

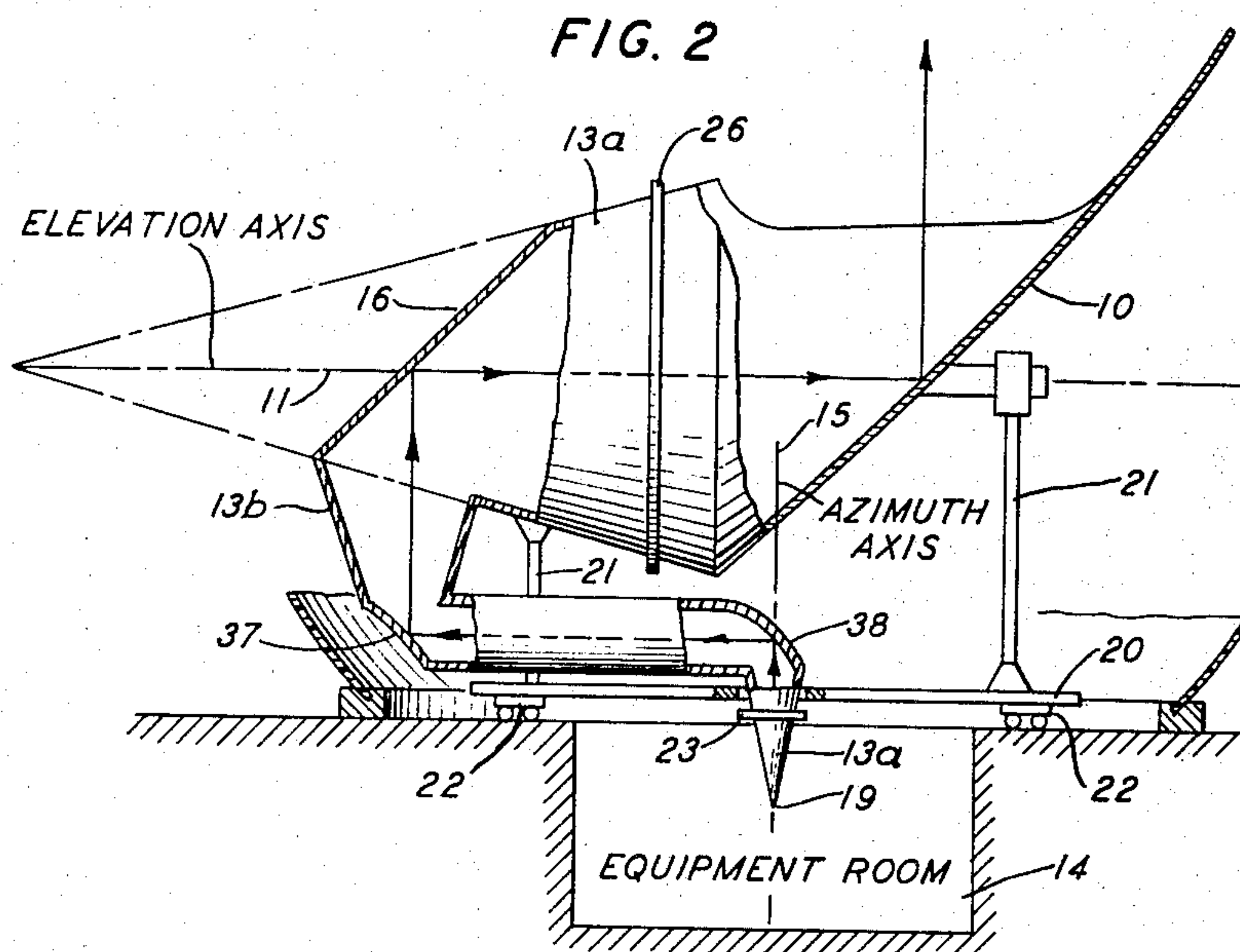
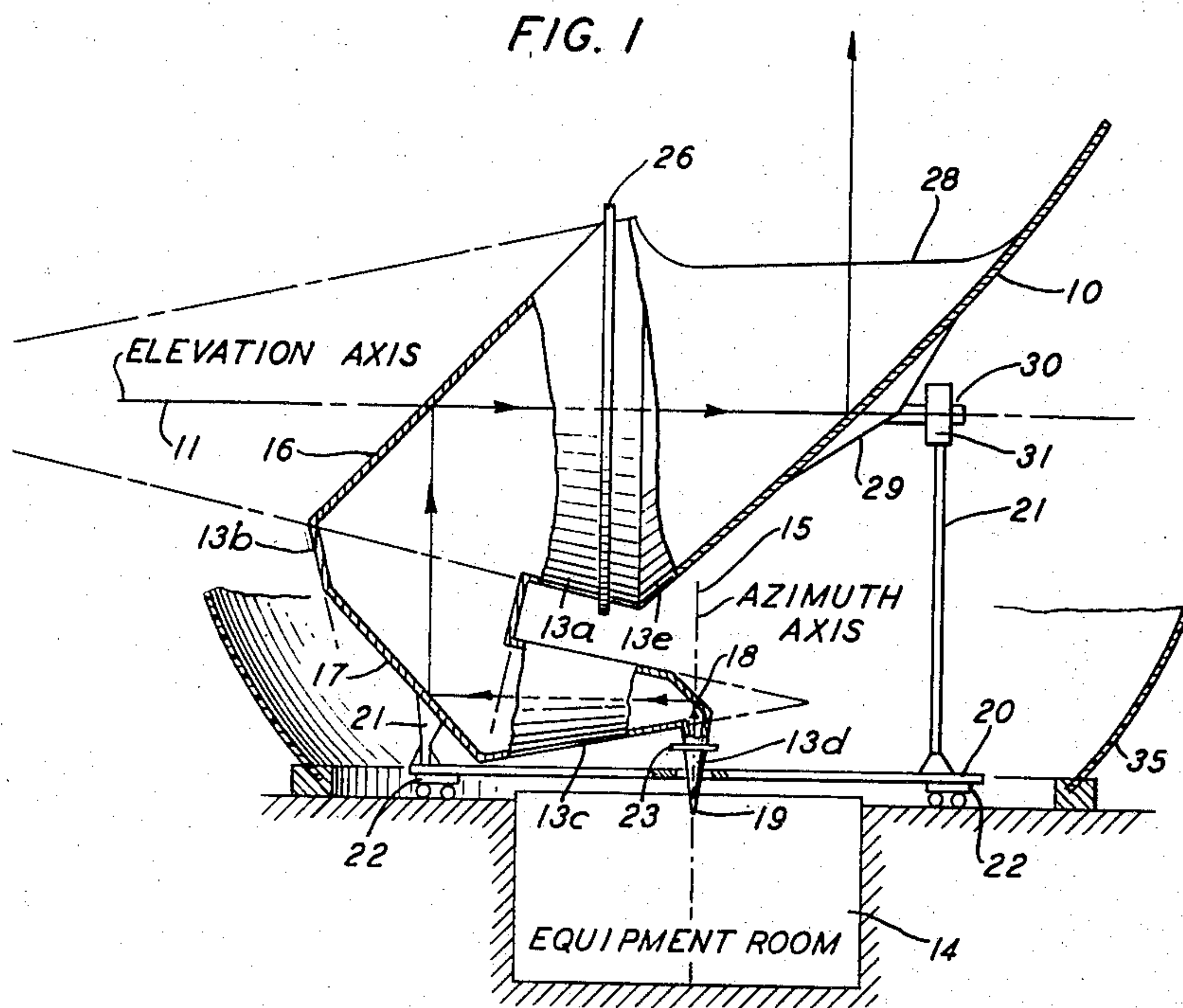
Dec. 5, 1967

A. J. GIGER

3,357,022

FOLDED HORN-REFLECTOR ANTENNA STRUCTURE

Filed Dec. 5, 1963



INVENTOR
BY A. J. GIGER
A. E. Hirsch
ATTORNEY

1

3,357,022

FOLDED HORN-REFLECTOR ANTENNA STRUCTURE

Adolph J. Giger, Murray Hill, N.J., assignor to Bell Telephone Laboratories, Incorporated, New York, N.Y., a corporation of New York

Filed Dec. 5, 1963, Ser. No. 328,291

9 Claims. (Cl. 343-762)

This invention relates to microwave antennas and more particularly to folded horn-reflector antennas arranged for rotation both in elevation and azimuth. Its principal objects are to reduce substantially the physical size of a steerable horn-reflector antenna and to avoid all translational motions of an associated equipment room during antenna movement.

The horn-reflector antenna has received wide acceptance as a low noise, broadband, microwave antenna. It is essentially a combination of a conical electromagnetic horn, and a reflector which is a sector of a paraboloid of revolution. The antenna is fed at the apex of the horn and the apex is coincident with the focus of the paraboloidal reflector. To insure a low receiving system noise temperature and low losses for the transmitting signal, the equipment room containing receiving apparatus, transmitting apparatus, or both, is located at, or as near as possible to, the point of coincidence of the apex and focus.

Aside from use as the transmitting and receiving antenna of broadband radio relay systems and the like, these antennas have, particularly because of their low noise properties, profitably been used in radio astronomy and similar applications. In such uses it is, of course, necessary that the antenna be moved in azimuth and elevation in order that a moving target may be tracked. If the terminal equipment is to be placed at the horn apex, the housing for it must also be a part of the rotating structure and must be physically moved as scanning takes place. Obviously, inclusion of the equipment house in the rotating structure adds materially to the difficulty in moving it with precision and further requires elaborate systems of slip rings, drag cables and the like to couple the station to external processing equipment. In addition, the larger structure is difficult to house, for example in a radome. In short, the smaller the antenna the easier it is to move during a tracking operation and the easier it is to house in a structure of moderate proportion.

Consequently a number of proposals have been made for reducing the physical size of a horn-reflector antenna. Thus, for example, it has been proposed that the guide horn coupling the paraboloidal reflector to the equipment house be folded, e.g., with one or more reflecting surfaces, to bring the focus of the paraboloidal surface and the apex of the horn to coincidence at a point nearer to the paraboloidal reflector than permitted with the usual straight cone design. The point of coincidence may be on the elevation axis at a point just behind the paraboloidal reflector or at some point away from the elevation axis. Although physical compactness is achieved by folding the horn in this manner, the equipment house must still be moved with the structure during scanning. By placing the housing on the elevation axis and coupling it to the horn with a rotating joint, half of the problem is solved. Yet, translational motions are required as the antenna structure is rotated in azimuth.

It is another object of the invention to comply with the requirement that receiving and transmitting equipment be placed in close proximity to the focus of the paraboloidal reflector, and yet to permit the equipment room to be held stationary as the antenna is moved both in elevation and in azimuth.

In accordance with the present invention, the horn portion of the antenna is multiply folded to reduce the

2

size of the antenna structure, the protective radome covering and the foundation, and to provide for more convenient placement of terminal equipment, namely, in a stationary equipment house at or near the apex of the horn. Antenna mobility is attained by supporting the paraboloidal reflector portion of the antenna for independent rotation about an elevation axis and coupling thereto, and to each other, a plurality of sections of a waveguide feed horn for bringing the focus of the reflector and the apex of the horn to coincidence on the azimuth axis.

Preferably, the principal axis of the paraboloidal reflector is folded such that it is, at the point of coincidence of focus of the reflector and apex of the horn on the principal axis, in substantial alignment with the azimuth axis. Accordingly, the entire structure, including the paraboloidal reflector and the coupled sections of waveguide feed horn may be supported for rotation about this axis. With this geometry, terminal equipment placed at or near the apex-focus of the antenna, is stationary with rotation in elevation or azimuth or both.

In the practice of the invention, a system of auxiliary reflectors is used to fold the waveguide feed horn to the desired shape, namely, one which brings the axes of the paraboloidal reflector and the horn at or near the point of apex-focus juncture in substantial alignment with the axis of azimuth rotation. In theory, one auxiliary reflector is sufficient, but in practice, three are preferred. Plane reflecting surfaces are satisfactory. A rotating joint couples the horn at a point near its apex to a waveguide system at the stationary terminal location. A similar coupling element is used to permit the paraboloidal reflector of the antenna to rotate independently in elevation. A possible saving in physical size and ease of implementation is secured by utilizing paraboloidal reflectors as the last two reflecting surfaces in the folded horn configuration. In this case, the beam between the two parabolic surfaces consists of essentially parallel rays.

The above and other features of the invention will be better apprehended from a consideration of the following detailed description of illustrative embodiments thereof taken in connection with the appended drawings, in which:

FIG. 1 is a simplified plan view of a folded horn-reflector antenna which embodies features of the present invention; and

FIG. 2 is a simplified plan view of a horn-reflector antenna of an alternative construction which embodies the features of the invention.

A simplified view, partially in section, of a directive antenna constructed in accordance with the features of the invention is shown in FIG. 1. It includes a section of a paraboloid of revolution 10 having its focus substantially in a horizontal plane which contains the elevation axis 11 of the antenna structure. Paraboloidal reflector 10 is thus arranged to direct energy incident on the reflector surface from an external source to a virtual focus on the elevation axis and energy originating on the axis to a selected target external to the structure. Energy collected by the reflector is directed along the elevation axis and, by way of a conical electromagnetic horn 13, to an equipment room 14 located at the point of coincidence of the focus of the reflector and the apex of the horn. In the conventional horn-reflector antenna of the sort shown and described in A. C. Beck et al., Patent 2,416,675, granted Mar. 4, 1947, the apex of the conical horn is arranged to have its unbroken axis coincident with the major axis of the reflector. In accordance with the present invention, however, the horn 13 is folded in such a manner that the focus-apex of the structure is brought to a common point on the azimuth axis 15. Preferably, the azimuth axis passes through the center of symmetry of the antenna structure.

A plurality of surfaces for reflecting electromagnetic energy is employed effectively to warp the horn into a "question mark" shape. Reflector 16 is thus positioned at an angle of substantially 45 degrees with elevation axis 11, and with its center approximately on the elevation axis, to redirect energy normal to it; reflector 17 is angled to establish an energy path substantially parallel to the elevation axis; and reflecting surface 18, similarly disposed at an angle substantially parallel to and spaced from reflector 17, is aligned to establish an energy path essentially congruent with the azimuth axis of the antenna. Each of the several reflectors is generally of an elliptical shape to truncate horn 13 at spaced points along its length. As a consequence, the focus-apex of the horn reflector configuration is brought to point 19 on the azimuth axis 15 of the structure outside of the major antenna structure. Further, the principal axes of the reflector 10 and horn 13 are in substantial alignment with axis 15.

Scanning of a hemisphere is achieved by rotating the entire structure about the azimuth axis and paraboloidal reflector 10 independently about the elevation axis. One simplified arrangement for rotating the antenna is shown. It will be evident to those skilled in the art, that the usual mechanical design considerations, for the most part omitted here, must be taken into account. Accordingly, the arrangement shown is to be considered solely as illustrative of the principles involved. The entire structure may be supported on a movable platform 20 by means of space frame members 21, only two of which are shown in the illustration. Platform 20 rests on trucks 22 which ride on circular tracks or the like.

A rotating junction 23 of a type known in the art and comprising, for example, two parallel quarter-wave open-ended flanges, couples the rotating assembly to the stationary apex section 13d of the conical horn; the apex itself is brought into equipment room 14. The subterranean location of the stationary equipment room has obvious advantages.

Rotation in elevation is achieved by means of rotating coupling 26 which connects conical horn section 13a to an assembly supporting paraboloidal reflector 10. Support assembly 13e of generally a conical configuration, is arranged to enclose entirely the paraboloidal reflector 10 except for an aperture 28 sufficiently large to accommodate a satisfactory antenna flare angle. Aperture 28 may be enclosed in a cylindrical protective section (not shown) if desired. The primary reflector 10 is made structurally rigid by means of support member 29 attached to its rear surface and shaft 30 coaxial with the elevation axis of the antenna. Shaft 30 may be attached to bearing 31 supported on frame 21. If desired, coupling 31 may include a suitable drive motor for providing the impetus for rotating the reflector structure about the elevation axis. Other forms of motivation may, of course, be used.

To protect the entire structure, a radome 35 or the like may be provided of sufficient diameter to clear the antenna structure as it is rotated in scanning. Obviously the radome may be of considerably smaller dimensions than would be required if the equipment room 14 were located on the elevation axis of the reflector 10 at the apex of the connecting horn.

FIG. 2 illustrates another variation of the compact steerable antenna of the invention. In general, the conical horn portion 13 of the structure is multiply folded to bring the apex-focus to a point on the azimuth axis. A number of reflecting surfaces generally placed as the corresponding surfaces in the antenna of FIG. 1 are used. However, to reduce even more the silhouette of the structure and to collimate signal waves near the apex-focus, plane reflecting surface 16 of the structure of FIG. 1 only is retained. Reflectors 17 and 18 of the antenna of FIG. 1 are replaced by reflectors 37 and 38 of a generally curved shape. Preferably, sections of paraboloids are used so that the beam between the parabolic surfaces

consists of parallel rays. The arrangement yields an added degree of freedom, particularly in the length of the parallel beam, over the construction illustrated in FIG. 1. Of primary importance with this embodiment, as with the earlier one, is that equipment room 14 remains completely stationary as the antenna structure is moved in azimuth.

Experience indicates that the use of an additional rotating joint, e.g., 26, in the horn portion of the antenna should result in but a negligible increase in antenna noise, perhaps as little as one degree Kelvin. Further, so long as the last two reflecting surfaces of the folded horn, e.g., 17 and 18, in FIG. 1 and 37 and 38 in FIG. 2, are many wavelengths in diameter, the possibility of increased signal reflections will be minimal. In this case, surface losses also will be negligible. With careful design, spill-over lobes may also be contained within reasonable limits.

The above-described arrangements are, of course, merely illustrative of the application of the principles of the invention. The auxiliary reflectors discussed herein, for the most part as plane reflectors, may, for example, be generally curved. With parabolic or hyperbolic reflectors, it will be apparent to those skilled in the art that the effective throat length of the horn portion of the antenna structure can be altered to permit a considerable degree of freedom in the exact arrangement of connecting guide sections and angles between sections. In all events, numerous other arrangements may be devised by those skilled in the art without departing from the spirit and scope of the invention.

What is claimed is:

1. A scanning antenna system which comprises, a paraboloidal reflector, means for supporting said reflector for independent rotation about an elevation axis and about an azimuth axis, and a plurality of sections of a waveguide feed horn coupled together and to said reflector for effectively folding said horn to bring the focus of said reflector and the apex of said horn to coincidence substantially on said azimuth axis.

2. In a directive antenna system, a paraboloidal reflector, means for supporting said reflector for independent rotation about an elevation axis and about an azimuth axis, and a plurality of sections of a waveguide horn coupled together and to said reflector for effectively folding said horn to bring the axis of said horn in substantial alignment with said azimuth axis at the focus of said paraboloidal reflector.

3. A directive antenna system, which comprises, a paraboloidal reflector, means for supporting said paraboloidal reflector for independent rotation about an elevation axis, a plurality of auxiliary reflectors supported by a system of waveguide horn sections coupled to each other and to said paraboloidal reflector for bringing the focus of said paraboloidal reflector to coincidence with the apex of said horn substantially on the azimuth axis, and means for rotating said paraboloidal reflector and said coupled horn sections in azimuth about the axis of the apex forming section of said horn.

4. A directive antenna system, which comprises, a paraboloidal reflector, means for supporting said paraboloidal reflector for independent rotation about an elevation axis, a plurality of auxiliary reflectors, a plurality of sections of a conical waveguide horn, means for coupling said waveguide horn sections and said auxiliary reflectors together to form a continuous waveguide path in said horn, the axis of said horn thus being bent by each one of said auxiliary reflectors to a configuration such that the axis of the apex section of said horn is perpendicular to said elevation axis, and means for rotating said horn and said paraboloidal reflector together in azimuth about said apex section axis.

5. A directive antenna system as defined in claim 4 wherein each of said plurality of auxiliary reflectors comprises, a substantially plane surface symmetrically aligned with the point of intersection of the axes of the two coni-

5

cal sections coupled thereby at the plane of truncation of said coupled conical sections.

6. A directive antenna system as defined in claim 4 wherein said auxiliary reflectors are paraboloidal surfaces each of whose focal axes is aligned with the axis of at least one of said conical sections.

7. A directive antenna system which comprises: a paraboloidal reflector; a tapered energy directive system for bringing the focus of said reflector in coincidence with the axis of azimuth rotation of said antenna, said energy directive system comprising, means for connecting a plurality of truncated guide sections in a configuration such that the longitudinal axis of the second of said sections is perpendicular to the longitudinal axis of the first section, the longitudinal axis of the third section is perpendicular to the longitudinal axis of the second section and the longitudinal axis of the fourth section is perpendicular to the longitudinal axis of the third section, a first energy reflecting surface at the junction of said first and said second sections oriented to provide a maximum transfer of energy from the longitudinal axis direction of said first section to the longitudinal axis direction of said second section, a second energy reflecting surface at the junction of said second and said third sections oriented to provide a maximum transfer of energy from the longitudinal axis direction of said second section to the longitudinal axis direction of said third section, and a third energy reflecting surface at the junction of said third and said fourth sections oriented to provide a maximum transfer of energy in the longitudinal axial direction of said third section to the longitudinal direction of said fourth section; rotatable means in said fourth section, and means for rotating said paraboloidal reflector and the sections

6

of said tapered energy directive system together in azimuth about the axis of said fourth section.

8. A directive antenna system as defined in claim 7 which includes a stationary enclosure for terminal communications equipment, means for coupling terminal equipment to said energy directive system, said coupling means including said rotatable means in said fourth section.

9. In combination with the directive antenna system defined in claim 3,

a stationary enclosure for terminal communications equipment positioned in axial proximity to the effective axis of azimuth rotation of said paraboloidal reflector and said coupled horn sections, waveguide feed member means affixed in said enclosure in alignment with said axis of azimuth rotation, and waveguide means for rotatably coupling said apex forming section of said horn to said waveguide feed member.

References Cited

UNITED STATES PATENTS

2,579,140	12/1951	Crawford	343—775
2,682,610	6/1954	King	333—73
2,817,837	12/1957	Dale	343—775
3,021,524	2/1962	Kompfner	343—781
3,156,917	10/1964	Parmegianni	343—782
3,165,747	1/1965	Wales	343—761
3,169,246	2/1965	Cook	343—914
3,284,802	10/1966	Dolling	343—782

HERMAN KARL SAALBACH, *Primary Examiner*.

C. BARAFF, *Assistant Examiner*.