

United States Patent [19]**Silbiger et al.**[11] **3,761,935**[45] **Sept. 25, 1973****[54] WIDE ANGLE MICROWAVE SCANNING
ANTENNA ARRAY WITH DISTORTION
CORRECTION MEANS****[75] Inventors:** **Richard J. Silbiger**, Dix Hills;
Lawrence N. Finch, II, Great Neck;
Ralph W. Logan, West Islip, all of
N.Y.**[73] Assignee:** **Republic Electronic Industries, Inc.**,
Huntington Station, N.Y.**[22] Filed:** **Mar. 6, 1972****[21] Appl. No.:** **232,149****[52] U.S. Cl.:** **343/754, 343/761, 343/909****[51] Int. Cl.:** **H01q 19/06****[58] Field of Search:** **343/753, 754, 755,
343/761, 781, 839, 909****[56] References Cited****UNITED STATES PATENTS**

2,656,464 10/1953 Robinson 343/781

3,005,983 10/1961 Chandler 343/753
2,524,292 10/1950 Iams et al. 343/761*Primary Examiner*—Eli Lieberman*Attorney*—Edward H. Loveman**[57] ABSTRACT**

A wide angle microwave scanning antenna array includes an assembly of two stationary, parallel, concentric, spaced cylindrical surfaces providing a path for microwaves. A rotating waveguide feeds microwave energy into one end of the assembly and a flat focusing lens at the output end of the assembly radiates the microwaves in a scanning plane and focuses the waves at a point moving in the plane. A helical mirror in the assembly reflects the microwaves from the input to the lens at the output. To correct for distortion and increase the angular range of distortion free scanning, a cylindrical corrector lens is located in the assembly between the input and the mirror.

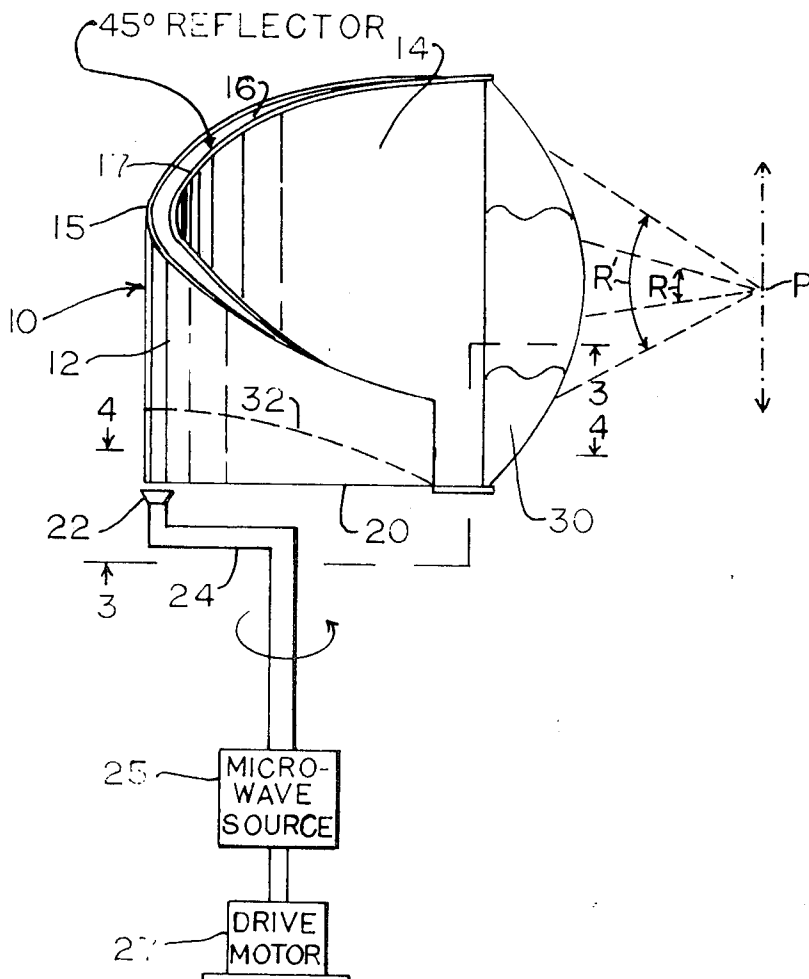
8 Claims, 7 Drawing Figures

FIG. 1

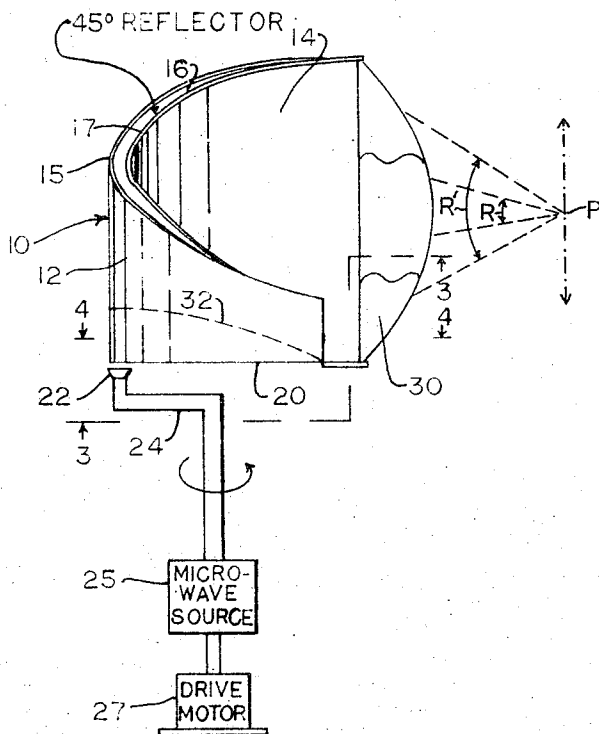
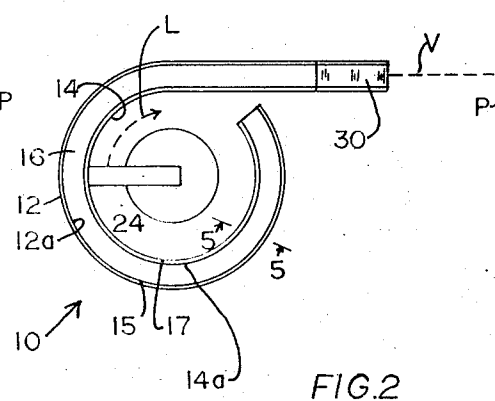


FIG. 2

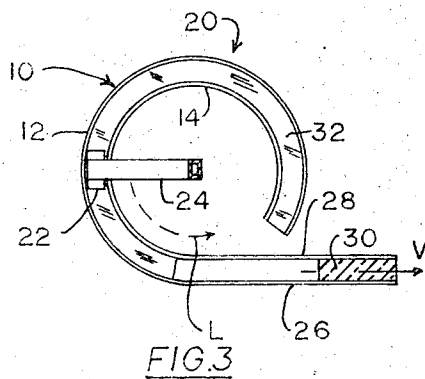


FIG. 3

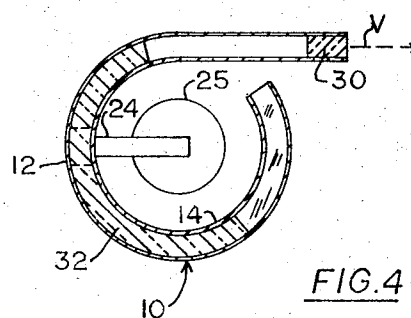


FIG. 4

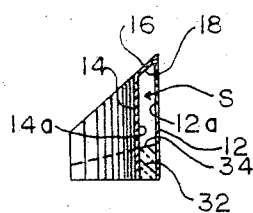


FIG. 5

2 Sheets-Sheet 2

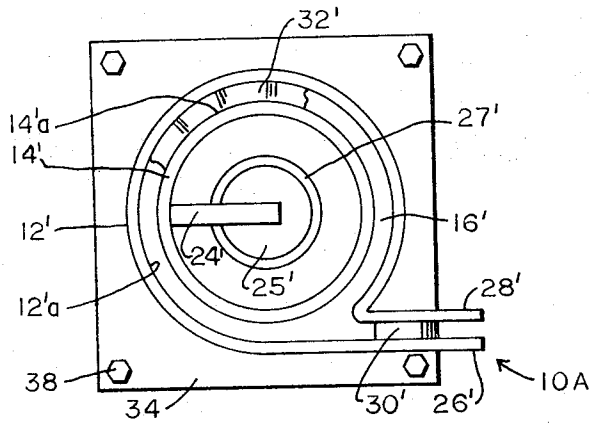


FIG. 6

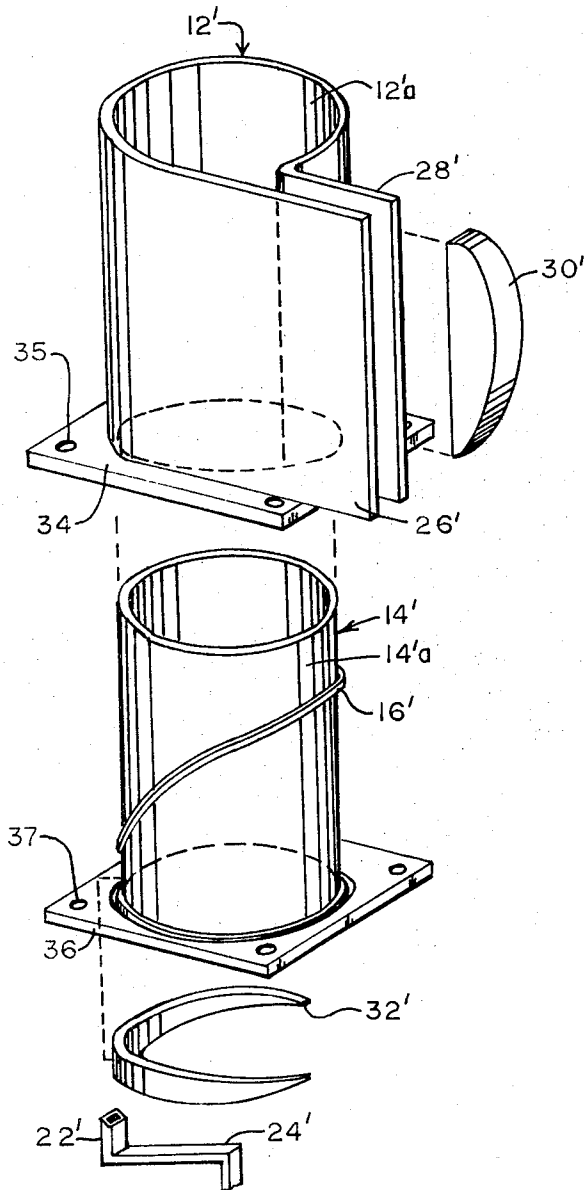


FIG. 7

WIDE ANGLE MICROWAVE SCANNING ANTENNA ARRAY WITH DISTORTION CORRECTION MEANS

This invention concerns a microwave scanning antenna assembly capable of wide angle scanning and more particularly concerns a microwave scanning antenna with means for minimizing distortion in energy distribution.

Cylindrical scanning antenna arrays have been known heretofore which employ a rotating microwave feed mechanism to perform a scanning function and produce conical coordinate elevation beams. Such cylindrical arrays suffer from severe defocusing effects at angles greater than 20° from the principal plane of the antenna. One conventional cylindrical microwave antenna array generally known as a "Lewis Scanner" employs parallel, cylindrical plates carrying between them a helical reflector disposed at an angle of 45° to the direction of microwave input parallel to the plates. A flat microwave lens disposed in the plane of the antenna output focuses the radiated microwaves into a narrow beam in an elevational plane. A waveguide which is the source of the microwave energy rotates around the plates to feed the energy to the array. This type of scanner has the basic disadvantage that feed motion away from the center position in the path of rotation causes large distortions in the distribution of energy over the lens surface due to defocusing.

The present invention is directed primarily at overcoming this difficult situation in a cylindrical microwave antenna. According to the invention, there is provided a distortion correcting, cylindrical microwave lens between the stationary parallel plates or surfaces of the array. The lens is made of any appropriate material such as a plastic having an index of refraction greater or less than unity. The distortion correcting lens can be employed in a microwave antenna excited in any waveguide mode, for example, TEM. The lens can correct for amplitude and/or phase distortion.

It is therefore a principal object of the present invention to provide a wide angle scanning antenna array having means for minimizing distortion.

It is another object of the present invention to provide a wide-angle scanning antenna array having a cylindrical lens for correcting distortion and increasing the angular range of scanning.

These and other objects and many of the attendant advantages of this invention will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings in which:

FIG. 1 is a diagrammatic side elevational view of a microwave antenna array embodying the invention;

FIG. 2 is a top plan view of part of the array of FIG. 1;

FIG. 3 is a horizontal sectional view taken along line 3—3 of FIG. 1;

FIG. 4 is a horizontal sectional view taken along line 4—4 of FIG. 1;

FIG. 5 is a fragmentary vertical sectional view taken along line 5—5 of FIG. 2;

FIG. 6 is a top plan view of another antenna array embodying the invention; and

FIG. 7 is an exploded prospective view of parts of the array of FIG. 6.

Referring, now to the drawings wherein like reference characters designate like or corresponding parts throughout, there is illustrated a microwave antenna array generally designated as reference numeral 10 including a pair of stationary, concentric, spaced parallel plates 12, 14. The plates are cylindrically curved to define spaced opposing surfaces 12a, 14a (FIG. 2). Upper edges 15, 17 of the respective plates 12, 14 are parallel to each other in a plane intersecting the cylindrical surfaces at an angle of 45°. A helical microwave mirror 16 is disposed helically at a pitch of 45° between the plates 12, 14. An underside 18 of the mirror 16 is exposed to microwave energy fed into the space S between the surfaces 12a, 14a of the plates 12, 14 from a bottom or input end 20 by a waveguide radiator 22 which is connected via a waveguide 24 to a source 25 of microwave power and rotated in a circular horizontal path L by a suitable drive motor 27.

The plates 12, 14 may be formed with a pair of flat, parallel sections 26, 28 at the output end of the array 10 where a microwave lens 30 is disposed to focus microwave energy radiated outwardly in plane V at point P. As the horn radiator 22 rotates the point P moves up and down in plane V. If the cylindrical plates 12, 14 are axially horizontal, the lens 30 and the scanning plane V will also be horizontal. To the extent described the array is generally conventional.

Now, according to the invention, there is provided a cylindrical distortion corrector lens 32 which is disposed between the plates 12, 14 at the input end 20. The lens 32 is curved at its upper end 34 in such a way as to compensate for defocusing, and for amplitude and phase distortion which otherwise occurs in the array 10 in the absence of the lens 32. This lens may be made of any suitable material which is transparent to microwaves but which has an index of refraction other than unity to effect preliminary focusing of the microwaves impinging on the reflective surface 18 of the helical mirror 16. The mirror 16 may be a separate member or may be formed as a ridge integral with either one of the plates 12 or 14.

The presence of the distortion corrector lens 32 makes it possible to extend the usual 20° range R (See FIG. 1) of substantially distortionless scanning in plane V to range R' which may be 45° or more. Thus the addition of the distortion corrector lens 32 makes it possible to accomplish with an array of given size distortion-free scanning in an angular range which heretofore could only be accomplished by an array of at least twice the size. Very large economies are thus effected in installation and servicing costs and in addition the installation is smaller in size and simpler in construction. For a given range of specified distortion-free scanning a saving of microwave input power of 50 percent or more may be obtained, simply by the addition of the distortion corrector lens 32.

Referring now to FIGS. 6 and 7 there is shown another antenna array 10A in which parts corresponding to those of the array 10 are designated by identical primed numbers. In the array 10A a helical mirror 16' is integrally joined to an outer surface 14'a of an inner cylindrical plate 14'. At one end of the plate 14' is a rectangular flange 36 provided with four corner holes 37. These holes register with four corner holes 35 in the flange 33 at the lower end of a cylindrical plate 12' with a bolt 38 placed in each pair of registered holes to secure the flanges together and thereby form a rigid as-

sembly. A lens 30' fits between lateral plate extensions 26', 28' and is secured in place thereinbetween. A cylindrical corrector lens 32' is fitted into the spaced between an inner surface 12'a of a plate 12' and the outer surface 14'a of the plate 12'. A microwave radiator 22' 5 carried by a waveguide 24' is rotated at the end of the plate assembly 12', 14' by a motor 27'. The radiator 22' is fed with microwaves by microwave source 25'. Although not shown, the inner cylindrical plate 14' is assembled to the outer cylindrical plate 12' by conventional means. 10

The operational advantages of array 10A are the same as described for array 10, with the additional advantage of improved mechanical construction.

It should be understood that the foregoing relates to only a limited number of preferred embodiments of the invention, which have been by way of example only, and that it is intended to cover all changes and modifications of the examples of the invention herein chosen for the purposes of the disclosure, which do not constitute departures from the spirit and scope of the invention. 15

The invention claimed is:

1. A wide angle microwave scanning antenna array, comprising 25
- an assembly of two stationary, concentrically spaced discontinuous cylindrically rolled members defining opposing curved surfaces for providing a path for microwaves therebetween,
 - said assembly having an input end for receiving microwaves directed into said array in one direction between said surfaces from a moving waveguide source of said microwaves,
 - said assembly having an output end extending in a generally tangential manner from the concentrically spaced members for radiating the received microwaves; 30
 - a focusing lens disposed at said output end for focusing the radiated microwaves to a moving point in a scanning plane;
 - a corrector lens disposed in said assembly for refracting in such a way microwaves entering said assembly so that distortion in focusing, amplitude and/or 35

phase of microwaves radiated from the focusing lens is substantially prevented in an angular range exceeding 20° in said scanning plane; and

a helical mirror disposed between said surfaces in said assembly and arranged to reflect microwaves leaving said corrector lens in said one direction to another direction parallel to said scanning plane.

2. A wide angle microwave scanning antenna array as defined in Claim 1, wherein said corrector lens is cylindrically curved and has an index of refraction other than unity.

3. A wide angle microwave scanning antenna array as defined in claim 1, further comprising a source of said microwaves disposed adjacent said input end of said assembly; and means for rotating said source in a circular path in a plane perpendicular to said one direction. 15

4. A wide angle microwave scanning antenna array as defined in claim 1 wherein said mirror is integral with one of said surfaces. 20

5. A wide angle microwave scanning antenna array as defined in claim 1, wherein said focusing lens is flat and disposed parallel to said scanning plane, said corrector lens being cylindrically curved and disposed at said input end of said assembly. 25

6. A wide angle microwave scanning antenna array as defined in claim 1, said helical mirror having a pitch of 45°.

7. A wide angle microwave scanning antenna array as defined in claim 1, further comprising a pair of outer and inner cylindrical plates disposed in spaced concentric disposition, said surfaces being defined at the inner side of said outer plate and the outer side of said inner plate, said mirror being integral with one of said surfaces; and mechanical means for holding said plates in fixed radially spaced position with said mirror therebetween. 30

8. A wide angle microwave scanning antenna array as defined in claim 7 further comprising a source of said microwaves disposed adjacent said input end of said assembly; and means for rotating said source in a circular path in a plane perpendicular to said one direction. 35

* * * * *

45

50

55

60

65