NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. 20546

MAR 7 1975

REPLY TO
ATTN OF: GP

TO: KSI/Scientific & Technical Information Division
Attn: Miss Winnie M. Morgan

FROM: GP/Office of Assistant General
Counsel for Patent Matters

SUBJECT: Announcement of NASA-Owned U.S. Patents in STAR

In accordance with the procedures agreed upon by Code GP and Code KSI, the attached NASA-owned U.S. Patent is being forwarded for abstracting and announcement in NASA STAR.

The following information is provided:

U.S. Patent No. : 3,866,233

Government or Corporate Employee : U.S. Government

Supplementary Corporate Source (if applicable) :

NASA Patent Case No. : GSC-11,760-1/11,783-1

NOTE - If this patent covers an invention made by a corporate employee of a NASA Contractor, the following is applicable:

YES ☐ NO ☒

Pursuant to Section 305(a) of the National Aeronautics and Space Act, the name of the Administrator of NASA appears on the first page of the patent; however, the name of the actual inventor (author) appears at the heading of column No. 1 of the Specification, following the words "...with respect to an invention of ..."

Bonnie L. Woerner

Bonnie L. Woerner
Enclosure

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(NASA-Case-GSC-11760-1) DISH ANTENNA HAVING SWITCHABLE BEAMWIDTH Patent (NASA) 9 p CSCL 09E
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United States Patent [19]
Schmidt

[11] **3,866,233**
[45] **Feb. 11, 1975**

[54] **DISH ANTENNA HAVING SWITCHABLE BEAMWIDTH**

[75] Inventor: **Richard F. Schmidt**, Seabrook, Md.

[73] Assignee: **The United States of America as represented by the National Aeronautic and Space Administration**

[22] Filed: **Sept. 10, 1973**

[21] Appl. No.: **395,868**

[52] **U.S. Cl.** **343/761**, 343/781, 343/837
[51] **Int. Cl.** **H01q 19/14**
[58] **Field of Search** 343/779, 781, 840, 761, 343/837

[56] **References Cited**

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Primary Examiner—Eli Lieberman
Attorney, Agent, or Firm—Robert F. Kempf; John R. Manning

[57] **ABSTRACT**

A switchable beamwidth antenna includes a concave parabolic main reflecting dish which has a central circular region and a surrounding coaxial annular region. A feed means selectively excites only the central region of the main dish via a truncated subreflector for wide beamwidth or substantially the entire main dish for narrow beamwidth. In one embodiment, the feed means comprises a truncated concave ellipsoid subreflector and separate feed terminations located at two foci of the ellipsoid. One feed termination directly views all of the main dish while the other feed termination, exciting the main dish via the subreflector, excites only the central region because of the subreflector truncation. In the another embodiment, the feed means comprises one feed termination and a convex hyperboloid subreflector via which the feed excites the main dish. The subreflector has a fixed central region via which the feed termination excites the central region of the main reflector and a retractable surrounding annular region via which the feed termination excites the annular region of the main reflector. Beamwidth switching is effected by retracting the annular region to truncate the subreflector.

7 Claims, 10 Drawing Figures

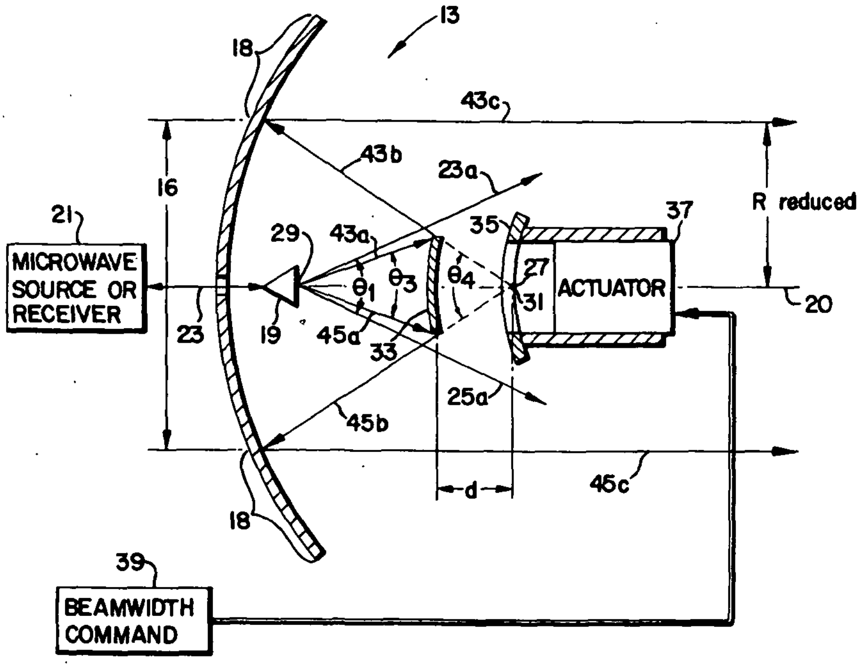


FIG. 1

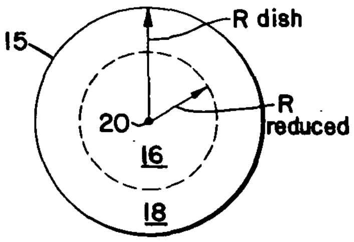
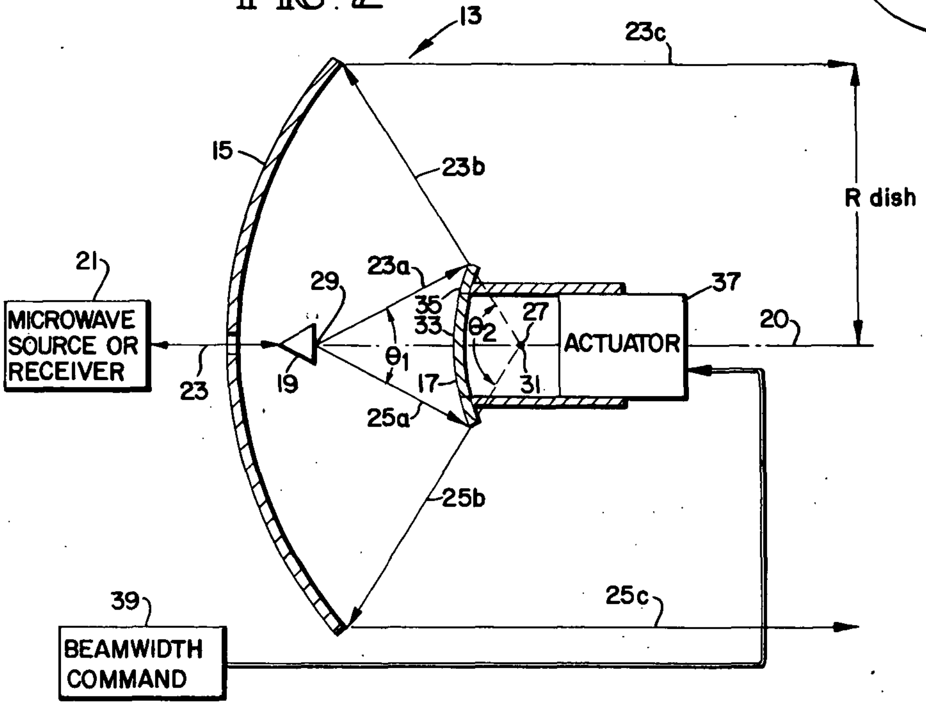


FIG. 2



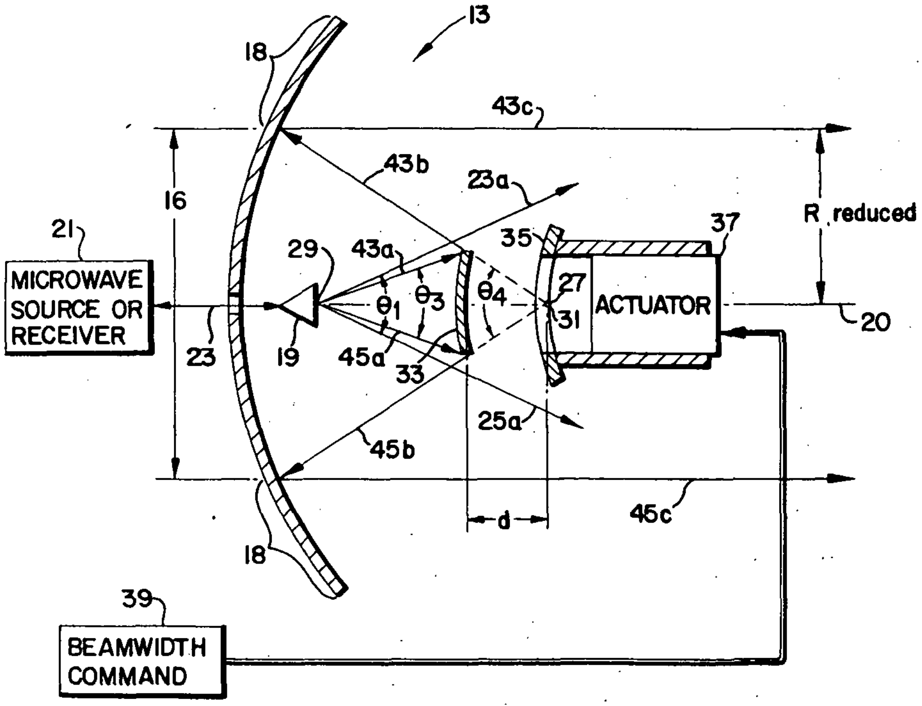


FIG. 3

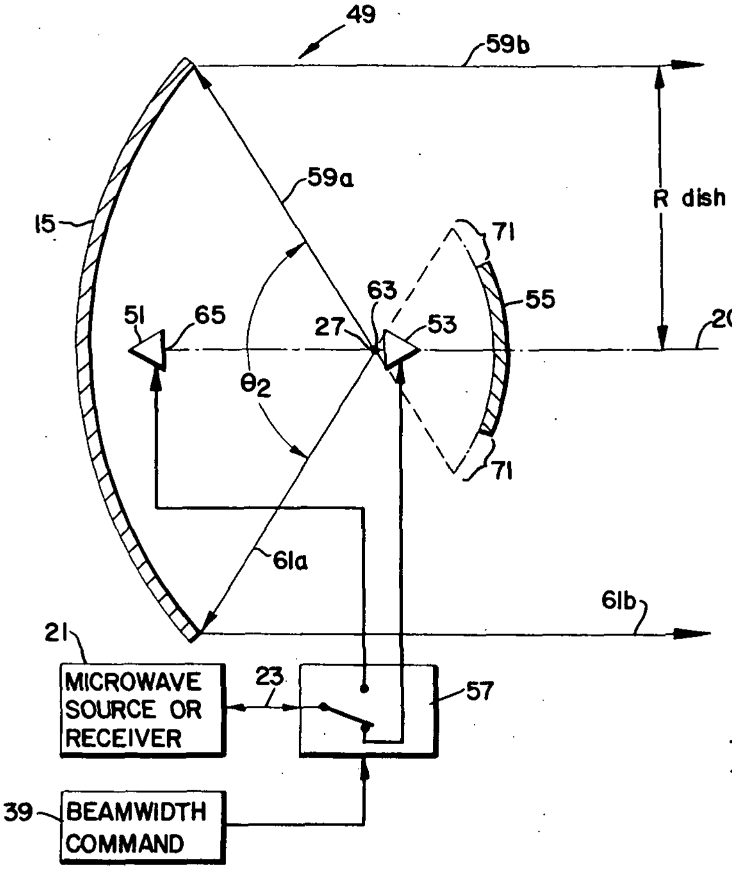

49
59b
59a
R dish
15
71
63
55
51
65
27
53
20
θ2
71
61a
61b
21
MICROWAVE SOURCE OR RECEIVER
23
57
39
BEAMWIDTH COMMAND

FIG. 4

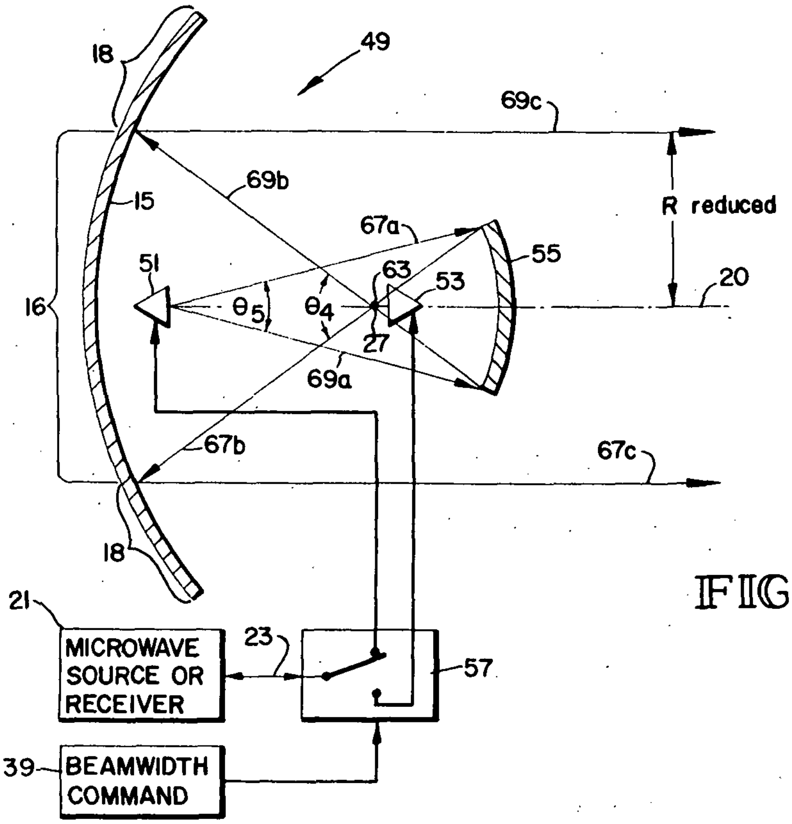

18
49
69c
R reduced
69b
15
67a
55
51
63
53
20
16
θ5
θ4
27
69a
67b
67c
18
21
MICROWAVE SOURCE OR RECEIVER
23
57
39
BEAMWIDTH COMMAND

FIG. 5

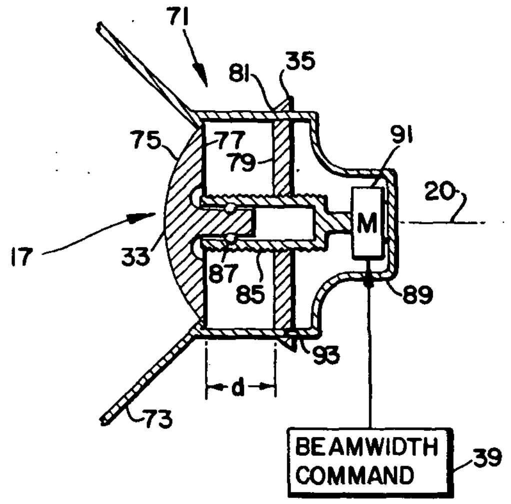


FIG. 6

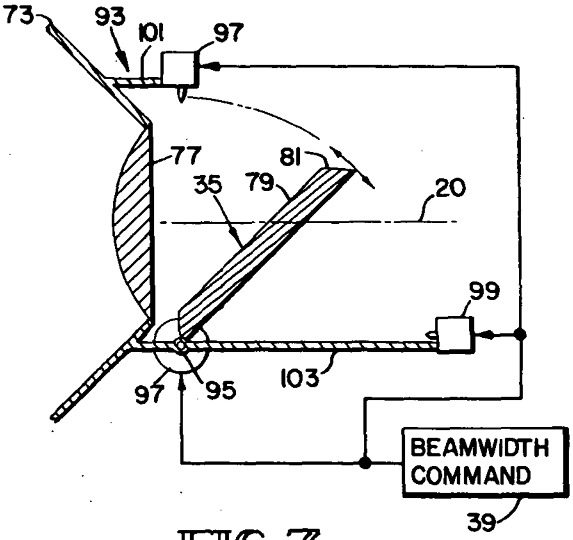


FIG. 7

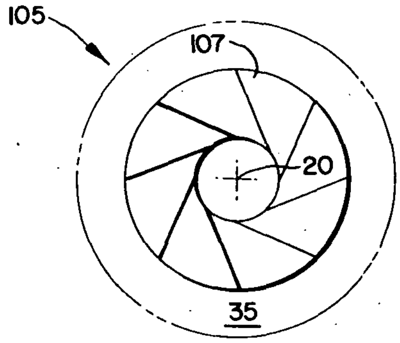


FIG. 8

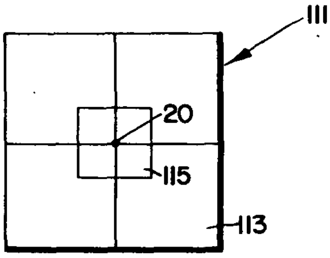
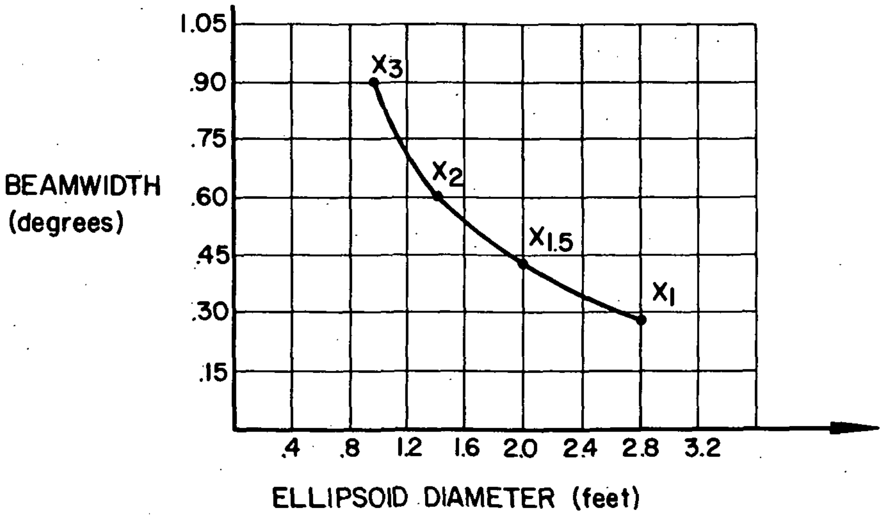


FIG. 10

FIG. 9



DISH ANTENNA HAVING SWITCHABLE BEAMWIDTH

ORIGIN OF THE INVENTION

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

FIELD OF THE INVENTION

The invention relates generally to switchable beamwidth or zoomable antennas and more particularly to a switchable beamwidth antenna employing a common main reflecting dish operable in at least two different beamwidth modes.

BACKGROUND OF THE INVENTION

The need frequently arises to augment narrow beamwidth (narrow field of view) transmitting and/or receiving antennas with a wide beamwidth "acquisition" mode. Since it is well known that antennas are reciprocal, having the same characteristics for transmitting as for receiving, the meaning of "acquisition" shall be detailed with respect to a receiving antenna with the understanding that "acquisition" for narrow beamwidth transmitting antennas and for narrow beamwidth transmitting/receiving antennas such as a radar, is substantially similar.

In the case of a narrow beamwidth (also referred to as "high antenna gain") receiving antenna there is great difficulty in pointing the antenna's narrow field of view in the direction of a transmitting station which must be done in order for the antenna to receive. If, at the sacrifice of antenna gain or efficiency, the antenna is initially switched to a wide field of view (wide beamwidth), the antenna is more easily pointed to subtend the transmitting station in the wide field of view. Then, an indication of pointing error may be derived by simultaneous lobing techniques, for example, to more precisely point the antenna. Once the antenna is pointed so that the transmitting station would be in its narrow field of view, "acquisition" is said to have occurred and the antenna may be switched to its narrow beamwidth mode to take advantage of greater antenna gain or efficiency. This narrow beamwidth may then be maintained, subtending the transmitting station (or "tracking") by simultaneous lobing techniques. Similar acquisition may be done to point a radar antenna at a target or a transmitting antenna at a receiving station.

The acquisition problem is particularly acute for narrow beamwidth antennas having large main reflector dishes of the type considered by the National Aeronautics and Space Administration for Tracking and Date Relay Satellites to relay to earth the data collected from orbiting earth observation satellites. These antennas, operating at 15 Gigahertz, would have a main dish on the order of 17.5 feet in diameter with a consequent narrow beamwidth of only 0.3°. Initial pointing of the narrow beamwidth antenna of the Data Relay Satellite toward an Earth Observation Satellite would be quite difficult to achieve because of significant relative motion between these satellites. Thus, a means for increasing the beamwidth of the antenna to effect "acquisition" is required.

Numerous techniques were considered and found to be unsatisfactory.

In one technique either a feed or a subreflector is axially shifted in position to defocus the antenna. This technique is not acceptable because, though the beamwidth is generally widened, the antenna pattern amplitude and phase characteristics are distorted. In another technique, a polarization sensitive grating is placed in front of the main dish to serve as a smaller main dish for a wide beamwidth mode. This grating, though smaller than the dish, is sufficiently forward to intercept all radiation coming from a feed. The grating passes, for example, vertically polarized radiation to the main dish, producing a narrow beamwidth but reflects horizontal polarization producing wider beamwidth. Thus, beamwidth can be switched by switching feed polarization. This technique suffers from restrictions on feed polarization; in particular, it does not permit the use of circular polarization which has both horizontal and vertical polarization components.

Another technique for increasing the beamwidth of the antenna is to change the frequency of operation. Since beamwidth is inversely proportional to the area of the main dish measured in wavelengths, the beamwidth may be decreased by decreasing frequency (increasing wavelength). This is an undesirable antenna system complication for satellite users which may also necessitate additional antenna feeds and consequent increased blockage of the satellite main dish, which causes a decreased antenna gain or efficientcy of the antenna. Moreover, it is desirable to interface with existing user single frequency equipment.

Still another technique for increasing beamwidth is to provide two feeds at one feed point with one feed exciting the entire main reflector for narrow beamwidth and a second feed exciting a smaller region of the main reflector for wide beamwidth. There are many difficulties with this approach the chief one being that if the second feed is to be sufficiently directive to excite only a portion of the main reflector, it would have to be geometrically large; such a large feed would significantly increase blockage of the main dish reflector decreasing antenna gain or efficiency. Furthermore, there are obvious difficulties in placing two feeds at the same point; the second feed must be displaced from the antenna axis if the first feed is located on the axis. It is desirable to have the capability of positioning the feed or feeds in both wide and narrow beamwidth modes on the axis of the antenna.

OBJECTS OF THE INVENTION

It is an object of the present invention to provide a new and improved switchable beamwidth antenna in which beamwidth switching is independent of feed polarization, feed directivity, or feed frequency.

It is a further object of the present invention to provide a new and improved switchable beamwidth antenna employing a main reflecting dish and feed therefor with a narrow beamwidth mode and a wide beamwidth acquisition mode wherein the feed or feeds in both modes can excite the main reflecting dish from the antenna axis.

It is yet a further object of the present invention to provide a new and improved switchable beamwidth antenna allowing flexibility in feed design, for example, permitting the use of electronically or mechanically scanned feed arrays for scanning the viewing direction of the antenna.

SUMMARY OF THE INVENTION

The present invention includes a switchable beamwidth antenna having a main reflecting concave parabolic dish and feed means effectively at a focal point on the dish boresight axis. Since the beamwidth of an antenna of this type is inversely proportional to the main dish area, the beamwidth can be increased by operatively using only a portion of the main dish. For wide beamwidth operation, the feed means excites only a central circular region of the main dish via a truncated subreflector while for the narrow beamwidth mode the entire dish is excited by the feed.

The invention has two main embodiments.

In the first embodiment a Cassegrain configuration is provided by a convex hyperbolic subreflector having an outer annular region that is selectively translated along the main dish boresight axis to excite different areas of the main dish in response to excitation from a single feed also located on the boresight axis of the main dish. The outer annular region is translated to an "out of focus" position in the wide beamwidth mode so that only a central circular region of the subreflector is operable for exciting the main dish. Since there is a substantially one to one mapping between the radiation on the subreflector and radiation on the main reflector, the feed cannot view the outer annular region of the main dish. Under such conditions it is said that the subreflector is "truncated." Hence only the central region of the main dish is effectively operative and the beamwidth of the antenna is consequently increased. Thus in the first embodiment, beamwidth switching is accomplished by mechanically truncating the subreflector.

In a second embodiment, electrical beam switching attained by providing a Gregorian configuration wherein a truncated concave ellipsoid subreflector has a major axis located on the boresight axis of the parabolic dish. The ellipsoid subreflector has two foci in front of the subreflector, whereby the subreflector focus nearest the subreflector is coincident with the focus of the main dish. A separate feed is provided at each subreflector focus and may be selectively activated to provide beam switching. A first feed, located at the main dish focal point, faces the main dish and excites its entire surface. The second feed, located at the focus of the ellipsoid furthest from the subreflector, faces the subreflector and excites the main dish via the subreflector. The ellipsoid has the characteristic that a real image of the second feed is formed at its nearer focus whereby, to the main dish, the second feed also appears to be at the focus of the main dish. Because of the effective truncation or reduction in size of the ellipsoid subreflector, the second feed excites only a central region of the main dish via the subreflector.

The above and still further objects, features, and advantages of the present invention will become apparent upon consideration of the following detailed description of several specific embodiments thereof, especially where taken in conjunction with the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a front view of a main dish of the antenna.

FIG. 2 is a schematic drawing in cross-section of a first embodiment of the switchable beamwidth antenna having a main dish and a partially retractable subreflector wherein the antenna is shown in the narrow beamwidth mode;

FIG. 3 is similar to FIG. 2, but with the antenna in the wide beamwidth mode;

FIG. 4 is a schematic drawing in cross-section of a second embodiment of the switchable beamwidth antenna having a main dish and a truncated subreflector, wherein the antenna is shown in the narrow beamwidth mode;

FIG. 5 is a schematic illustration of the second embodiment of FIG. 4 in the wide beamwidth mode;

FIG. 6 is a schematic drawing in cross-section of a first embodiment for partially retracting the subreflector of FIGS. 2 and 3;

FIG. 7 is a schematic drawing in cross-section of a second embodiment for partially retracting the subreflector of FIGS. 2 and 3;

FIG. 8 is a schematic drawing in front view of a third embodiment for partially retracting the subreflector of FIGS. 2 and 3;

FIG. 9 is a design graph indicating the antenna beamwidth for the second embodiment of the switchable beamwidth antenna in the wide beamwidth mode of FIG. 5, versus the subreflector diameter (or degree of truncation); and

FIG. 10 is a schematic drawing in front view of a multi-frequency feed.

DETAILED DESCRIPTION OF THE INVENTION

In FIG. 1, the front view of a main dish 15 of an antenna is illustrated as being divided by an imaginary circle into a central circular region 16 and a surrounding annular region 18. The inventive beamwidth switching antenna embodiments take advantage of the realization that there is substantially a one to one mapping between radiation on a subreflector and radiation on the main dish 15. If a feed excites, i.e., views or illuminates, the entire main dish 15, a narrow beamwidth is produced, while if the feed excites only the central region 16, a wide beamwidth pattern is derived. In order for a feed which is not highly directive to excite only the central region 16, the feed excites the main reflector via a subreflector. In particular, this subreflector must be truncated or reduced in size with respect to what its size would be in the usual antenna configuration. The truncated subreflector can be achieved by effectively removing an outer annular region which would ordinarily be responsive to the radiation that maps into the outer annular region 18 of the subreflector 15.

Referring to FIGS. 2–5, the inventive beamwidth switching antenna embodiments will be described primarily by utilizing the principles of geometric optics for ease of understanding. It should be understood that geometric optics provide only an approximation and that the more complex, more comprehensive principles of diffraction theory must be occasionally referred to in order to fully describe the invention. It should also be noted that antennas are reciprocal devices having the same beamwidth characteristics for reception and transmission. The description shall, for convenience only, primarily describe the antenna of the invention as a transmitting device, but it is to be understood that the term excitation refers to either receiving or transmitting, as is the usual practice of the art.

In FIGS. 2 and 3 there is illustrated a relatively large reflecting concave paraboloid dish 15, a smaller convex hyperboloid subreflector, and a feed 19 in Cassegrain configuration. The main dish **15**, subreflector **17**, and feed **19** are coaxial with antenna boresight axis **20**, with subreflector **17** facing main dish **15** while feed **19** faces the subreflector. The feed **19**, supplied with microwave radiation from source **21** via a conduit or waveguide **23**, illuminates subreflector **17** with a cone of radiations bounded by rays **23***a* and **25***a*; the cone optimally subtends an angle θ_1 to just illuminate the entire subreflector. This cone of radiation is reflected by subreflector **17** toward the main dish **15**. Due to the convexity of the main subreflector **17**, the reflected cone bounded by rays **23***b* and **25***b*, which impinge the main reflector **15**, has an included angle θ_2 greater than θ_1; this greater included angle should optimally just subtend the main dish. Rays **23***c* and **25***c* define the cone of radiation reflected from main dish **15** and transmitted down boresight axis **20**. The included angle of this finally transmitted cone of radiation or beam is zero, relative to boresight axis **20**, the transmitted rays **23***c* and **25***c* being parallel by geometric optic principles. Paraboloid main dish **15** has a focal point **27** on axis **20** behind the subreflector **17**, whereby if dish **15** were illuminated directly from this point, rays **23***c* and **25***c* would be parallel. Hyperboloid subreflector **17** has two foci, one focus **29** in front of the subreflector and one focus **31** in back. Back focus **31** is located at the parabola focal point **27**, whereby the radiation from the feed **19** appears to come from the back focal point to produce collimated or parallel antenna output radiation. (If the back focus **31** were not located at the main dish focal point **27**, deep nulls would be present in the antenna pattern because of defocusing.) Thus, a virtual image of feed **19** is formed by the subreflector **17** at the main dish focal point **27**.

Although the output radiation appears parallel by geometric optical principles, in fact, the exit beam actually diverges due to diffraction. The beamwidth angle of this exit beam is inversely proportional to the radius of the main dish **15** measured in wavelengths at the operating frequency of the antenna.

The subreflector **17** is partitioned into a fixed central circular region **33**, coaxial with axis **20**, and a retractable annular region **35** coaxially surrounding the central region. In response to a beamwidth command signal **39**, linear actuator **37** axially moves the annular region **35** a distance "*d*" to an out of focus position, preferably in back of the fixed central region **33**. This movement effects a broadening of the beamwidth of antenna **18**. Radiation within a reduced angle θ_3 of the cone of radiation from feed **19** is intercepted by the fixed central region **33**. The cone of reduced angle, which just subtends the outer boundaries of the subreflector central portion **33** is bounded by rays **43***a* and **45***a*. Reflection of this cone of radiation by the subreflector causes a cone of radiation with included angle θ_4 bounded by rays **43***b* and **45***b* to impinge on the main dish **15** at a reduced radius. The outer annular region **18** of the main reflector is not illuminated. The transmitted beam, bounded by rays **43***c* and **45***c*, appears to have come from a smaller radius dish **15**, i.e., from the central circular region **16** of the main dish. There is thus an increase of beamwidth given by diffraction theory due to a reduction of the apparent area of main dish **15**.

Rays **23***a* and **25***a* which do not strike any part of the subreflector **17** are negligible in the antenna far field because of low feed directivity. Similarly, any rays (not shown) striking the retracted annular region **35** of the subreflector cause diverging or uncollimated rays to be reflected from the main dish. A computer simulation, further discussed infra, has shown the retraction distance "*d*" should be at least four wavelengths to preclude any significant effect of the subreflector retracted annular region **35** on the resultant wide beamwidth antenna pattern.

FIGS. **4** and **5** are cross-sectional illustrations of a second embodiment **49** of the switchable beamwidth antenna of the invention wherein two feeds **51** and **53** and a truncated or reduced size concave ellipsoid subreflector **55**, located on the antenna boresight axis **20**, cooperate with the main reflecting concave paraboloidal dish **15** in a Gregorian configuration. Feed **53** is located at the main dish focal point **27** facing the main dish. In FIG. **4**, source **21** supplies the feed **53** with radio frequency or microwave radiation via conduit **23** and microwave switch **57** in response to a narrow beamwidth command issued to switch **57**. Feed **53** directly illuminates the main dish **15** with a cone of radiation having the included angle θ_2, bounded by rays **59***a* and **61***a*, which optimally just illuminates the entire main dish. Upon reflection of this cone by main dish **15**, a collimated output beam, bounded by rays **59***b* and **61***b*, is produced having an initial large radius, equal to the dish radius, and a corresponding narrow beamwidth given by diffraction theory.

In FIG. **5**, feed **51**, facing the ellipsoidal subreflector **55**, illuminates the main dish via the subreflector to produce a wide beamwidth. The ellipsoidal subreflector has a major axis that is coincident with boresight axis **20**, and on which lie a near focus **63** and a far focus **65** that are positioned between the concave sides of the subreflector and main dish **15**. The subreflector **55** is positioned with its near focus **63** coincident with the main dish focal point **27**, and the feed **51** is positioned at the subreflector far focus **65**. Microwave source **21** supplies energy to feed **51** via conduit **23** and switch **57** in response to a wide beamwidth command issued to the switch **57**. The feed **51** illuminates the subreflector with a cone of radiation having a small included angle, θ_5, which optimally just subtends the subreflector. This cone of radiation is bounded by rays **67***a* and **69***a*. Due to the concavity of the subreflector, the radiation reflected therefrom, defined by rays **67***b* and **69***b*, goes through a focus at the subreflector near focal point **63**. Therefore, a cone of radiation with included angle θ_4 aimed at the main reflector appears to be initiated from the focal point **63**. This cone of radiation strikes the dish **15** at a reduced radius. A reduced radius collimated beam bounded by rays **69***c* and **67***c* is produced because the subreflector is truncated or of too small a size for the feed to illuminate the outer annular region **18** of the main dish. To illuminate the entire main reflector from feed **65** via subreflector **55**, the subreflector would have to be larger by an annular region **71** (shown in FIG. **4**, dashed). Thus, in this second embodiment, beamwidth switching is accomplished by electrically switching microwave excitation from source **21** between feed **53** for wide beamwidth and feed **51** for narrow beamwidth.

Referring next to FIG. **6**, a first embodiment **71** is shown for retracting the outer annular region **35** of the hyperboloid subreflector **17** of FIGS. **2** and **3**. Subreflector **17** is spaced axially from the main dish **15** by a spider or group of struts **73**. Struts **73** hold the fixed central portion 33 of the subreflector and support the mechanism for axially retracting the subreflector's annular region 35. The central portion 33 of the subreflector has a front convex reflecting surface 75 and a back substantially flat surface 77. The retractable, outer annular region 35 has a front flat surface 79, corresponding to the flat surface 77 and a surrounding convex annular region 81 which merges with convex surface 75 in the non-retracted position. A rotary, reversible motor 89 is supported by a cage 91, joined to struts 73. The motor 89, in response to beamwidth command 39, axially moves the central region back surface 77 and the annular region 35 front surface 79 into abutment when there is a narrow beamwidth command, and axially separates these surfaces a distance *d* when there is a wide beamwidth command. This axial movement or translation is effected by a worm 85 driven by the motor at one end, and which is journaled at the other end in bearing 87 at the back surface 77 of the fixed central region 33. Worm 85 is threaded into a hole 95 in the center of annular region 35. To prevent rotation of annular region 35, it is keyed to the cage 91 via holes 93 in the annular region.

FIG. 7 is an illustration of a second embodiment 93 for retracting region 35 wherein region 35 is formed as a metallic hyperbaloidal slice 79 that is hinged for rotation about axis 95, perpendicular to axis 20. Axis 95 is located at an extreme of the annular surface 81. Motor 97 rotates annulus 79 about axis 95 in response to beamwidth command 39. When a narrow beamwidth is commanded, surface 77 and 79 abut; when a broad beamwidth is commanded, these surfaces are preferably separated by 90°. Solenoid actuated catches 97 and 99, supported by extensions 101 and 103 of the struts 73, retain the annulus 79 in the retracted or unretracted position. When a change of beamwidth is commanded, both catches, also responsive to beamwidth command 39, unlock to permit the rotation of plate 79 by motor 97 to the commanded position.

In FIG. 8, still another embodiment 105 is shown for truncating the subreflector 17 wherein region 35 is composed of a metal iris 107. Iris 107 is axially rotated by a motor (not shown) between a retracted position in which the iris, covering a portion of the fixed central region 33, leaves the surrounding annular region 38 vacant, and an extended position where the iris 107 fills the region 38.

With respect to the various techniques shown for truncating the convex subreflector 17 to produce two beamwidth modes, it should be understood that these techniques can be used to further truncate the concave subreflector 55 of FIGS. 4 and 5 to produce three beamwidth modes.

Practical dimensions for the inventive embodiments have been determined in conjunction with a 5 foot focal length, 12.5 foot diameter main parabolic dish 15 for 15 Gigahertz (0.0656 foot wavelength) operation. The narrow beamwidth of such a dish without subreflector truncation is approximately 0.30°. A minimum of 50 percent beamwidth increase is desired in the wide beamwidth (truncated subreflector) mode.

For the first embodiment, the back focus 27 of hyperboloid subreflector 17 is 0.426 feet in back of the subreflector and its front focus 29 is 1.114 feet in front of the subreflector. Prior to truncation the subreflector 17 is 1.25 feet in diameter, while the fixed central region 33 is 0.65 feet in diameter to achieve a beamwidth of 0.45° in the retracted position. The retraction distance *d* is preferably at least four wavelengths or 0.2624 feet.

For the second embodiment, the near focus 63 of ellipsoid subreflector 55 is 1.25 feet in front of the subreflector, and its further focus 65 is 5.00 feet in front of the subreflector. If the subreflector were not truncated, it would be 2.8 feet in diameter. Truncation of the feed to approximately 2 feet in diameter yields a 50 percent increase in beamwidth.

FIG. 9 is a design curve for the second embodiment with the beamwidth in degrees as ordinate and the diameter of the subreflector 55 as abscissa. As can be seen, a smooth curve is obtained which can yield a multiplication of the beamwidth by a factor up to 3 as the subreflector is truncated. This Gregorian embodiment 49 is particularly attractive because of the instantaneous and reliable nature of the electronic switching of microwave switch 57.

As mentioned earlier, geometric optic principles are approximate in nature and diffraction theory must be resorted to in order to fully describe the invention. The numerical embodiments of the invention were verified using a computer simulation which accounted for the diffraction effects between the subreflector and the main dish and for the diffraction effects at the main dish. The subreflectors were divided up into plural square regions, each having sides of 0.3 wavelengths, and the main dish was also divided into plural square regions having sides of 2 wavelengths. The square regions were considered to be coherence areas. The radiation from a feed with assumed radiation patterns was collected in each square region on the subreflector and a resultant source obtained for each square. The radiation from each of these sources was collected in each square of the main reflector and a second set of sources on the main reflector was thereby obtained. The pattern of far field radiation from these second sources was then calculated to obtain the far field pattern of the antenna with various sized subreflectors. These patterns verified that the design curve of FIG. 9 is indeed a smooth curve.

The simulation also showed that in the Cassegrain embodiment of FIGS. 2 and 3 sharp interference resonances existed if the distance *d* is less than four wavelengths. The resonances then became harmonic and not sharp for distances greater than four wavlengths.

FIG. 10 shows a nested multifrequency feed 111 adapted to be used with the invention. Four large S band horns 113 abut to define a square four feed array centered about axis 20. Nested at the interior corners of the horns 113 are four smaller X-band horns 115 which abut to form a smaller square array centered about axis 20. The antenna of the invention is adaptable to multifrequency operation by using such a nested feed. Also, the square four feed array is adaptable to either amplitude or phase simultaneous lobing or monopulse techniques for determining antenna pointing errors. For simultaneous lobing, it is important that the phase and amplitude of signals received at each of the four horns be equal when the transmitter of the signal is located on axis 20. It is further important that these parameters smoothly vary as the transmitting source departs from the antenna axis by an angle. Computer simulation has verified that these parameters vary smoothly for source angles ranging from zero to well in excess of half the beamwidth.

Having described embodiments of my invention it is clear that numerous modifications of these embodiments are possible within the invention's spirit and scope. Of particular import is the fact that antennas are reciprocal devices useful for transmitting, receiving, or both. It is intended that the invention not be limited except by the following claims which are generic to transmitting and/or receiving antennas.

What is claimed is:

1. A switchable beamwidth antenna having a wide beamwidth state and a narrow beamwidth state at a single predetermined frequency, said beamwith state being responsive to a beamwidth selection command source comprising:

a main reflecting dish having a boresight axis and a direction of view along said axis, wherein said dish may be divided with an imaginary contour coaxial with the boresight axis into a central portion and an outer portion bordering the central portion; and

single frequency means responsive to the beamwidth selection command source, exciting substantially only the central portion of the main dish in the wide beamwidth state, and for exciting both the central and outer portions of the main dish in the narrow beamwidth state, said exciting means including a reducible subreflector defining in the reduced state a truncated subreflector for exciting only the central portion of the main dish so as to achieve the wide beamwidth state.

2. The antenna of claim 1 wherein said exciting means comprises:

a feed positioned to view in the same direction as the main dish;

a subreflector facing the main dish, said subreflector comprising the truncated subreflector which is a fixed reflecting central portion via which the central portion of the main dish is excited by the feed and a retractable outer reflection portion via which the outer central portion of the main dish is excited by the feed only in the narrow beamwidth state; and

means for retracting the outer portion of the subreflector, said means including an actuator responsive to the beamwidth selection command.

3. The antenna of claim 2 wherein said main dish is a concave paraboloid having a focal point in front of the dish; said subreflector is a convex hyperboloid having first and second conjugate foci coaxial with the main dish, and said hyperboloid is located with the first focus at the main dish focal point; said outer retractable portion of said subreflector is annular in shape and continuous with said central portion prior to its retraction; and said subreflector is coaxial with the dish and located at second focus.

4. The antenna of claim 3 wherein said retracting means comprises means for axially moving the outer portion of the subreflector.

5. The antenna of claim 4 wherein said retracting means comprises means for axially moving said subreflector at least four wavelengths at said single frequency.

6. The antenna of claim 3 wherein said retracting means comprises means for rotating the outer portion of the reflector surface about an axis substantially perpendicular to the main dish axis.

7. The antenna of claim 3 wherein said outer portion of said subreflector is an iris annulus having a retracted position overlapping the central portion of the subreflector and wherein said retraction means comprises a motor for axially rotating the iris.

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