

April 2, 1968

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ANTENNA DRIVE MECHANISM

3,376,576

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4 Sheets-Sheet 1

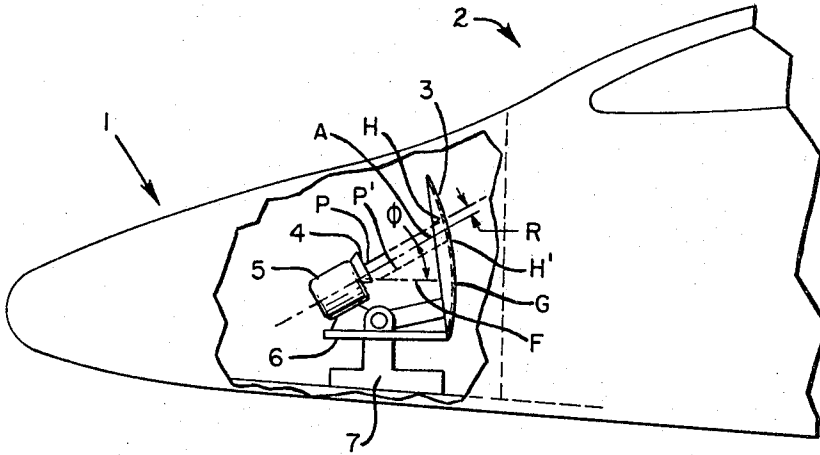


FIG-1

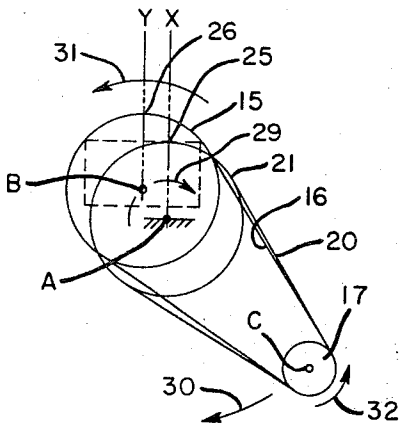


FIG-4

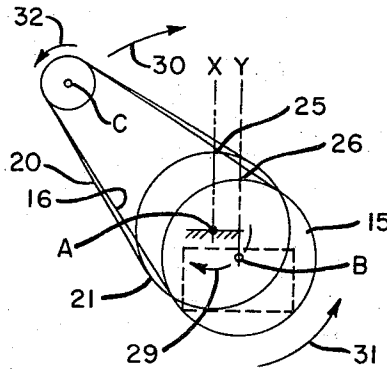


FIG-6

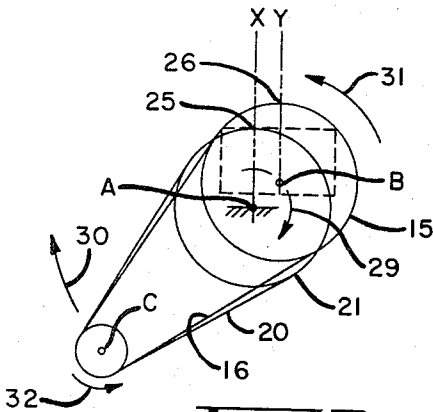


FIG-5

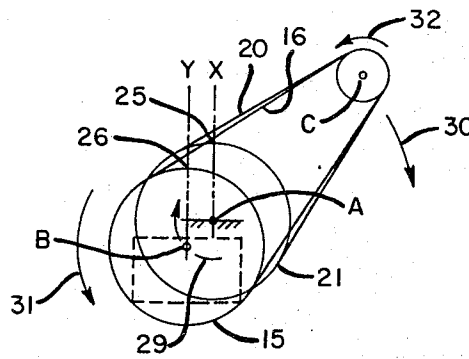


FIG-7

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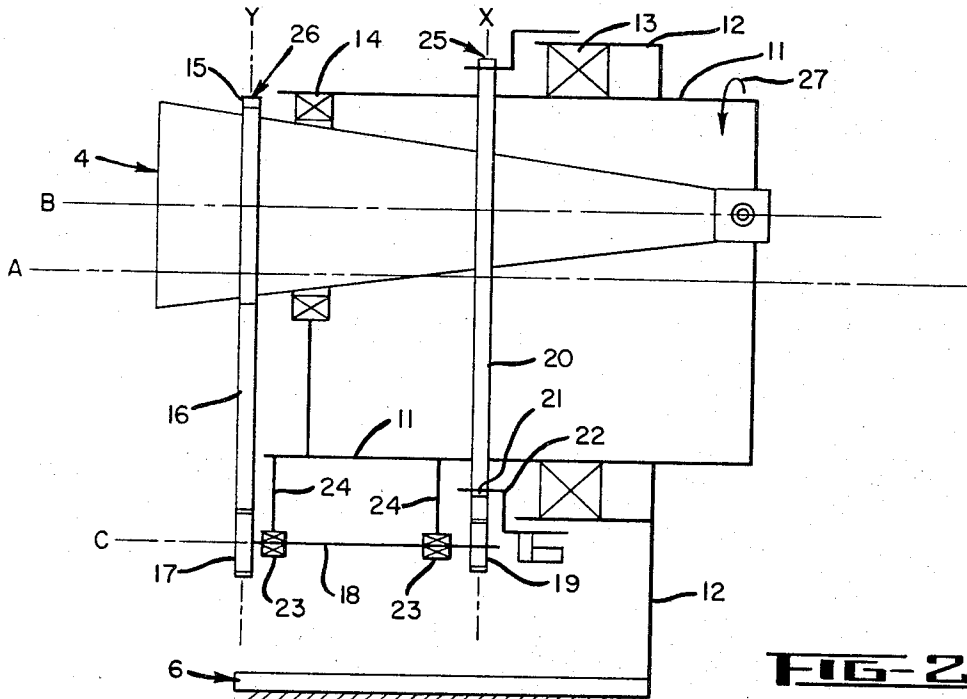


FIG-2

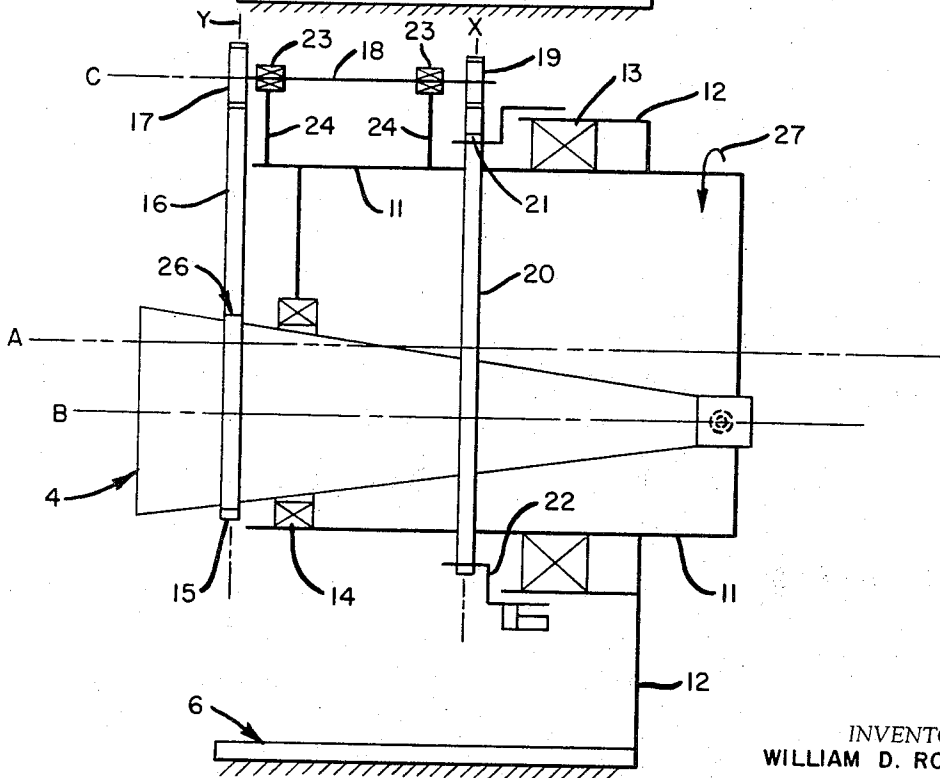


FIG-3

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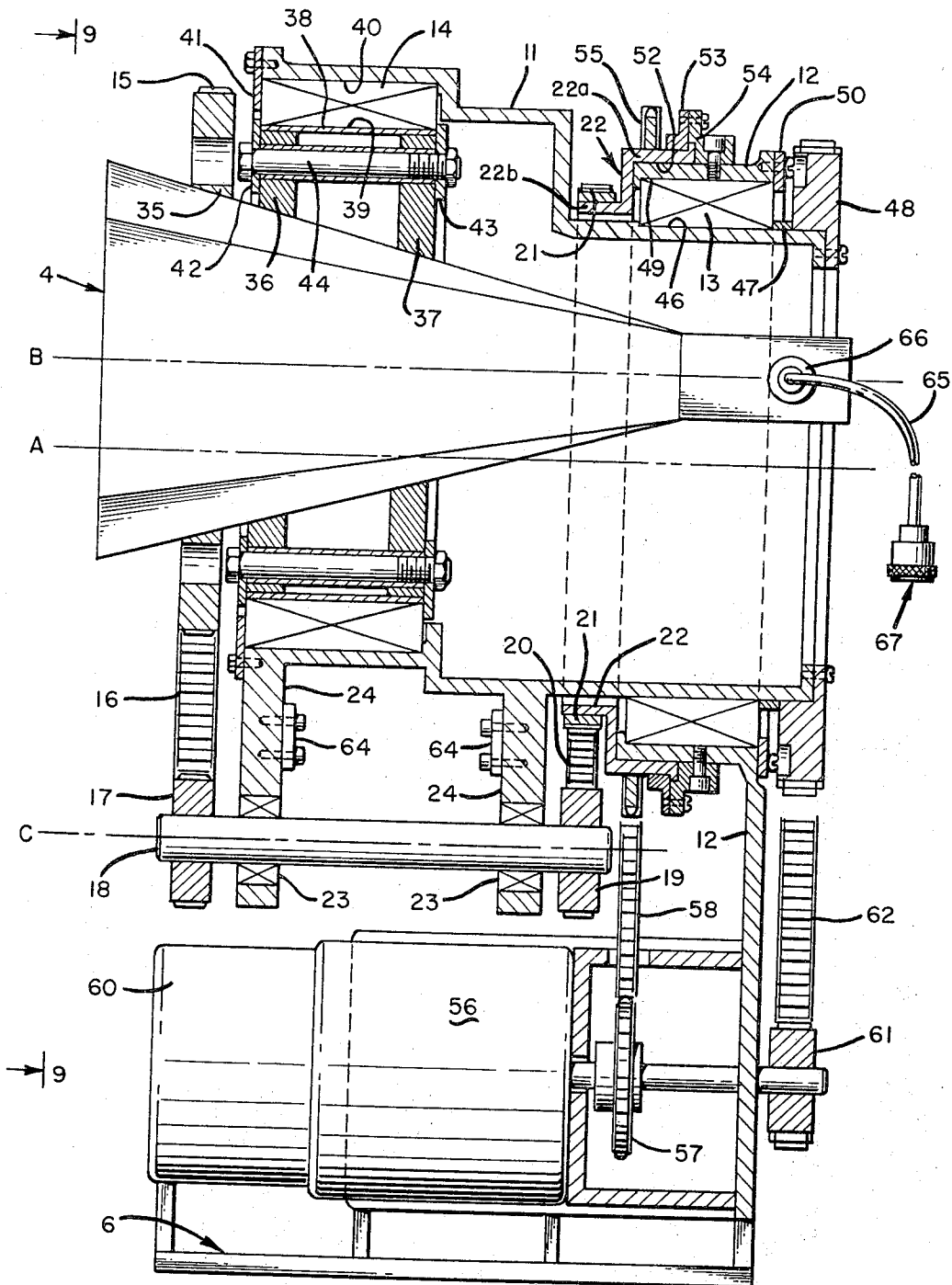


FIG-8

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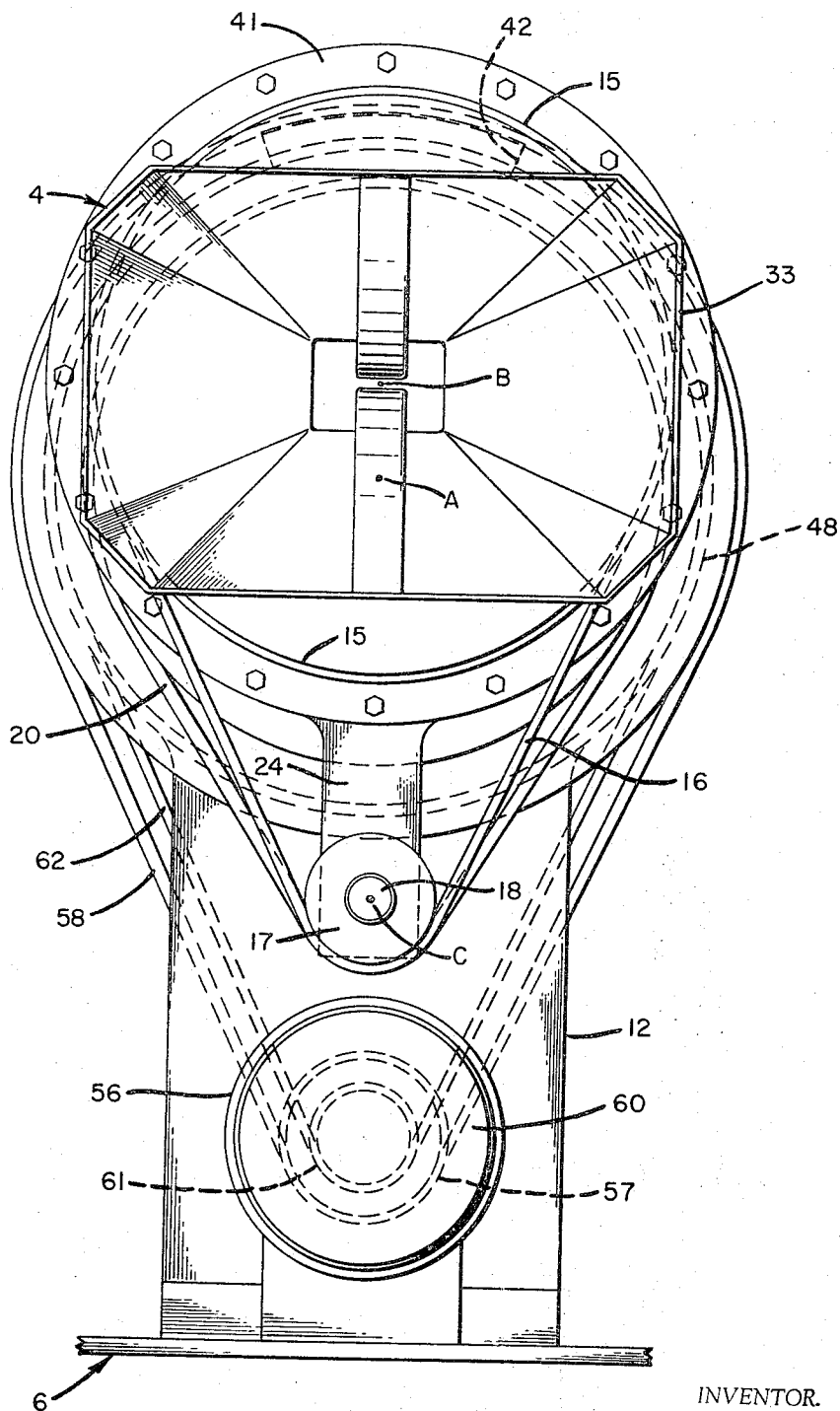


FIG-9

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3,376,576

ANTENNA DRIVE MECHANISM

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4 Claims. (Cl. 343-761)

ABSTRACT OF THE DISCLOSURE

A linearly polarized horn antenna is rotatably mounted in an inner housing which, in turn, is rotatably mounted in a stationary outer housing. The longitudinal axes of the horn and inner housing are parallel. Rotation of the inner housing causes movement of the horn in a curved path about the inner housing axis, and, through a direction reversal mechanism, induces rotation of the horn about its axis in a opposite direction from that of the inner housing. The polarization of the horn is thus maintained constant.

This invention relates to mechanism for providing movement of a device in a curved path and more particularly to a drive mechanism for providing revolution of the antenna element of an automatic tracking system.

In order to eliminate possible confusion as to the meaning of terms used hereinafter, the following definitions are employed in the description of this invention. The word "rotation" refers to movement of a body in a curved path about an axis, not necessarily an axis through the body, such that any point on the body transcribes a circle about the axis. The word "revolution" refers to movement of a body in a curved path about an axis such that any line of the body (whether perpendicular, parallel or skew to the axis) remains parallel to its initial position to which it returns upon completing a cycle. The word "nutation" refers to movement of a body in a curved path such that the longitudinal axis of the body rotates about and transcribes a conical surface about a longitudinal reference axis while the orientation of the transverse axis of the body remains fixed. Revolution as used herein is the same as nutation except that in the former the longitudinal axis of the body transcribes a cylindrical surface rather than a conical surface about the reference axis.

A linearly polarized conical scan tracking system requires movement of a linearly polarized primary feed about a first reference axis while maintaining the polarization of the primary feed constant. A nutation mechanism providing this type motion is described in the patent application of R. F. Huelskamp, Ser. No. 303,322, filed Aug. 20, 1963, now Patent 3,312,975, issued Apr. 4, 1967 and assigned to the assignee of this invention. This mechanism operates advantageously in ground based systems requiring conical scanning motion, but is less suited for airborne applications because of critical limitations on size and weight.

An object of the invention is the provision of an antenna drive mechanism which is compact and lightweight so as to be suitable for airborne applications.

Another object is the provision of such a drive mechanism that does not require a planetary gear drive mechanism for its operation.

Another object is the provision of a drive mechanism capable of moving an antenna in both conical and cylindrical scanning motions.

Another object is the provision of a drive mechanism having a small scanning radius.

A further object is the provision of a drive mechanism for moving an antenna such that the antenna has the same radiation patterns for "scan up" and "scan down" positions of the antenna.

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A more specific object is the provision of a horn antenna drive mechanism which is contained within the space defined by opposite ends of the antenna.

Still another object is the provision of such a mechanism with means for adjusting the angular position of the horn antenna about its longitudinal axis during scanning movement of the antenna.

A further object is the provision of a dynamically balanced lightweight drive mechanism which does not require rotary joints.

Another object is the provision of such a mechanism that eliminates the need for a flexible coupling to prevent rotation of the horn antenna about its longitudinal axis.

Another object is the provision of a drive mechanism for revolving a horn antenna about an axis.

In accordance with this invention, the drive mechanism comprises an inner housing rotatably mounted in bearings in a stationary outer housing. A linearly polarized horn antenna is rotatably mounted in bearings in the inner housing with its longitudinal axis parallel to the longitudinal axis of the inner housing. Rotation of the inner housing causes the horn axis to describe a cylindrical surface about the axis of the inner housing. The rotation of the inner housing, translated through a direction reversal mechanism, also causes the horn to rotate in the opposite direction about the horn axis. By rotating the horn about its axis at the same angular velocity with which it moves about the axis of the inner housing, there is revolution rather than rotation of the horn about the axis of the inner housing and the polarization of the horn is constant.

The foregoing and other objects of this invention will be better understood from the following description of a preferred embodiment thereof, reference being had to the accompanying drawings in which:

FIGURE 1 is an elevation of the nose of an aircraft with part cut away to show an automatic tracking antenna with a drive mechanism embodying this invention;

FIGURES 2 and 3 are schematic drawings of the horn antenna and the inner and outer housings and bearings for two positions of the horn in its movement about the axis of the inner housing;

FIGURES 4, 5, 6 and 7 show four positions of the horn during revolution about the axis of the inner housing as viewed from the left in FIGURES 2 and 3;

FIGURE 8 is a transverse central section of the horn antenna and the drive mechanism; and

FIGURE 9 is a front end view of the horn antenna and drive mechanism taken on line 9-9 of FIGURE 8.

Referring now to FIGURE 1, an antenna system which includes a drive mechanism embodying this invention is shown within the radome in the nose section 1 of an airplane 2. The antenna system comprises a parabolic reflector 3 and primary feed device 4, such as a horn antenna. Horn 4 is mechanically coupled to a drive mechanism 5 which causes the propagating axis P of the horn to transcribe a cylinder about an axis A of the drive mechanism. Reflector 3 and drive mechanism 5 are mounted on support 6 so the axis A and focal axis F intersect at an angle ϕ (as shown in FIGURE 1) at the focal point of the reflector, e.g., the aperture of the horn contains the focal point of the reflector. Support 6 is mounted on a pedestal 7 for tracking movements in azimuth and elevation. Pedestal 7 is rigidly secured to the framework of the aircraft.

Axis P of horn 4 is at all times parallel to the axis A. Electromagnetic wave energy is radiated by horn 4 toward portions of the reflector lying generally above the intersection G of the focal axis F and the reflector. Axes P and P' represent the propagating axis of the horn in the "beam up" and "beam down" positions, re-

spectively. It is possible to obtain a very small scan radius R with the cylindrical scan provided by drive mechanism 5. This small scan radius means that the beam maxima (the inter-section H of the axis P and the reflector) moves over a small area of the reflector, between H and H'. Thus, since the horn at all times illuminates approximately the same area of reflector, there is little change in the shape of the antenna radiation pattern as the horn moves about the axis A.

Referring to FIGURES 2 and 3, drive mechanism 5 comprises an inner housing 11 rotatably supported in a stationary outer housing 12 by bearings 13 for rotation about the longitudinal axis A of the inner housing. Horn 4 is rotatably supported in inner housing 11 by bearing 14 for rotation about horn axis B which is parallel to the axis A of inner housing 11.

Horn 4 has an externally secured sprocket 15 operatively connected by an endless band 16, such as a chain, to a sprocket 17 and a shaft 18 to a sprocket 19. A chain 20 which engages a sprocket 21 on a cylindrical polarization housing 22 is operatively connected to sprocket 19. Housing 22 and sprocket 21 attached to it are normally refrained from rotation. Shaft 18 is journaled in bearings 23 mounted in arms 24 of inner housing 11. The axis C of shaft 18 is parallel to the axis A of inner housing 11.

A reference axis X is drawn through a point 25 on the periphery of sprocket 21, perpendicular to the axis A of inner housing 11. A reference axis Y is drawn through a point 26 on the periphery of sprocket 15, perpendicular to the axis B of horn 4 so axes X and Y are parallel. Arrow 27 indicates the direction of rotation of inner housing 11, which is clockwise when FIGURES 2 and 3 are viewed along axis A from left to right.

FIGURES 4, 5, 6 and 7 are schematic representations of sprockets 15, 21 and 17 during one revolution of the horn about the inner housing axis A.

Consider that inner housing 11 is caused to rotate in a clockwise direction as indicated by arrow 27 in FIGURES 2 and 3. This rotation of inner housing 11 causes sprockets 15 and 17 to move in a clockwise direction about axis A as indicated by arrows 29 and 30, respectively (see FIGURES 4-7). Thus, axis B of horn 4 generates a cylindrical surface about axis A. Since chain 20 is refrained from rotation by sprocket 21 and housing 22, sprocket 19 "walks" on chain 20 in a clockwise direction (as indicated by arrow 30). This movement of sprocket 19 causes counterclockwise rotation of sprockets 15 and 17 about their respective axes B and C, as indicated by arrows 31 and 32, respectively (see FIGURE 4). Movement of sprocket 19 also causes chain 20 to move about non-rotating sprocket 21.

By making the diameter of sprockets 15 and 21 equal, horn 4 and inner housing 11 rotate (in opposite directions) at the same angular velocity about their respective axes B and A. Sprocket 15 therefore does not rotate about the axis A of inner housing 11. Rather, sprocket 15 makes one revolution about axis A for each rotation of the inner housing. This movement of horn 4 and sprocket 15 is graphically represented in FIGURES 4 through 7 by reference axes X and Y which remain parallel as sprocket 15 revolves around axis A. Thus, when a linearly polarized horn antenna is driven by a mechanism incorporating this invention, the polarization of the horn antenna remains constant as it revolves about a longitudinal reference axis, in this case axis A.

Since inner housing 11 rotates about its axis A, a simple drive mechanism connected to it is sufficient to induce revolution of the horn antenna. No rotary joints are required because the horn does not rotate about the axis A.

Referring now to FIGURES 8 and 9, the antenna 4 comprises a tapered ridged waveguide horn. Annular members 35, 36 and 37 have tapered inner mounting surfaces bonded to the similarly shaped outer surface of the horn.

A metal sleeve 38 (see FIGURE 8), having its axis coincident with the axis B, is bonded to the outer surfaces of members 36 and 37. Sleeve 38 has an outer cylindrical mounting surface 39 engaging the inner race of bearing 14. The front (left as viewed) end of inner housing 11 has an inner cylindrical mounting surface 40 having an axis coincident with axis B and engageable with the outer race of bearing 14. Bearing 14 is preferably a duplex bearing pair such as a Fafnir Y96PW1 manufactured by the Fafnir Bearing Company, New Brighton, Connecticut having approximately an 80,000 inch-pound overturning-movement rating with a one inch bearing spacer. Bearing 14 is prevented from moving in inner housing 11 by retaining ring 41. The horn is secured in the inner housing by retainer plates 42 and 43 removably connected to members 36 and 37 by bolts 44.

The rear (right as viewed) of inner housing 11 has an outer cylindrical mounting surface 46 (see FIGURE 8) which engages the inner race of annular bearing 13 and whose axis is coincident with the axis A. Bearing 13 is preferably a duplex bearing pair as is bearing 14. Bearing 13 is prevented from axial movement on inner housing 11 by annular spacer 47 and sprocket 48 which is bolted to the inner housing.

Stationary outer housing 12 has an inner cylindrical mounting surface 49 which engages the outer race of annular bearing 13. Horn 4, inner housing 11 and bearing 13 are prevented from axial movement in outer housing 12 by annular retainer ring 50 which is bolted to the outer housing. The polarization housing 22 is a stepped collar having a cylindrical inner mounting surface 52 engageable with the outer surface of outer housing 12 and is axially locked on the outer housing by retainer rings 53 and 54. Housing 22 is preferably formed of bearing material such as copper-bronze. A sprocket 55 is secured to the rear step 22a of the polarization housing. The sprocket 21 is non-rotatably secured to the forward step 22b of the polarization housing.

In order to selectively control adjustment of the polarization of the horn, a polarization drive motor 56 mounted on housing 12 has a drive sprocket 57 connected by chain 58 to sprocket 55. When motor 56 is de-energized, housing 22 is locked against rotation by the engagement of chain 58 with sprocket 55. When motor 56 is energized, chain 58 causes angular displacement of sprocket 55 and housing 22.

Inner housing 11 is rotated about its longitudinal axis A by a drive motor 60 mounted on support 6 and secured to outer housing 12. Drive motor 60 and sprocket 61 drive a chain 62 that engages the driven sprocket 48 on the inner housing.

In order to dynamically balance the horn 4 which is offset from axis A, counterweights 64 are secured to arms 24 of inner housing 11. The counterweights rotate with the inner housing and are located on the side of axis A diametrically opposite from the axis B of the horn.

Rotation of inner housing 11 causes shaft 18 and sprockets 17 and 19 to move in a curved path about axis A. As shaft 18 and sprocket 19 move, the latter "walks" on chain 20 and rotates sprocket 19, shaft 18 and sprocket 17 about axis C. This rotary motion is translated through chain 16 to the horn 4 to cause the latter to revolve rather than rotate about the axis A of the inner housing.

The angle of polarization of the horn may be changed during revolution thereof. Through selective energization of polarization drive motor 56, rotation of sprocket 57 causes rotation of driven sprocket 55 and polarization housing 22 about the inner housing axis A. The rotation of housing 22 and sprocket 21 causes rotation of chain 20 which changes the rate of rotation of shaft 18 about axis C and thus changes the polarization of the horn.

In order to provide for transmission of radio frequency energy to and from the horn antenna, a coaxial cable 65 is connected to a coaxial connector 66 on the rear of the horn. The other end of the coaxial cable is connected

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to external equipment. Coaxial line 65 is sufficiently torsionally flexible to accommodate changes in polarization normally required in operation, e.g., from 0° to 180°, and therefore no rotary joints are required in the mechanism.

Although this invention has been shown and described in relation to a preferred embodiment thereof, variations and modifications will be apparent to those skilled in the art. For example, drive mechanism 5 will provide nutation of horn 4 if the latter is mounted in inner housing 11 so the axis B intersects axis A and a flexible section is included in shaft 18. The scope and breadth of this invention is therefore to be determined from the following claims rather than from the above detailed disclosure.

What is claimed is:

1. In a scanning antenna system having a reflector and a primary feed device with a longitudinal axis defining the direction of propagation of electromagnetic waves toward the reflector, a mechanism for moving the device relative to the reflector to produce scanning movement of reflected waves comprising,

an inner housing supporting the device for rotation about an axis of the inner housing and the axis of the device,

the axis of the inner housing being laterally spaced from and parallel to the axis of the device,

means for rotating said inner housing in one direction at a constant angular velocity about its axis for moving the device in a curved path about the inner housing axis,

means for maintaining constant the polarization angle of the feed device during rotation of the inner housing comprising

an outer housing

a collar mounted on said outer housing for selective rotation about the inner housing axis, and

means interconnecting said inner housing and collar and the device for translating rotation of said inner housing to the device for rotating the device about the axis of the device in a direction opposite to said one direction at an angular velocity equal to the angular velocity of the inner housing for revolving the device about the axis of said inner housing.

2. The antenna system according to claim 1 wherein said interconnecting means comprises

a shaft rotatably supported in said inner housing for rotation about the inner housing axis and the longitudinal axis of the shaft,

first endless band drive means operatively connecting said shaft member and said collar for rotating said shaft about its axis, and

second endless band drive means operatively connecting said shaft and the device for rotating the device about the second axis for revolving the device about the first axis.

3. In a scanning antenna system having a reflector and a primary feed device with a longitudinal axis defining the direction of propagation of electromagnetic waves toward the reflector, a mechanism for moving the device

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relative to the reflector to produce scanning movement of reflected waves comprising

an inner housing having an axis,

said feed device being supported in said inner housing for rotation about the axis of the device,

an outer housing supported in fixed relation to said reflector and having bearings for supporting said inner housing and the device for rotation about the axis of the inner housing,

the axis of the device being laterally spaced from and parallel to the axis of the inner housing,

means for rotating said inner housing in one direction at a constant angular velocity about its axis for moving the device in a curved path about the inner housing axis,

means for maintaining constant the polarization angle of the feed device during movement thereof, said maintaining means comprising

a collar mounted on said outer housing for rotation about the inner housing axis,

means for selectively preventing rotation of said collar,

a shaft support in the inner housing for rotation about the inner housing axis and the longitudinal axis of the shaft,

said shaft axis being offset from the inner housing axis and parallel thereto,

a first endless chain operatively connecting said shaft to said collar whereby said shaft rotates about its axis, and

a second endless chain operatively connecting the feed device to said shaft whereby the feed device rotates about its axis in a direction opposite to said one direction at an angular velocity equal to the angular velocity of said inner housing.

4. The antenna system according to claim 3 wherein said means for selectively preventing rotation of said collar comprises

first and second driven sprockets non-rotatably secured to said collar,

said first driven sprocket being operatively connected to said shaft by said first endless chain,

a polarization motor supported on said outer housing,

a drive sprocket connected to said motor, and

a third endless chain interconnecting said drive sprocket and said second driven sprocket.

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