront is perpendicular to the planes containing the collector sets. Now, the voltage intercepted by the antenna 31 will be different in phase than the signal intercepted by the antenna 30. Thus a resultant voltage will exist between the antennas 30 and 31 and this voltage will be induced from the primary winding to the secondary winding of transformer 36. Also, since the antennas 32 and 33 are in the same position as the antennas 30 and 31, respectively, with respect to the wavefront of the signal 52, the same voltage difference will appear between the antennas 32 and 33, and therefore across the secondary of the transformer 37, as will appear across the secondary of the transformer 36. By cross-connecting the two secondary windings, therefore, the current from one secondary winding will be equal in amplitude and opposite in phase to the current from the other winding, leaving no resultant current in the cross-connections. Consequently, the

total reaction of the antenna pairs 30—31 and 32—33 to the signal 52 is the same as if the antenna pairs were replaced by the single antennas of an ordinary Adcock system.

But a response will be obtained from the reaction of antenna pairs 26—27 and 28—29. Considering first the collector set 26—27, the voltage induced in antenna 27 will be different in phase than the signal intercepted by the antenna 26. This voltage difference will appear across the terminals 38 and 39 of the transformer 34. Although the difference in phase between the antennas 28 and 29 will be the same as the difference between antennas 26 and 27, the resultant output voltage from the collector set containing antennas 26 and 27 will be different in phase from the resultant output voltage of the collector set containing antennas 28 and 29. This phenomenon occurs when the distance between the midpoints of the two antenna pairs is different than the wave length of the signal, or integral multiple thereof. Consequently, the difference of vector voltage between antennas 26 and 27 is equal in amplitude to, but different in phase than, the difference of vector voltage between antennas 28 and 29. Thus, a voltage difference will appear across the two cross-connections between the transformers and this voltage difference will be equal to the output of the terminals 22 shown in Fig. 2. The feature of phase differences between antennas of an antenna pair and also between antenna pairs is maintained for signals from any direction except signal 54 and signal 55, which is travelling in a plane 180° different in azimuth from signal 54. Since no response is obtained from signals having the direction of signals 54 and 55 and since maximum response is obtained from a signal having the direction of signal 52 and signal 53 which is 180° different in azimuth from signal 52, it may be seen that the response pattern of the antenna arrangements of Figs. 2 and 3 will be a "figure eight" pattern as shown in Fig. 3A. Thus, by rotating the loop arrangement of Fig. 2, a position may be found where no voltage is induced therein from a signal which it is desired to exclude, but at the same time voltages will be induced in the antenna arrangement for signals from any other direction.

It should be noted that although the antenna arrangement of Fig. 2 has been discussed from the viewpoint of receiving incoming signals, this same arrangement may also be used as an arrangement for transmitting antennas. This may be accomplished by introducing the output of the transmitter to the same terminals—i. e., the terminals 22—which would normally connect to the receiving equipment.

While certain preferred embodiments of this invention have been described, it is realized that many modifications and variations of this invention may be made and no limitations upon this invention are intended other than may be imposed by the scope of the appended claims.

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

What is claimed is:

1. A directive antenna system having substantially zero responsiveness to signals from a certain direction but finite responsiveness to signals from all other directions, said system comprising a rotatable member, a pair of identical loop antennas attached to said rotatable

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member at opposite ends thereof, means for rotating said member and to simultaneously rotate each of said loop antennas in an opposite direction to the rotation of said member such that said loops are always parallel, and means for combining the outputs of said loops to indicate the direction of incoming signals.

2. A directive antenna system, having substantially zero responsiveness to signals from a certain direction but finite responsiveness to signals from all other directions, said system comprising a rotatable member, a pair of identical loop antennas attached to said rotatable member at opposite ends thereof, means for rotating said member and to simultaneously rotate each of said loop antennas in a direction opposite to the rotation of said member such that said loops are always parallel, and transformer means interconnecting the loop antennas of each of said sets to produce an output signal therefrom characteristic of the direction of the incoming signal.

3. A directive antenna system, having substantially zero responsiveness to signals from a certain direction but finite responsiveness to signals from all other directions, said system comprising a rotatable member, a pair of antenna means attached to said rotatable member at opposite ends thereof, means for rotating said member and to simultaneously rotate each of said antenna means in a direction opposite to

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the rotation of said member such that the plane of the antennas remains fixed in bearing, and means combining the outputs of said antenna means to indicate the direction of incoming signals.

4. A directive antenna system, having substantially zero responsiveness to signals from a certain direction but finite responsiveness to signals from all other directions, comprising at least one pair of antenna means oppositely disposed with respect to a common axis rotatable in a circular path about the common axis, means maintaining the plane of said antennas fixed in bearing during their circuit of rotation, and means combining the outputs of said antenna means to indicate the direction of incoming signals.

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