

Meek et al.

[54] **SCHWARZCHILD RADAR ANTENNA
UTILIZING A RING SWITCH FOR
GENERATING A SECTOR SCAN**

[75] Inventors: James M. Meek, Silver Spring;
Clarence F. Ravillious, Rockville;
Whilden G. Heinard, Bethesda, all
of Md.

[73] Assignee: The United States of America as
represented by the Secretary of the
Army, Washington, D.C.

[22] Filed: Feb. 26, 1973

[21] Appl. No.: 335,876

[52] U.S. Cl. 343/754, 343/755, 343/761,
343/779, 343/781, 343/837

[51] Int. Cl. ... H01g 3/14, H01g 19/10, H01g 19/18

[58] Field of Search 343/754, 755, 761, 779,
343/781, 837

[56] **References Cited**

OTHER PUBLICATIONS

"Electronics Abroad" in Electronics, October 30,
1967, Vol. 40 No. 22; pages 169-170.

Primary Examiner—James W. Lawrence

Assistant Examiner—Marvin Nussbaum

Attorney, Agent, or Firm—Edward J. Kelly; Herbert
Berl; Saul Elbaum

[57]

ABSTRACT

A Schwarzschild Antenna has main and subreflectors. A ring switch disposed behind the aperture in the main reflector generates a unidirectional sector scan beam that is collimated and transmitted to the far field, via the reflectors. The ring switch is comprised of two ring-shaped waveguide halves one of which rotates with respect to the other. Feed horns are mounted to one of the rings and are directed radially inwardly. Microwave energy from a transmitter is communicated to the horns, via the ring switch. Microwave energy emanating from the horns is directed by a lens to a rotatable mirror reflector that in turn reflects the resultant sector scan energy to the main and subreflectors of the antenna. The mirror reflector can be rapidly repositioned to allow the direct communication of a separately generated conical scan to the main and subreflectors of the antenna.

10 Claims, 4 Drawing Figures

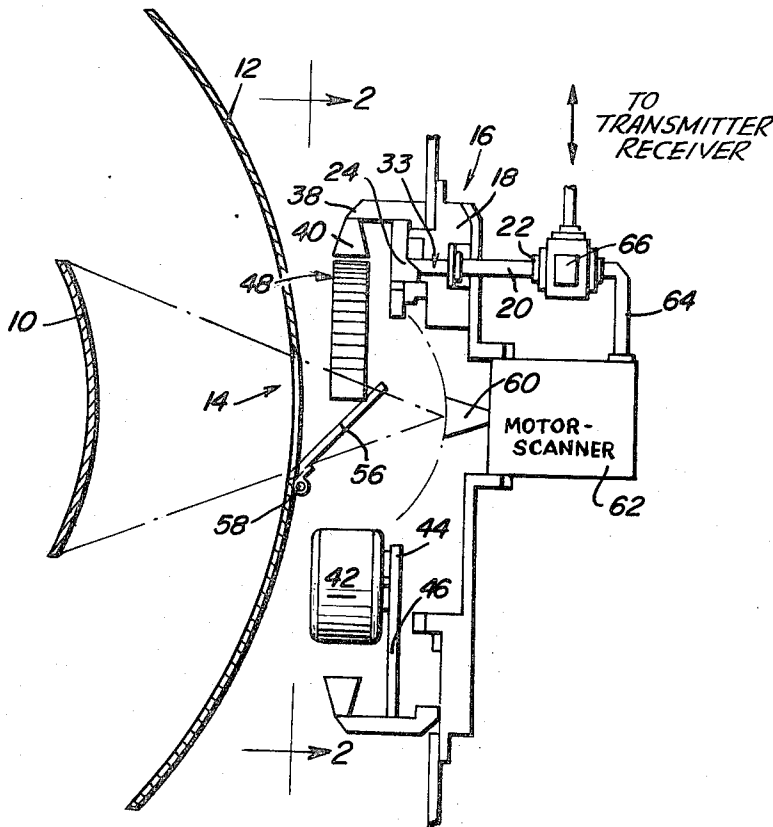


Fig. 1

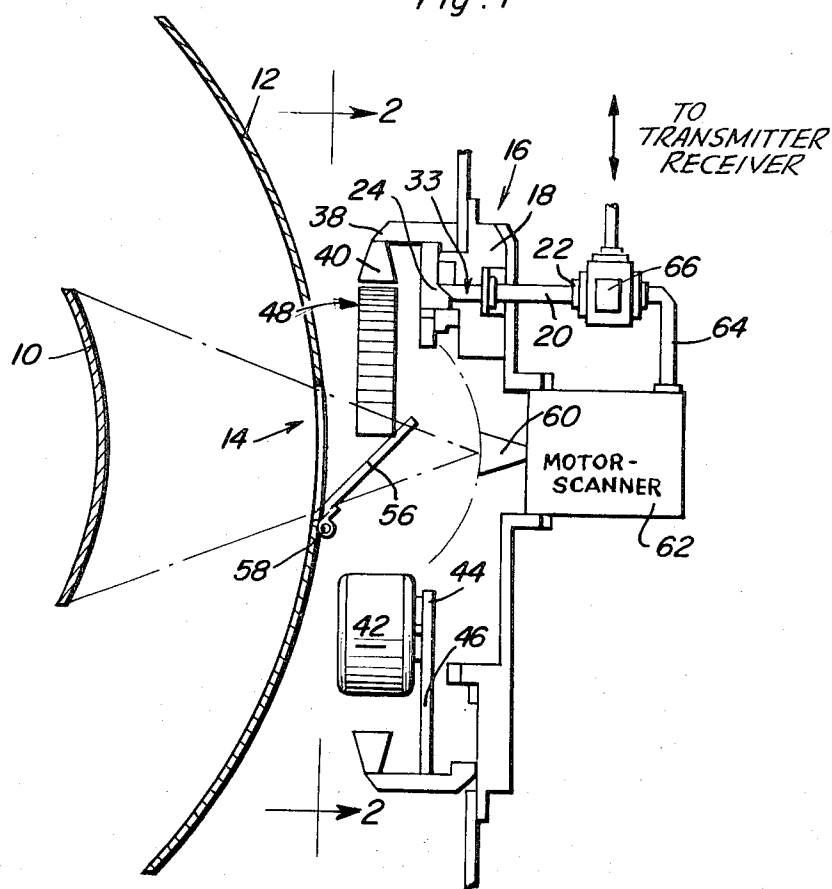
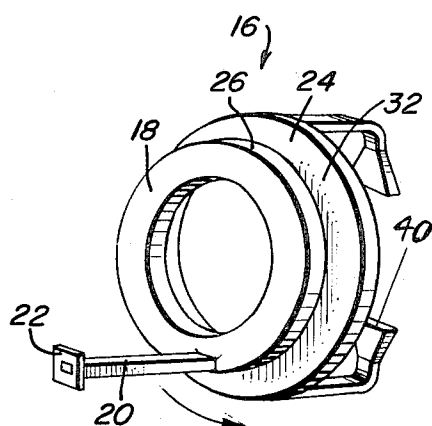


Fig. 3



SHEET 2 OF 2

Fig. 2

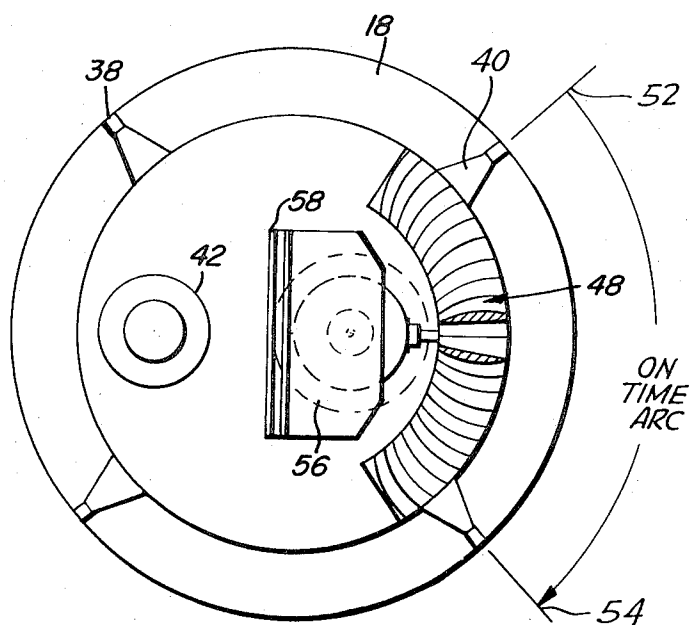
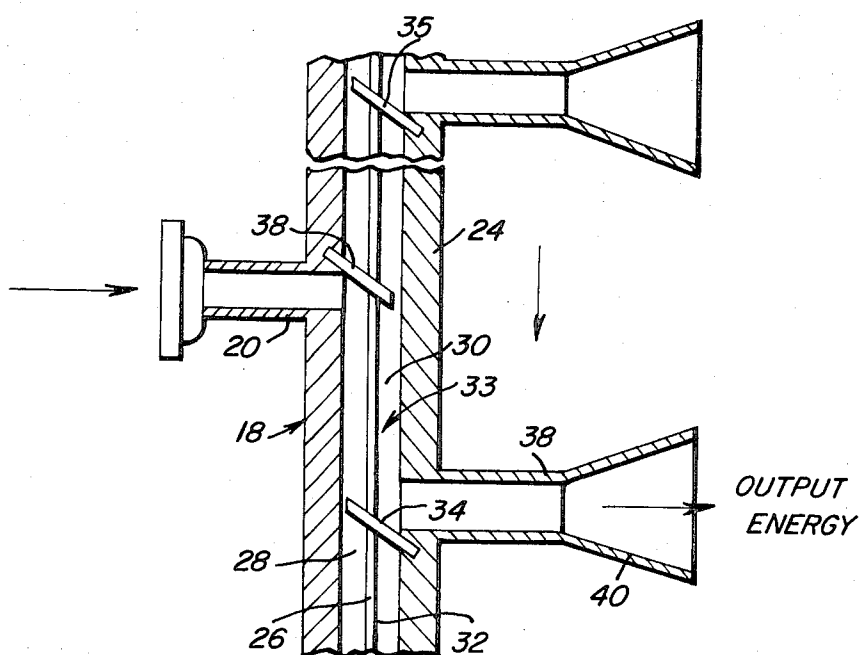


Fig . 4



SCHWARZCHILD RADAR ANTENNA UTILIZING A RING SWITCH FOR GENERATING A SECTOR SCAN

RIGHTS OF THE GOVERNMENT

The invention described herein may be manufactured, used, and licensed by or for the United States Government for governmental purposes without the payment to us of any royalty thereon.

FIELD OF THE INVENTION

The present invention relates to a Cassegrain Antenna, and more particularly to a Schwarzschild Antenna capable of selectively generating a relatively wide angle unidirectional sector scan or a conical scan.

BRIEF DESCRIPTION OF THE PRIOR ART

The prior art relating to microwave antennas includes a structure known as a Cassegrain Antenna which is comprised of coaxial paraboloid-hyperboloid reflectors. The Cassegrain has met with wide acceptance because its structure eliminates the need for mounting a heavy feed radiator far in front of the main reflector of the antenna. An improvement of the Cassegrain came with the discovery of an antenna structure known as the Schwarzschild Antenna which is basically a modified Cassegrain with reflectors shaped to form an aplanatic system. As those of skill in the art know, the aplanatic Schwarzschild meets the Abbe sine condition and evidences superior off-axis microwave focusing capability, when compared with the older, conventional Cassegrain. Although the Schwarzschild Antenna has been designed to operate in the conical scanning mode, there has not been a satisfactory design, heretofore capable of effecting rapid switching between this mode and a sectoral scan mode in one antenna assembly.

Therefore, in conventional radar systems where relatively wide angle unidirectional sector scanning is required along with conical scanning or monopulse tracking, a relatively complicated antenna structure becomes necessary. A result of this complexity is that there is a decrease in performance characteristics and flexibility.

BRIEF DESCRIPTION OF THE PRESENT INVENTION

The present invention is directed to a Schwarzschild Antenna which cooperates with a ring switch for transmitting, to the far field, a relatively wide angle sector scan. The switch is comprised of two relatively rotatable bodies that resemble concentric, axially juxtaposed donuts with waveguide channels formed therein. The radially positioned feed horns communicate with the waveguide channel and produce a sector scan during operation of the ring switch. This sector scan is reflected from a centrally located mirror reflector, which in turn transmits the sector scan to the main and subreflectors of the Schwarzschild Antenna. The result is a generation of a relatively wide angle sector scan in the far field.

The mirror reflector mentioned is hingedly mounted so that it may be rotated to a non-operating position. In this mode of operation, the r.f. operation of the ring switch is deenergized and instead, a conical scanner is energized. The generated conical scan is transmitted

directly through an aperture formed in the main reflector of the antenna. After subsequent reflection between the main and subreflectors of the antenna, a conical scan is generated in the far field. A reciprocal situation exists during operation of the antenna system during receive.

BRIEF DESCRIPTION OF THE FIGURES

FIG. 1 is a side elevational view of the present invention illustrating a unidirectional sector scan apparatus and a conical scan apparatus.

FIG. 2 is a side elevational view taken along a plane passing through section line 2—2 of FIG. 1.

FIG. 3 is a perspective view of a donut ring switch as employed in the present invention.

FIG. 4 is a partial developed view of the ring switch shown in FIG. 3.

DETAILED DESCRIPTION OF THE INVENTION

Referring to the figures, and more particularly FIG. 1 thereof, a side elevational view of the present antenna system is illustrated. A subreflector 10 is shown to be in radially spaced relation to a larger main reflector 12. A rectangular aperture 14 is centrally formed in the main reflector 12. A ring switch that generates a sector scan is generally indicated by reference numeral 16, and is shown to be positioned behind the aperture 14.

FIG. 3 more particularly illustrated the mechanical structure of the ring switch. A first stationary ring or hub, that is donut shaped, is denoted by 18. This ring permits the introduction of microwave energy to an interiorly formed annular waveguide through a waveguide pipe section 20 that has an inlet fitting 22. The interior structure of the switch 16 will be discussed. The stationary ring 18 cooperates with a rotating donut-shaped ring 24 that also has an interiorly formed annular waveguide groove. The interface surface of ring 18 is indicated by 26, while the interface surface of ring 24 is denoted by 32.

As evidenced by FIG. 4, the interface surface 26 of the stationary ring 18 has an annular groove 28 formed therein. Similarly, the interface surface 32 of the rotating ring 24 has an annular groove 30 formed therein. The annular grooves 28 and 30 are disposed in concentric registry to form a closed channel or waveguide generally indicated by reference numeral 33. When microwave energy is fed to the waveguide 33 through waveguide portion 20, it impinges upon a miter 38 that causes the microwave energy to be reflected 90°. The miter 38 is embedded in the body of the stationary ring 18 at an angle of 45°. The reflected energy travels downwardly along the length of the waveguide 33 until it impinges against a second miter 34 that is embedded in the body of the rotatable ring 24 at an angle of 45°. The latter mentioned miter 34 is adjacent the inlet of a short waveguide portion 38 that communicates with an outwardly flared pyramidal horn 40. Thus, when the energy traveling down waveguide 33 impinges against the miter 34, the energy is reflected 90° so that it may enter the waveguide 38 for subsequent transmission through the feed horn 40 when the antenna system operates as a transmitter.

The miters 34 and 38 have comb-like structures to allow the passage of miters such as 34 past the stationary miter 38. This is necessary because the miters such

as 34 move relative to the stationary miter 38 since the miters 34 are mounted on a rotatable ring.

In operation of the ring switch as shown developed in FIG. 4, as the upper illustrated miter 35 passes through the miter 38, microwave energy fed through the waveguide 20 will immediately begin communicating with the feed horn associated with the miter 35. As soon as this happens, no further output energy will be developed through the waveguide 38 and its associated horn 40. Accordingly, the utilization of miters insures that only one of the horns 40 will be transmitting energy. It should be noted that if an iris were placed in the center of a waveguide spanning the narrow E-plane dimension, r.f. current would flow on the iris, producing in effect a short circuit. A high VSWR would result, indicating reflection of microwave energy back toward the signal source. The teeth of the miter are somewhat analagous to the iris except that the current flow is between a waveguide wall, via a tooth, to an adjacent wall in an orthogonally placed guide. In this case, energy is not reflected back toward the source, but is propagated around the corner away from the source. If a single tooth (post) 38 is placed in the center of one miter, it would be possible to place two teeth 35, symmetrically disposed about the waveguide center, permitting passage of tooth 38 during operation without actual contact. (The maximum E-field strength for the dominant (TE₁₀) mode is at the center of the H-plane dimension). Thus, satisfactory performance may be obtained with the double-single tooth combination; however additional miter teeth may be symmetrically installed if desired, so long as mechanical operating clearance is maintained.

In order to drive the rotating ring 24, a motor 42, shown in FIGS. 1 and 2, drives a gear 44 that in turn meshes with a ring gear 46 around the internal periphery of the ring switch member 24.

In order to improve the directivity of microwave energy produced from the horns 40 (FIG. 2) during the time interval when the ring switch communicates energy to a particular horn, an arcuate metal plate lens generally indicated by 48 is disposed along an arc that defines the "on-time" of a particular horn 40 during its rotation. Thus, when a particular horn 40 (assuming clockwise rotation, for example) reaches the starting point of the on-time arc as indicated approximately by 52, the horn thereat transmits energy of which the direction is corrected by the metal plate lens 48. As the ring 24 rotates, the horn communicating with the lens will continue to deliver a constant level of microwave energy to the lens until it reaches the cut off point, at the end of the on-time arc, as indicated approximately by 54. The phases of the wavelets of the microwave energy as they exit from the side of the lens opposite the juxtaposed horn (40) are such that the combined new phase front will be directed (after subsequent reflection) to a point at the center of the subreflector. While the illustration shows approximately 2 1/2 lens channels illuminated, investigations have shown that six, or even more, channels may be illuminated by the horn at any position, a desirable condition to minimize scan cogging.

Attention must be paid to providing a primary beamwidth that adequately illuminates the subreflector for all on-time positions of horn 40.

The width of lens orthogonal to scan direction determines primary beamwidth in one plane. The beam-

width in the scan direction is controlled by the aperture of the several active lens channels combined. Generally larger apertures provide narrower beamwidths and smaller apertures provide broader beamwidths illuminating the subreflector.

The metal plate lens 48 can be constructed so that it is comprised of a plurality of individual plate members 50 that have varying E-plane (scan direction) spaces therebetween or varying path lengths as illustrated, by convolutions in E- or H-plane, to create the focusing effect. An alternate design for this lens is a dielectric lens (not shown) that achieves the same directivity results. In the case of dielectric lenses, rather than varying spaces between individual metal plate members, individual dielectric blocks are installed that have varying lengths or varying refractive indices to achieve proper phasing. (The appearance of such a lens is similar in configuration to that of FIG. 2 except that the sides of the blocks may be straight or curved.)

In all cases the lens exit arc should be arranged to coincide with the Schwarzschild focal arc.

Referring to FIG. 1, the sector scan energy transmitted by the ring switch 16 is directed from the upper illustrated horn 40, through the lens 48, to a hinged mounted rotatable mirror 56. The hinge connection is shown at 58. As the sector scan energy passes through the lens 48, it impinges upon the mirror 56 and is reflected therefrom through the rectangular aperture 14 formed in the main reflector 12. Thereafter, the subreflector 10 and the main reflector 12 operate upon the sector scan energy in the conventional manner for transmission of the sector scan beam to the far field. In effect, the lens provides a directive point source moving through the focal arc which is translated to a high gain pencil, oval or fan beam, scanning in the far field.

The reciprocal situation occurs when the antenna system operates in receive.

An advantage of the present invention resides in the rapid switching capability that permits the selection of either conical scanning or unidirectional sector scanning while both scanners are rotating at speed. To achieve conical scanning, the mirror 56 is pivoted clockwise (FIG. 1) so that it clears the aperture 14. Simultaneous with the switching of mirror position, microwave energy is switches off in the channel leading to horn 40 and on in the channel leading to horn 60. The horn 60, nutating at or near the principal focus of the reflectors, emits a steady flow of microwave energy which causes the generation of a conical scan in the far field, via the subreflector and main reflector, 10 and 12, respectively. The motor scanner 62 drives the horn 60 in its nutating manner while a waveguide 64 delivers microwave energy to the motor scanner 62 through a conventional double-throw waveguide switch 66. The latter waveguide switch has two output ports so that it can selectively communicate microwave energy to either the ring switch 16 or the motor scanner (conical scan) 62. To return to sector scan mode, the procedure is essentially reversed, both motors being up to speed.

As an additional design consideration, reference is made to FIG. 4. Although an interface slot or clearance is illustrated in the center of narrow wall waveguide 33 it is possible to locate the interface slots in the waveguide corners between the rings 18 and 24. Further, in order to prevent energy leakage, chokes are formed

5

around the interface slots. The microwave chokes are one-fourth wavelength deep grooves running concentric to the annular waveguide 33. Two chokes should be provided, one at the inner perimeter and one at the outer perimeter of the annular guide.

In order to simplify the explanation of the ring switch, FIG. 4 is shown to have the interface slot centered in waveguide 33.

It should be understood that the invention is not limited to the exact details of construction shown and described herein for obvious modifications will occur to persons skilled in the art.

Wherefore, we claim the following:

1. A Schwarzschild Antenna having main and subreflectors, the antenna being capable of generating a high-gain, unidirectional sector-scanning beam by apparatus comprising:
 - a stationary ring having a microwave energy input therein;
 - waveguide means formed in the stationary ring for transmitting microwave energy to a mating rotating ring that has waveguide means formed therein;
 - horn means mounted to the rotating ring for directing communicated microwave energy from the waveguide means of the rotating ring along a radially inward spacial direction during traversal of the horn means through a preselected arc thereby generating a unidirectional sector scan beam; and
 - means for reflecting the generated unidirectional sector scan beam to the far field via the main and subreflectors, during transmission.
2. The subject matter of claim 1 together with means for generating a conical scan beam when the sector scanner microwave propagation is de-energized, and further wherein the reflecting means is rotationally repositioned to permit direct microwave energy communication from the conical scanner means to the far field, via the main and subreflectors.
3. The subject matter of claim 1 together with means for driving the rotating ring in rotation about an axis

6

concentric with the center of the stationary ring.

4. The subject matter of claim 1 wherein both mentioned waveguide means include cooperating miter means therein to direct input energy through the horn means only when the horn means traverses the preselected arc.

5. The subject matter of claim 4 wherein the miter means comprises a first miter that is stationarily positioned in the waveguide means of the stationary ring; and

further wherein the miter means includes at least one miter stationarily positioned in the waveguide means formed in the rotating means;

the miters of the stationary and rotating rings having means formed therein to allow the miter in the rotating ring to freely pass the miter in the stationary ring as the former rotates.

6. The structure of claim 5 wherein the miters are comb-like structures with offset teeth that permit said free passage.

7. The subject matter of claim 5 wherein the horn means comprises two or more feed horns;

each feed horn having a miter associated therewith, the associated miter being positioned in the waveguide means of the rotating ring at a point adjacent a communicating connection point of a respective horn.

8. The structure defined in claim 1 together with a microwave lens positioned along the preselected arc to provide the directivity of the primary energy of the produced sector scan.

9. The structure set forth in claim 2 wherein the reflecting means is pivotally mounted to the antenna to permit its rotational switching between the positions respectively associated with the unidirectional sector scan and the conical scan.

10. The apparatus defined in claim 1 wherein the horn means are characterized by an output flare that is pyramidal in shape.

* * * * *

45

50

55

60

65