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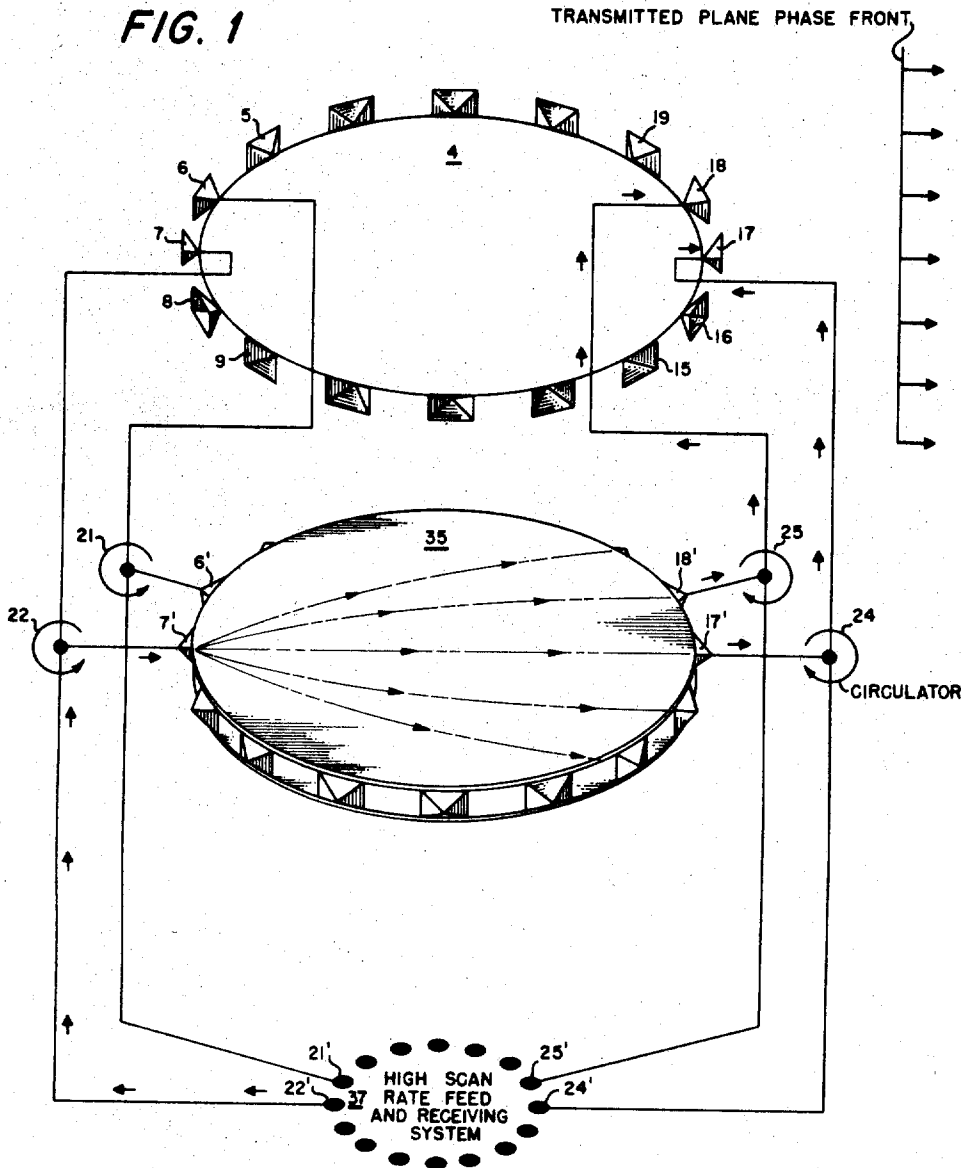
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NONRECIPROCAL OMNIDIRECTIONAL RAPID SCAN ANTENNA SYSTEM

Filed Aug. 17, 1966

Sheet 1 of 2



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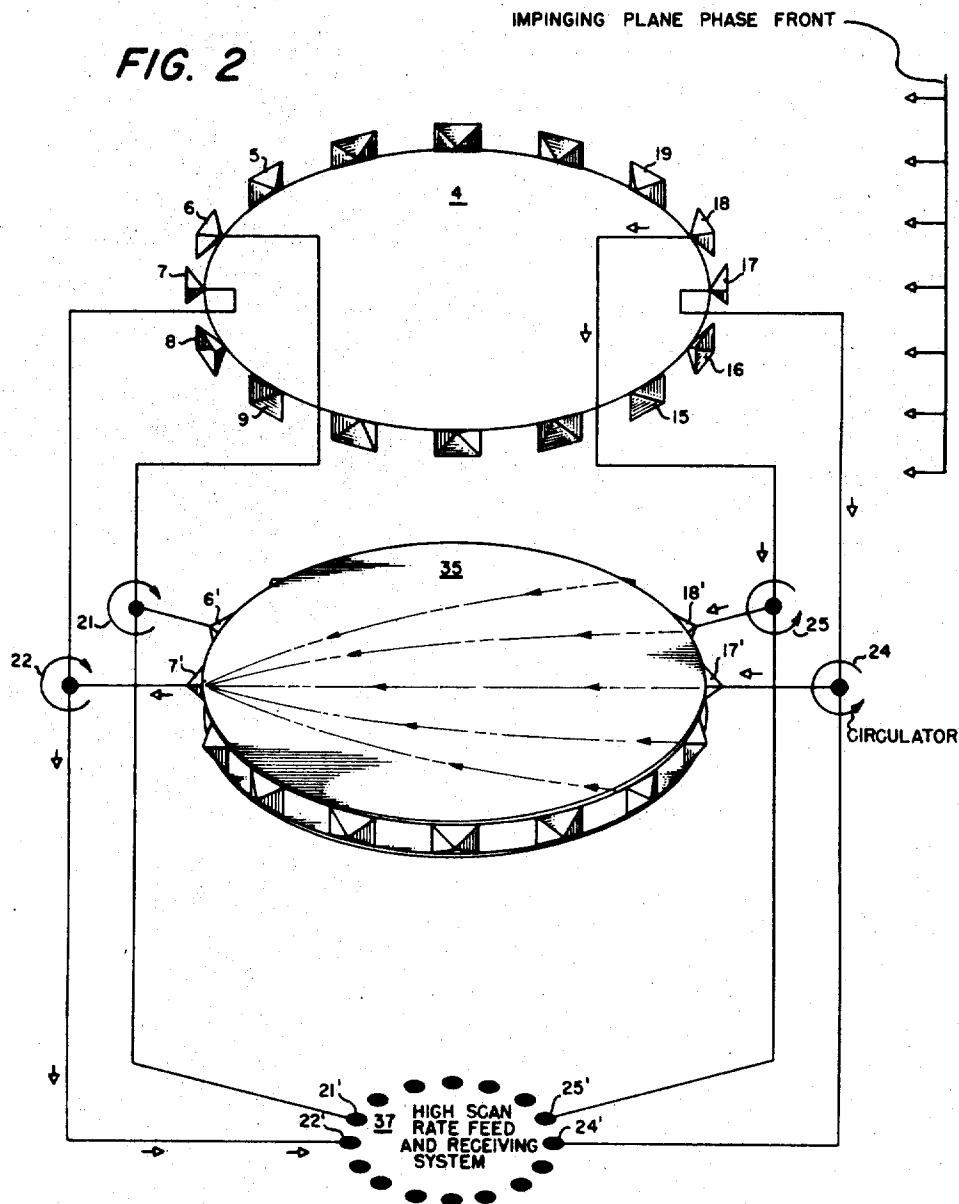
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NONRECIPROCAL OMNIDIRECTIONAL RAPID SCAN ANTENNA SYSTEM

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Continuation-in-part of application Ser. No. 521,220, Jan. 17, 1966. This application Aug. 17, 1966, Ser. No. 573,040

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8 Claims

ABSTRACT OF THE DISCLOSURE

A rapid scan antenna system for sequentially transmitting and receiving signals on a time sharing basis in any direction. The system may include a Luneburg lens having the same number of ports as there are wave-guide horns. The horns, ports, and an antenna feed and receiving system are interconnected by three-port circulators to permit sequential transmission and reception on a time sharing basis.

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.

This application is a continuation-in-part of application Ser. No. 521,220, filed Jan. 17, 1966, for "Omnidirectional Retrodirective Antenna."

The present invention relates generally to improvements in nonreciprocal antenna systems which are capable of sequential reception and transmission of electromagnetic energy, and more particularly to a new nonreciprocal, omnidirectional, rapid scan antenna system whereby a signal can be transmitted in any direction for one time interval and whereby a signal can be received during another time interval from that direction or from any other direction in azimuth.

In the field of scanning antenna systems it has been the general practice to employ a series of linear antenna arrays to permit rapid 360° coverage, and it has also been the general practice to employ mechanically rotating systems to enable the transmission and reception of electromagnetic energy over 360° of azimuth. Although such devices have served the purpose, they have not proved entirely satisfactory under all conditions of service for the reasons that a considerable amount of complex equipment is required in the case of the use of a series of linear arrays and that, in the case of mechanical scanning devices, the scan rate is extremely slow and requires a large time interval for a complete scan of the horizon.

The general purpose of this invention is to provide a rapid scan antenna system which embraces all of the advantages of similarly employed scanning antenna systems and possesses none of the aforescribed disadvantages. To attain this, the present invention contemplates a unique arrangement of three port circulators, electromagnetic energy refraction or focusing devices such as a Luneburg lens or an R-2R system, a circular focusing antenna array, and a high scanning rate feed system, whereby a signal can be rapidly scanned for 360° around the horizon while receiving a signal from any point on the horizon on a time sharing basis. In addition, because the present invention provides for an active antenna as opposed to a passive reflector it is able to impress intelligence on the radiated or reradiated signal.

An object of the present invention is the provision of a rapid scan antenna system.

Another object is to provide such a device that will rapidly scan a signal through a total of 360° in azimuth.

A further object of the invention is the provision of a

nonreciprocal, omnidirectional, rapid scan antenna system which will sequentially transmit a signal to and receive a signal from any direction in azimuth.

Still another object is to provide a nonreciprocal antenna system which is capable of transmitting signals toward any direction in azimuth and which is capable of receiving signals from any direction in azimuth on a time sharing basis.

Other objects and features of the invention will become apparent to those skilled in the art as the disclosure is made in the following detailed description of a preferred embodiment of the invention as illustrated in the accompanying drawings in which:

FIG. 1 shows a perspective view of one embodiment of the invention in a transmit mode with some electrical connections not shown for the purpose of clarity;

FIG. 2 illustrates a perspective view of the same embodiment of the invention in a receiving mode with some electrical connections not shown for the purpose of clarity.

Referring now to both drawings, wherein like reference characters designate like or corresponding parts throughout the several views, there is shown in FIGS. 1 and 2 a complete circular ring 4 of receiving and radiating focusing elements, such as wave guide horns, some of which elements are designated as 5-9 and 15-9. Each of the elements in the ring 4 is electrically connected to one port of a three-port circulator. The connections are exemplified in the figures by the couplings between 6 and 7, and circulators 21 and 22, and between elements 17 and 18 and circulators 24 and 25, respectively.

Each of the circulators, in turn, is electrically connected by means of one of its remaining ports to a Luneburg lens 35, which has a diameter equal to the diameter of ring 4. As exemplified in the figures, circulators 21, 22, 24 and 25 are electrically connected to Luneburg lens 35 by means of ports 6' and 7' and by means of ports 17' and 18', respectively. The electrical lengths of the connections between each of the receiving and radiating focusing elements and their respective circulators must be uniform with respect to each other, as must be the electrical lengths between each circulator and the Luneburg lens.

In addition, each of the circulators 21, 22, 24 and 25 is electrically connected by means of its remaining port to an element of the high scanning rate feed system 37. As exemplified in the figures, these circulators are electrically connected to the high scanning rate feed system 37 by means of ports 21', 22', 24' and 25', respectively. Here again, the electrical lengths of the connections between each of the circulators and their respective feed system ports must be uniform with respect to each other in order to maintain the necessary phase relationships of transmitted and received energy.

In the operation of the nonreciprocal, omnidirectional, rapid scan antenna system an electromagnetic signal may be transmitted, for example, from the high scanning rate feed system 37 through one of its ports 22' to circulator 22. The signal is then directed by circulator 22 into the port 7' of the Luneburg lens 35. A Luneburg lens, e.g. lens 35, has the property that when energy is received by one port 7', the energy is dispersed by the action of the lens so as to feed the energy into the ports on the opposite side of the lens 35, e.g. the ports 17' and 18'. The energy is formed by the action of the lens 35 into a wave which exits the lens 35 at ports 17' and 18'; this energy is then routed through equal length electrical connections to radiating elements 17 and 18, respectively, and the energy then leaves the antenna as a plane wave indicated in FIG. 1 as the transmitted plane phase front. It is apparent, from the circular symmetry of the antenna, that this ability to transmit will be effective for all angles in

azimuth and that by the action of the conventional high scanning rate feed system 37 the transmitted energy can be rapidly scanned in all directions of azimuth.

In addition to the transmission of energy from the antenna system, energy can also be received from any direction in azimuth on a time sharing basis with the transmission of energy by means of switching the circulators which are preferably of the "latching" type. A "latching" type circulator is one which requires no continuously applied electrical power in order to remain in a desired conducting state, but rather requires only an electrical pulse. In the operation of the receiving mode of the nonreciprocal rapid scan antenna system of this invention, the directions of conduction of the circulators are switched and as shown in FIG. 2, an electromagnetic wave is received, for example, by the receiving and radiating elements 17 and 18. The energy from this incident wave is routed from each focusing element 17 and 18 through equal length electrical connections to circulators 24 and 25, respectively, where the energy is then directed through another set of equal length electrical connections to the Luneberg lens 35. A Luneberg lens, e.g. lens 35, also has the property that when energy from a plane wave is incident and is received, for example, by the ports 17' and 18', the energy is focused down to port 7' on the opposite side of the lens 35. The energy then exits from lens 35 through port 7' and is routed by circulator 22 to the high scanning rate feed system 37 and into element 22' where the energy is received by the conventional system 37, which has the capability of receiving as well as transmitting energy. Again, it is apparent from the circular symmetry of the antenna that is capable of receiving energy for all angles of arrival, and it is also obvious that it is possible to sequentially transmit energy and receive energy by the use of this antenna system by means of switching the "latching" type circulators, e.g. 21, 22, 24, and 25 between the transmit and receive states.

It can therefore be seen that the invention very effectively provides for nonreciprocal, omnidirectional, rapid scan antenna system which avoids the complexity necessary in the use of linear arrays and which is capable of far greater scanning rates than has heretofore been possible by the use of mechanically rotating systems. This antenna system can be used in a wide variety of applications wherein high scanning rates and 360° coverage are required such as in radar systems used to detect high speed aircraft and missiles, IFF, or as a repeater in a microwave system, to name just a few examples.

It should be understood, of course, that the foregoing disclosure relates to only a preferred embodiment of the

invention and that numerous modifications or alterations may be made therein without departing from the spirit and the scope of the invention as set forth in the appended claims.

What is claimed and desired to be secured by Letters Patent of the United States is:

1. In a nonreciprocal, omnidirectional, rapid scan antenna system, the combination comprising:
 - receiving and radiating elements;
 - high scanning rate feed and receiving means;
 - a plurality of three-port circulators; and
 - electromagnetic energy focusing means operatively coupled to said elements and to said feed and receiving means by said three-port circulators to enable the transmission of a signal in any direction in azimuth on a time sharing basis with the reception of a signal from any independent direction in azimuth.
2. The combination of claim 1 wherein said receiving and radiating elements are oriented in a complete circular ring.
3. The combination of claim 1 wherein said electromagnetic focusing means comprises a Luneberg lens.
4. The combination of claim 3 wherein the diameter of said Luneberg lens is equal to the diameter of said circular ring.
5. The combination of claim 1 wherein each of said circulators is connected to said high scanning rate feed and receiving means by equal-length electrical connections.
6. The combination of claim 1 wherein each of said receiving and radiating elements is connected to its respective circulator by equal-length electrical connections.
7. The combination of claim 1 wherein each of said circulators is connected to said focusing means by equal-length electrical connections.
8. The combination of claim 1 wherein said circulators are latching type circulators.

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U.S. Cl. X.R.

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