Oct. 1, 1963 J. BANCHE ET AL 3,105,969

ANTENNA REFLECTOR CONSTRUCTION

Filed Dec. 23, 1960 3 Sheets-Sheet 1

Fig.1

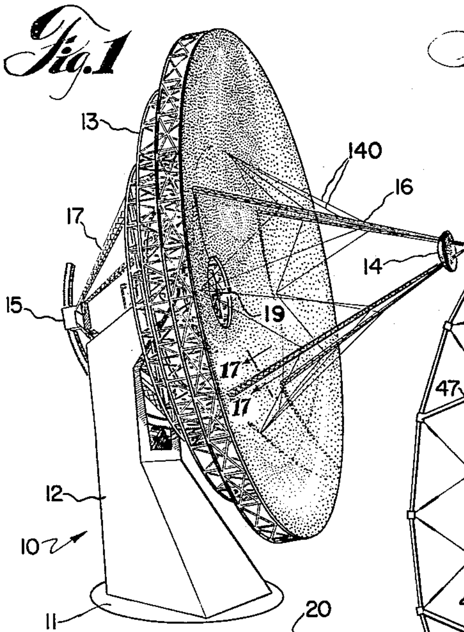


Fig.2

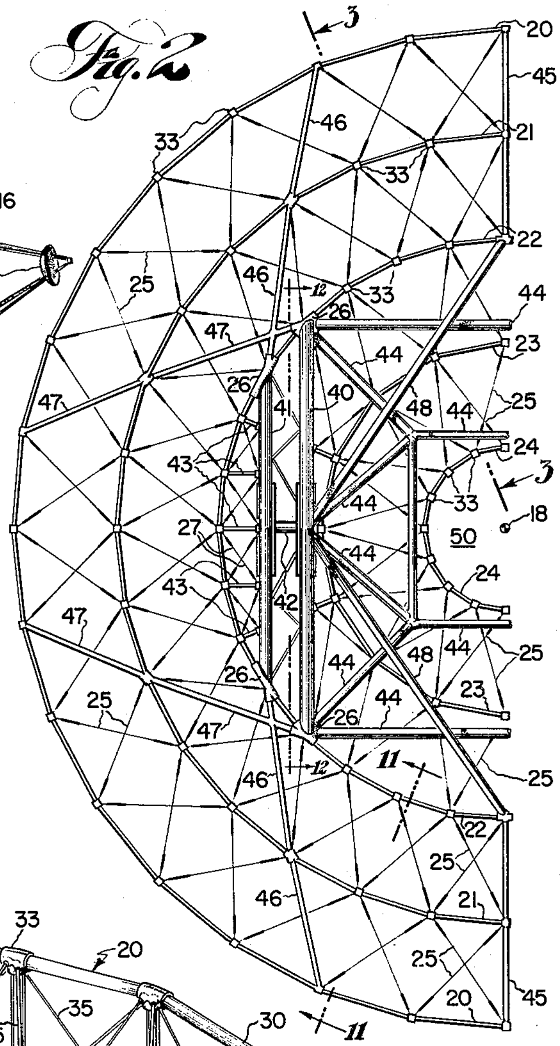


Fig.3

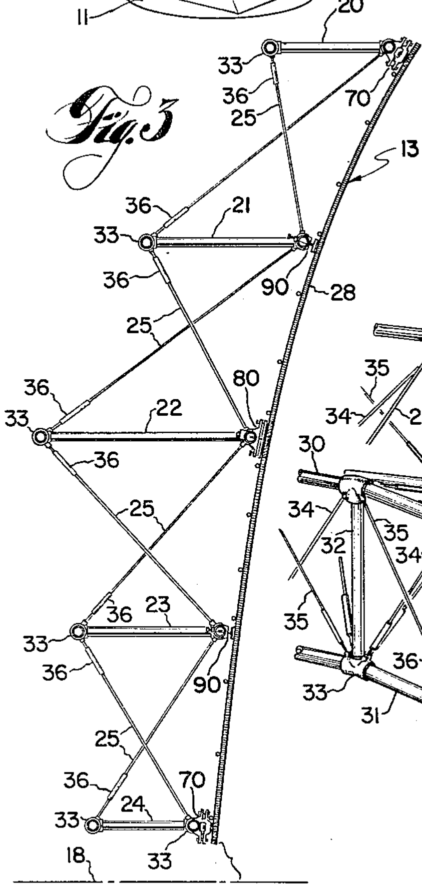
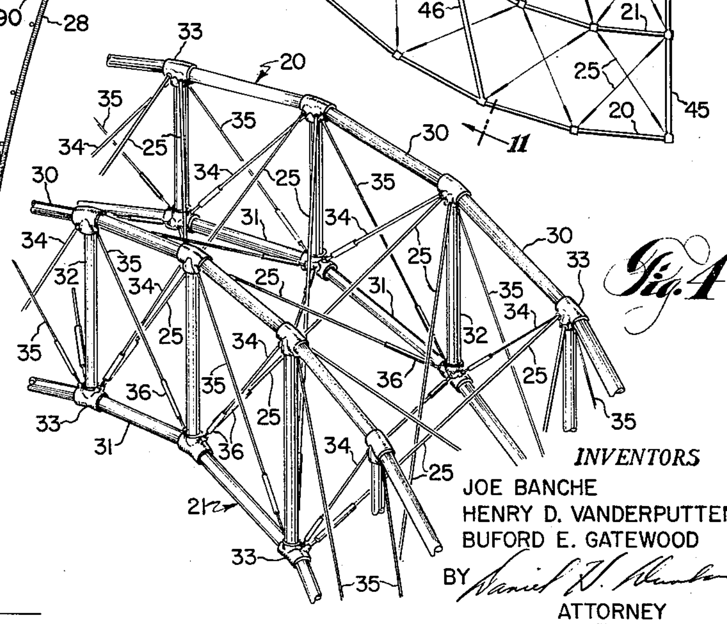


Fig.4



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ANTENNA REFLECTOR CONSTRUCTION

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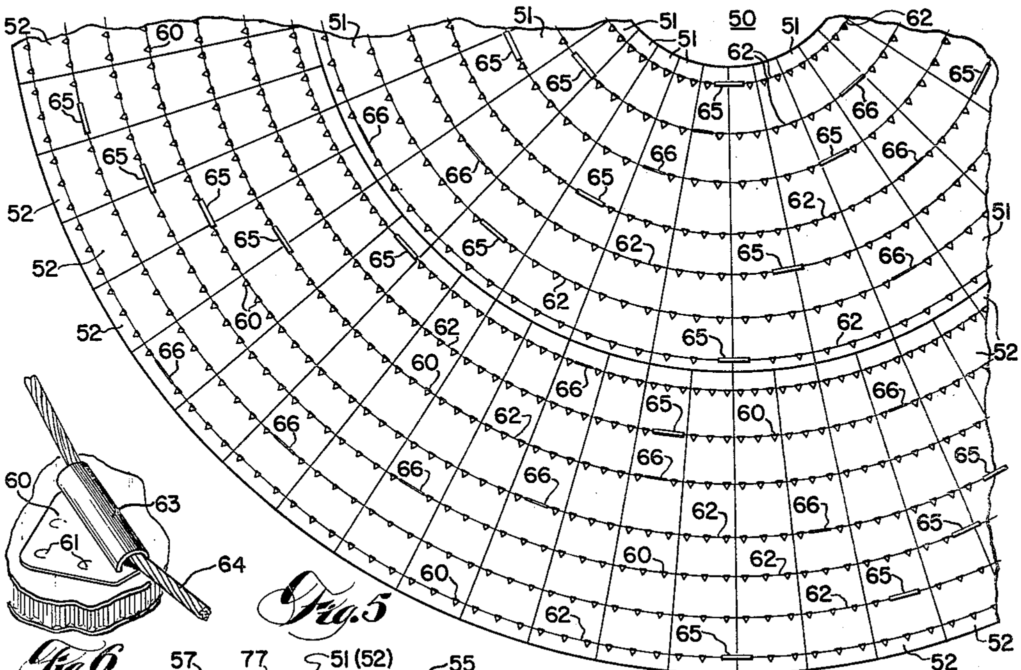

Fig. 5

Fig. 6

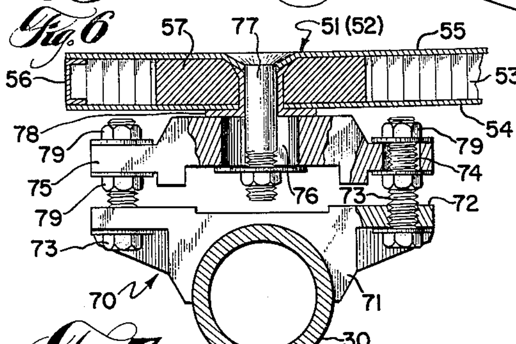

Fig. 7

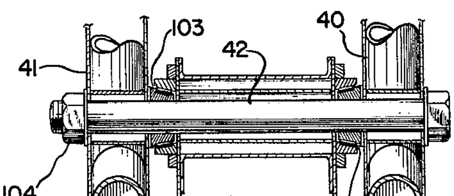

Fig. 10

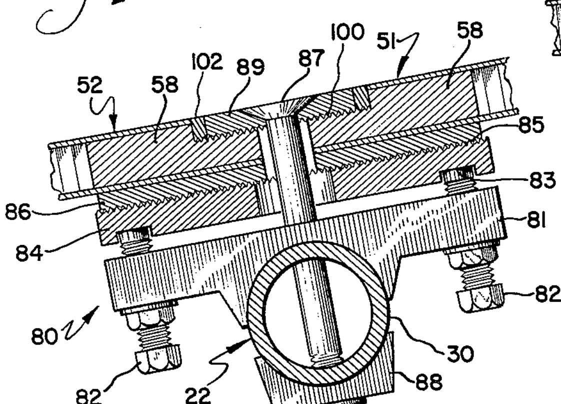

Fig. 8

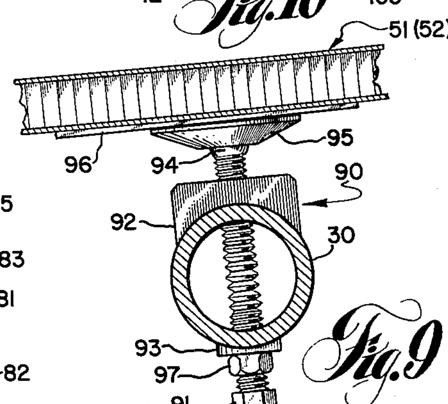

Fig. 9

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ANTENNA REFLECTOR CONSTRUCTION

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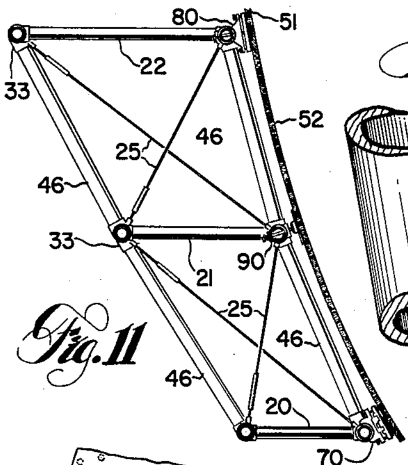

Fig. 11

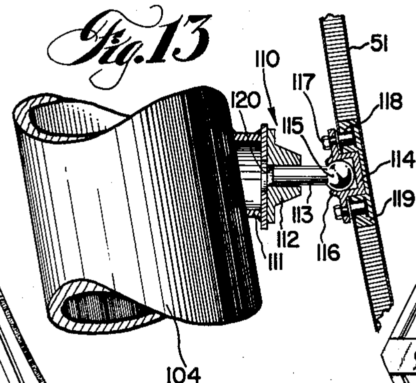

Fig. 13

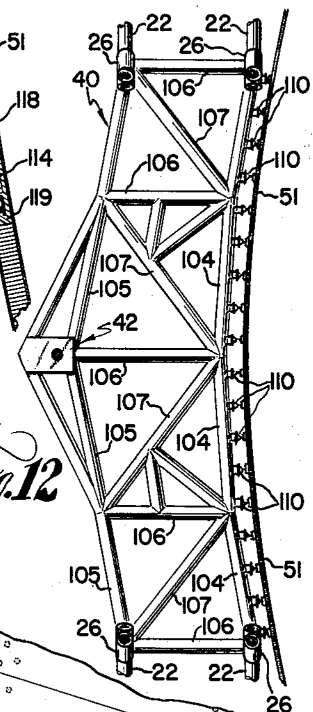

Fig. 12

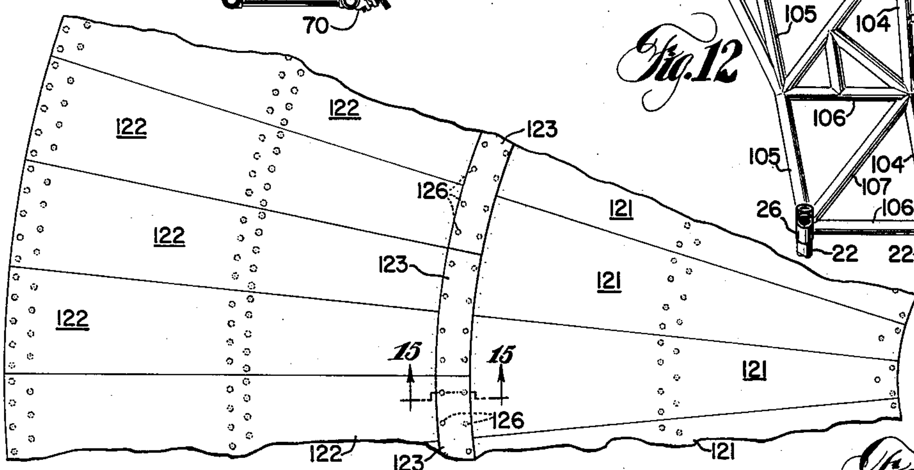

Fig. 14

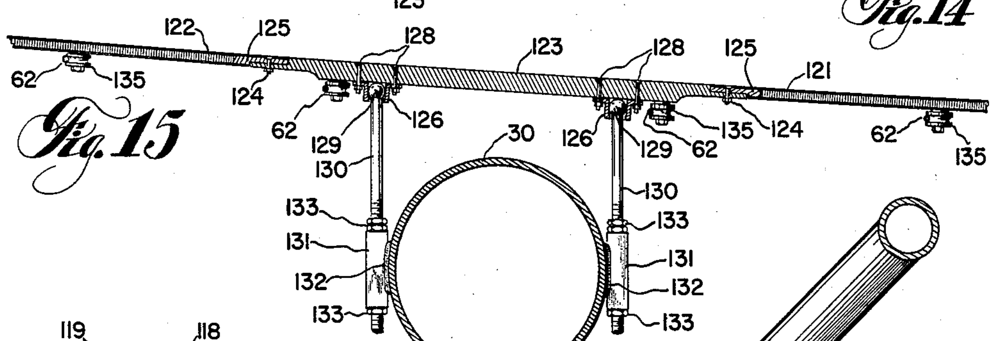

Fig. 15

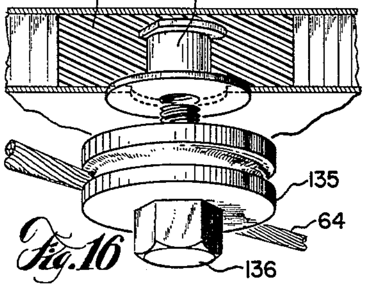

Fig. 16

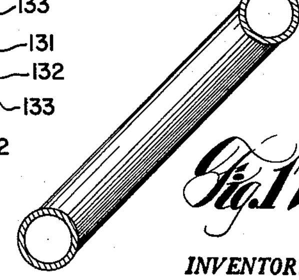

Fig. 17

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Patented Oct. 1, 1963

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3,105,969
ANTENNA REFLECTOR CONSTRUCTION
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Filed Dec. 23, 1960, Ser. No. 78,137
5 Claims. (Cl. 343—915)

This invention relates to a ground-based precision antenna system and especially concerns a novel construction for large-diameter reflectors used in such systems. Antenna systems of the type herein disclosed are particularly useful in connection with scientific investigations of the ionosphere, emissions from planetary atmospheres, solar corona effects, and various phenomena and problems encountered in navigation, communications, and the like. The invention described and claimed herein has found particular utility in connection with the use of radio equipment having operating capabilities at frequencies up to 10,000 megacycles per second.

Although a ground-based precision antenna system typically employs other major equipment items in addition to a large-diameter primary reflector surface, this invention is essentially concerned with the principal energy-reflecting surface contained therein. In order that precision quality and operability be maintained in the antenna system it is necessary to provide a primary reflector construction which obtains an optimum minimization of both surface deflection and total weight throughout a comparatively wide range of surface operating positions. During operation of a typical precision antenna having a large-diameter reflector, the reflector system components are often rotated together through an elevation angle of approximately 90° and through an azimuth angle of approximately 360°. Unnecessary or improperly distributed weight in the reflector can be the source of excessive surface deflections which result in unsatisfactory system performance. The use of additional material to develop further rigidity in the reflector structure may be the cause of undesirable system tracking inertia and also tends to compound the deflection problem. System performance penalties which cannot be tolerated may thereby be incurred.

The invention detailed and claimed herein has found utility in connection with an antenna system having a primary reflector designed with a diameter of approximately 120 feet and weighing approximately 70,000 pounds. The maximum permissible surface deviation of the primary reflector from a true paraboloid for all operational conditions was not to exceed $\pm 0.075''$ when measured essentially parallel to the reflector axis. The maximum deviation of any point in the reflector with respect to the theoretical or desired reflector surface position was found to be approximately $\pm 0.072''$. This deviation was a net value based upon the most adverse effects of deflection, temperature, and fabrication and placement tolerances.

Accordingly, it is an important object of our invention to provide an antenna reflector construction which achieves an optimum relation between total weight and maximum induced surface deflection throughout a comparatively wide range of reflector rotational movements and positions.

Another object of our invention is to provide an antenna reflector construction which may be readily assembled and rigged in the field to close dimensional tolerances.

Another object of this invention is to provide a large-diameter, precision antenna reflector that is not significantly distorted due to thermal expansion or contraction thereof in an operating environment which may vary from as low as 0° F. to 110° F. and which may involve appreciable temperature gradients across the diameter thereof.

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Another object of this invention is to provide an antenna reflector construction which has a capability of efficiently transmitting dead weight and operating loads from reflector surface panels into backup structure throughout a wide range of operating positions.

Another object of our invention is to provide a large-diameter reflector which may be mounted to a cooperating support in the region of its center of gravity.

A still further object of this invention is to provide a precision antenna with joined reflector surface panels which act as a dimensionally stabilized integral shell whose radially inward and outward portions are comparatively free to move radially with respect to attached supporting backup structure to thereby minimize any surface deflection which would otherwise be induced during re-positioning of the entire reflector assembly.

Other objects and advantages of this invention will become apparent during a consideration of the description and drawings of this application.

In the drawings:

FIG. 1 illustrates a ground-based antenna system having the reflector of this invention incorporated therein;

FIG. 2 is a partial plan view of the backup structure and support means structure provided in the reflector of FIG. 1 taken from the underside thereof;

FIG. 3 is a sectional view taken at line 3—3 of FIG. 2;

FIG. 4 is a partial perspective view of a portion of the backup structure illustrated in FIGS. 2 and 3;

FIG. 5 is a partial plan view of the surface panel arrangement utilized in the reflector shown in FIG. 1 taken from the underside thereof;

FIG. 6 is a perspective detail of a clip-cable arrangement utilized in connection with pre-stressing the reflector surface panels included in our invention;

FIGS. 7, 8, and 9 illustrate details of connections used to secure the surface panels illustrated in FIG. 5 to the backup structure illustrated in FIG. 2;

FIG. 10 is a partial sectional view of a bearing assembly which may be used to connect the support means structure of the reflector of our invention to a cooperating mount;

FIG. 11 is a sectional view taken at line 11—11 of FIG. 2 to illustrate the positioning of auxiliary backup structure used in our invention;

FIG. 12 is a sectional view taken at line 12—12 of FIG. 2 to illustrate details of a portion of the support means structure utilized in this invention;

FIG. 13 illustrates details of a shear connector means shown generally in FIG. 12 and used to attach the surface panels employed in our invention to the reflector support structure portion;

FIG. 14 is a partial plan view of an improved and preferred surface panel arrangement which may be utilized in connection with our invention;

FIG. 15 is a sectional view taken at line 15—15 of FIG. 14;

FIG. 16 is a perspective view of a preferred detail which may be used as an alternate to the clip-cable arrangement illustrated in FIG. 6; and

FIG. 17 is a sectional view taken at line 17—17 of FIG. 1.

The major structural components of the antenna system 10 illustrated in FIG. 1 are: base 11, elevation-azimuth mount 12, primary reflector 13, secondary reflector 14, ballast 15, and secondary support arrangements 16 and 17. Base 11 serves as a foundation and is commonly secured to bed rock with ledge anchors in a conventional manner. Mount 12 is provided with drive mechanisms (not shown) for rotating the attached reflectors and equipments in both azimuth and elevation. Details of the structure for mount 12 and the drive means contained therein may take a typical form and therefore do not comprise a part of our invention. Primary reflector 13 is generally provided with a near-continuous reflecting surface having a paraboloid form and is pivotally connected to mount 12. Secondary reflector 14 is most often provided with a hyperbolic form reflecting surface oriented toward the reflecting surface of reflector 13 and is connected to reflector 13 by secondary support 16. The struts of support 16 are each essentially planar in cross section and are each stabilized laterally by cables which preserve structural integrity and rigidity. Such struts are also oriented radially with respect to the parabolic surface of reflector 13 to minimize RF blockage. Also, the ballast designated 15 is connected to and carried by reflector 13 through the secondary support designated 17. Although FIG. 1 illustrates antenna system 10 as having the ballast designated 15, the use of such ballast (and cooperating support 17) may not be necessary depending upon considerations which are subsidiary to the reflector construction. For instance, the provision of elevating means for placing radio equipment component 19 into a cooperating position with respect to a centrally located opening in reflector 13 may require that a minimum amount of balancing ballast be employed. In FIG. 1, radio equipment component 19 is illustrated as a feed horn device positioned within the opening located at the center of the paraboloid reflector surface.

To achieve the advantages of our invention, reflector 13 is essentially comprised of backup structure, support means, reflector surface panels attached to the backup structure and to the support means by a preferred arrangement of connector components, and suitable bearing means for rotatably connecting the support means to system mount 12 and for carrying all loads from the reflector into the mount. Illustration of the reflector backup structure construction is provided in FIGS. 2 through 4. For purposes of description, the backup structure may be divided into a basic portion and an auxiliary portion as hereinafter detailed.

The basic backup structure portion is symmetrical about the radio frequency axis 18 of the system and consists, in the case of the illustrated antenna system, of five concentric truss-type ring beams 20 through 24 connected to each other essentially by inter-ring tension members 25 and also by the hereinafter-detailed auxiliary backup structure portion. Axis 18 may also be referred to as the principal axis of symmetry of the reflector. Beam 22 is designated the main ring beam and essentially cooperates with the hereinafter-described support means for connecting the backup structure to the mount therefor. Each ring beam includes upper cap members 30, lower cap members 31, vertical struts 32, and T fittings 33, all connected to each other. See FIG. 4. Each cap member and each vertical strut member is preferably suitably welded to the T fittings cooperating therewith. Ring beams 20, 21, 23, and 24 have diagonal inter-cap tension members 34 and 35. Main beam 22 is preferably provided with diagonal inter-cap compression struts (not shown) of larger cross-section in lieu of inter-cap tension members. Each of the previously-mentioned tension members is secured at either end to a T fitting 33 by a conventional connector (not shown) and includes a turnbuckle component designated 36. Inter-ring tension rods 25, being pre-stressed or pre-loaded and additionally diagonally positioned with respect to axis 18, serve to place each ring beam 20—24 in hoop compression. It is preferred that the components of the ring beams be fabricated of an aluminum alloy such as 6061–T6 or 6062–T6.

Because we contemplate that the reflector of our invention will be pivotally connected to a suitable elevation mount or elevation-azimuth mount such as component 12, we provide a support means in the form of inner and outer truss-type beams 40 and 41 and the horizontally-oriented bearings 42 connected thereto. Such truss-type beams and cooperating bearings carry the entire weight of the reflector 13, as well as the weight of other components such as secondary reflector 14, ballast 15, secondary supports 16 and 17, and radio equipment 19, into mount 12. Each end of each beam is rigidly connected at upper and lower extremes to the upper and lower cap members 30, 31 of main ring beam 22 by suitable connector means 26. The end connectors 26 of inner beam 40 essentially divide main ring beam 22 into four equal segments. The hereinafter-described auxiliary backup structure is employed to additionally connect portions of the basic backup structure to the support means beam and bearing arrangements. The reflector support means also includes shear struts 43 and cross ties 27 for additionally connecting the upper and lower cap members of outer beams 41 to main ring beam 22, and inter-connected compression members 44 for maintaining opposed beams 40 in proper spaced-apart relation.

The primary purpose of the auxiliary backup structure which we utilize in our invention is to provide resistance to anti-symmetrical loads which would otherwise cause significant deflections in the reflector surface during antenna system operation. Besides this, the auxiliary backup structure establishes stabilizing forces for the upper and lower cap members 30 and 31 of outer ring beams 20 and 21 and adds to the basic rigidity of the backup structure for symmetrical loads. The auxiliary portion of the disclosed backup structure is essentially comprised of inter-connected tubular structural members which attach to the lower and upper cap members of various of the ring beams and to the support means but is not entirely symmetrical with respect to the radio frequency axis 18 of the system. The number and orientation is generally a function of specific considerations. In the configuration illustrated in the drawings, tubular members 45 each attach to and extend from upper and lower cap members 30 and 31 of ring beam 20 to the corresponding cap members 30 and 31 of ring beams 21 and 22. Tubular members 45, it should be noted, are essentially parallel to the vertical axis of symmetry of reflector 13 when such reflector is positioned with axis 18 oriented horizontally. Tubular members 46 of the auxiliary backup structure are each oriented in a generally similar direction and attach to the upper and lower cap members 30 and 31 of ring beams 20 and 21 and to the corresponding cap members of main ring beam 22 at the attach points or end connectors 26 of outer beams 41. See FIG. 11. Tubular members 47 of the auxiliary portion of the backup structure are oriented in a generally horizontal direction and are connected to the upper and lower cap members of ring beams 20 and 21 and to the corresponding cap members of main ring beam 22 at the attach points or end connectors 26 of inner beams 40. The auxiliary backup structure portion of the reflector also includes diagonal tubular members 48 which extend from attach points (connectors) in main ring beam 22 at the region of members 45 to the center region of the innermost beams 40. The compression strut components designated 44 are arranged to frame the opening 50 provided in the reflector and thus also provide carry-thru of the backup structure. Such opening may be necessary, in the case of Cassegrain-type antennas, to accommodate electronic equipment items for the proper transmission or propagation of energy.

The face of reflector 13 is essentially comprised of reflector surface panels 51 and 52. In the arrangement of surface panels illustrated in FIG. 5, the innermost row of panels has 32 similar units in number. Each surface panel 51 therein has a generally trapezoidal form and extends from the edge of reflector opening 50 radially outward to an opposite circumferential edge positioned adjacent main ring beam 22. An outer row of sixty-four surface panels 52 extends radially outward from an edge adjacent the outer circumferential edge of assembled panels 51 to the region of outermost ring beam 20. Each panel 52 has a generally trapezoidal form similar to that of panel 51 and has an innermost end width which in this case is one-half of the outermost end width of a panel 51. The ratio of the number of inner to outer row panels is not restricted to that which is described herein. When two rows of panels are included, essentially only two different sizes of surface panels are used to develop the parabolic reflecting surface of reflector 13. Any number of rows may be employed depending on the design.

We prefer that panels 51 and 52 each be fabricated as a conventional aircraft-type honeycomb sandwich panel. Accordingly, such panels include a honeycomb core 53, and metal skin members 54 and 55 bonded to core 53 with a suitable adhesive (not shown). Skin members 53 and 54 may be formed to the required parabolic contour by stretch press equipment or the like. Edge closeout members 56 serve to protect panel interiors against moisture penetration and add to the structural rigidity. Each surface panel may further include a number of interiorly-located hard point inserts 57 which are employed in securely connecting the panels to the backup structure and to the support means hereinbefore-described. Panel closeout components located in the region of main ring beam 22 should take the form of solid members such as 58 illustrated in FIG. 8. This is important if proper support for reflector 13 is to be developed. Although not shown, we prefer that the radially-oriented closeout members of each surface panel include channel-like recesses for receiving expandable inserts which can be used to adjust the circumferential spacing between adjacent panels, if necessary. In all likelihood, such adjustable inserts would be used only at intervals around each row of panels. Also, such radial closeout members might advantageously be provided with depending integral tabs (not shown) that subsequently receive bolts to thereby restrict relative movement between adjacent panels in a direction generally normal to the surface of the panels. Such additional detail arrangements are considered within the capability of those skilled in the art.

Each row of surface panels 51 and 52, after being attached to the backup structure and to the support means by the hereinafter-described connector devices, is preferably stressed to develop a hoop compression relative as between all panels in the row. For this purpose, our reflector surface includes attachment members 60 secured to the underside of each surface panel 51 and 52 by welds 61 (or rivets or the like) and circumferentially continuous cable assemblies 62. Attachment members 60 each may include a rigid-up-turned, hook-like flange 63 which engages a portion of the pre-stretched cable 64 contained in assembly 62. See FIG. 6. Adjustable turnbuckle devices 65 and tension spring members 66 are included in each cable assembly 62 to achieve a pre-stressed relation in the reflector face. The spring constant of each spring member 66 is selected to maintain small load changes for reltaively large changes in spring length. Comparatively large changes in spring length may be directly associated with thermal expansion or contraction or the like developed within panels 51 and 52 and the backup structure. Under certain design conditions it may prove feasible to eliminate this spring if a favorable cable stiffness can be achieved.

FIGS. 7 through 9 and 13 schematically illustrate functions which we prefer to achieve when attaching the joined prestressed reflector face panels to the previously-described backup and support means structure. In general, each disclosed connector arrangement provides a means for obtaining fine adjustment of the reflector face

to its prescribed surface contour and also develops the proper anchoring of each cooperating panel to the backup structure. The details of connector assembly 70 shown in FIG. 7 may be used at ring beams 20 and 24. The details shown in FIG. 8 relate to a connector assembly 80 which may be used at main ring beam 22. The adjustable connector devices 90 of FIG. 9 are positioned in the regions of ring beams 21 and 23 of the backup structure.

The connector 80 of FIG. 8 operates to secure generally abutting edges of adjacent panels 51 and 52 against movement relative to each other in a radial direction and in directions normal to the panel surfaces. Connector 80 does, however, permit circumferential movement of the panels relative to each other, as well as circumferential and radial movement of the joined panels relative to the backup structure, to compensate for expansion and contraction differences. The connector device 70 illustrated in FIG. 7 also permits both radial and circumferential movement of the retained surface panel relative to the backup structure. This particular connector does, however, prevent movement of panels attached thereby in directions normal to the face of the reflector. The connector or support 90 of FIG. 9 permits both radial and circumferential movement of the panel and restricts movement of the panel normal to its surface but such restriction is only in a direction toward the adjacent ring beam upper cap member.

Referring to FIG. 7, connector unit 70 includes bar member 71 secured to a beam upper cap member 30 in a cross-wise manner by welding or the like. Cap member 30 is typically located in either ring beam 20 or ring beam 24. Each arm of bar 71 is provided with a threaded opening 72 which receives the threaded adjustment bolt designated 73. Such bolts additionally cooperate with unthreaded openings 74 provided in the opposing arms of bar member 75. This last bar member includes an oversized opening 76 through which attachment bolt 77 is projected. The cooperating panel 51 (52) and its interiorly contained hard point insert 57 receives the shaft and head of attachment bolt 77 and flanged bushing 78. Bushing 78 contacts the upper surface of bar member 75 when the cooperating nut and washer of attachment bolt 77 are drawn tightly against the underside of the bar. Adjustment of bar member 75 relative to upper cap member 30 and bar member 71 are achieved by turning adjusting bolts 73 and the lock nuts 79 cooperating therewith in a conventional manner. Opening 76 is sufficiently large to permit some circumferential and radial displacement of bolt 77 relative thereto.

The connector device 80 of FIG. 8 includes a bar member 81 welded to an upper cap member 30 of main beam 22 in a crosswise direction. Threaded adjusting bolts 82 cooperate with threaded openings in bar member 81 and the ends thereof cooperate with recesses 83 provided in the underside of support member 84. The upper surface of support member 84 is provided with serrations 85 which extend in a circumferential direction and which cooperate with similar serrations provided in support plates 86. Panels 51 and 52 have support plates 86 securely attached thereto. A tensioned attach bolt 87 is provided for connecting panels 51 and 52 to the upper cap member 30 of the main beam. The shaft of bolt 87 passes through the illustrated openings in support members and plates 84 and 86, cross-bar 81, cap member 30, and saddle member 88. Plate 89 cooperates with the head of attachment bolt 87 and is provided with serrations 100 which cooperate with similar serrations 100 provided in close-out members 58. These additional serrated components limit relative movement to a circumferential direction but do allow for a degree of adjustment in panel positioning. The nut and washer combination 101 which cooperates with the threaded end of bolt 87 may be tightened to bring panels 51 and 52 into a rigid connection with main beam 22. However, such joined panels are comparatively free to move or to thermally contract or expand in circumferential directions and radially relative to the main beam. Close-out members 58 are generally large in cross-section since they are of great structural significance as to symmetrical loads. In this respect they provide the necessary hoop compression to support the reflector panels at the main ring beam means with very little deflection in the panels. Metallic filler 102 may be employed, if desired, to eliminate excessive discontinuity in the reflector surface.

Connector 90 is illustrated in FIG. 9 and is provided for the purpose of limiting deflection of a cooperating panel 51 (52) in a direction normal to the surface of the reflector. Connector 90 includes a threaded adjustment bolt 91 which cooperates with threaded openings provided in an upper cap member 30 of a ring beam 21 or 23. Adjustment bolt 91 also cooperates with aligned, threaded openings provided in the saddle members 92 and 93 attached to cap member 30. The upper end of adjustment bolt 91 cooperates with a ball 94 that is rotatably contained within a recess (not shown) provided in foot member 95. Foot member 95, in turn, makes contact with a metal plate 96 attached to the underside of the reflector surface panel to improve the distribution of reaction loads therein. Lock nut 97 is provided for retaining the adjustment bolt-foot member combination in proper position with respect to the related ring beam assembly. Components 94 and 95 essentially provide a ball and socket joint. It will be noted from FIG. 9 that connector 90 functions to restrain the cooperating surface panel 51 (52) against movement toward cap member 30 only.

FIG. 12 illustrates truss-type beam 40 in elevation and also discloses the preferred shear connector means 110 which are employed in our invention for attaching the joined reflector surface panels to the reflector support means portion. Beam 40 includes upper cap members 104, lower cap members 105, and vertical struts 106. Struts 106, as well as the various diagonal members 107, are welded to such cap members. Shear connectors 110 are attached to panels 51 and to beam 40 throughout the length of upper cap members 104 and in spaced-apart relation.

Referring to FIG. 13, connector 110 is comprised of a saddle 111 and mounting block 112 combination that is connected to upper cap member 104 and a slide bolt 113 and fitting 114 combination that is connected to panel 51. Mounting block 112 is preferably connected to a radially aligned tubular saddle 111 by conventional adjustable fastener means (not shown). A ball end 115 provided on slide bolt 113 is held in position in fitting 114 by swaged lips 116 or similar means. Suitable threaded fastener means 117 are provided to cooperate with openings in fitting 114 and with the threaded inserts 118 provided in the cured resin core portion 119 of panel 51. The shaft of bolt 113 is slidably contained in the opening 120 provided in mounting block 112 and is matched to close tolerance to avoid joint losses. In this manner a connector is provided whereby the assembled reflector panels are permitted movement relative to the backup structure and support means in a direction along the axis 18 of the reflector. When the reflector assembly is pivoted into a near-vertical position, gravity loads associated with the reflector surface are transmitted from the surface panels into the support means essentially in by-pass relation to the backup structure thereby inducing minimum deflections in the reflector surface during near-vertical operation.

FIG. 14 is a plan view of a preferred arrangement of reflector surface panels. Inner panels 121 and outer panels 122 generally correspond to the previously-discussed surface panels 51 and 52. However, panels 121 and 122 are joined to each other and to the backup structure differently. Details of a preferred connector for this purpose are illustrated in FIG. 15.

Plate members 123 are provided to fulfill the necessary rigidity requirements in the reflector face much in the same way as closeout members 58 previously described. They also connect adjacent edge portions of panels 121 and 122 to each other. As shown in FIG. 15, fastener means 124 are arranged to cooperate with each plate 123 and with openings provided in closeout members 125 of surface panels 121 and 122 in a conventional manner. Each plate means is provided with radially-aligned (or staggered if suitable to the design) connector components 126 at the underside thereof and fastener devices 128 are employed for securing connector components 126 to the plate. A generally spherical bearing surface is contained within each connector component 126 and cooperates with a portion of the ball end 129 provided at the upper extreme of each rod 130. Rod 130 is slidably contained in the sleeve 131 that is connected to upper cap member 30 of ring beam 22 by the weld designated 132; suitable nut means 133 is provided for positioning rod 130 in proper position with respect to sleeve 131. The ball end 129 of each rod 130 is essentially a part of a ball and socket connector and is inserted in fitting 126 before it is attached to plate means 123. During use of reflector 13 we contemplate little movement of ball end 129 relative to the backup structure; such movement will be accompanied by unnoticeable bending of rods 130 relative to the main ring beam.

A similar connector means 126, 130 is preferably employed to connect the reflector surface panels to ring beams 20, 21, 23, and 24. The connector devices are staggered along the inner and outer radial extremes of upper cap members 30 thereof. Connector fittings similar to 126 (but not shown) may be attached to panels 121 and 122 through the use of inserts similar to those which are designated 118 in FIGS. 13 and 16.

In FIG. 16 we also disclose a preferred form of means for attaching cable assemblies 62 to the underside of the reflector surface panels. As indicated above, cured resin cores 119 may be located in each surface panel and have a non-rotatable threaded insert 118 positioned therein. In the FIG. 16 arrangement a grooved, metal wheel 135 is attached to the insert by threaded and shouldered fastener means 136. Cable 64 is arranged to cooperate with the groove in wheel 135. This arrangement minimizes frictional forces which otherwise would be encountered during thermal expansion and contraction of the integrated reflector shell.

Details of the bearing arrangement suggested by FIG. 2 are illustrated in FIG. 10. The inner and outer support means beam components of the reflector assembly are again referenced generally as 40 and 41. A typical support arm portion of elevation-azimuth mount 12 is illustrated in cooperating relation with such beams. Tapered roller bearings 103 are carried by bearing component 42 and by suitable bearing support attached to the support arm of mount 12 in a conventional manner. Bearing member 42 projects through beams 40 and 41 and may be secured in position by the nut designated 104. Other conventional bearing details may be used in connection with our invention in place of the arrangement illustrated in FIG. 10.

As previously described, secondary reflector 14 is supported from primary reflector 13 by the struts of support structure 16. As shown by the cross-sectional view of FIG. 17, each of such struts essentially has a planar form. It is preferred that the length of each strut be aligned radially with respect to the parabolic contour of reflector 13 to thereby minimize the blockage of RF energy. Cables 140 (FIG. 1) are each connected at one extreme to main ring beam 22 at the other extreme to a point on each strut which is intermediate reflector 13 and reflector 14. In this manner we are able to develop adequate support for reflector 14 when reflector 13 is moved to a near-vertical position and yet not adversely affect the desired operating efficiency or capability of the system.

Several additional comments are appropriate in connection with this description of our invention. We prefer that secondary support members 16 and 17 (FIG. 1) be attached to the main ring beam of reflector 13 at a region adjacent the ends of beams 40 and 41. In this manner the loads associated with such supports may be efficiently transmitted into elevation-azimuth mount 12 in bypass relation to the surface panel and backup structure portions of reflector 13. Undesirable deflections in the reflector face otherwise attributed to such supports are thereby avoided during operation of the antenna system.

Also, the invention described herein incorporates what we term an axial-load type design philosophy. We thereby achieve minimum deflections consistent with minimum weight. Because of our extensive use of axially-loaded members, bending deformations are minimized in the backup structure. Reflector pre-loading or pre-stressing developed in inter-ring tension members 25, tensioned cable assemblies 62, and the like minimizes slenderness ratio problems and produces an improved inter-action between backup structure and reflector surface panels. Also, use of a welded construction in the ring beams is effective to reduce joint losses and further minimize the deflections otherwise associated therewith.

It is to be understood that the forms of the invention herewith shown and described are to be taken as preferred embodiments of the same, but that various changes in the shape, size, number, and arrangement of parts may be resorted to without departing from the spirit of the invention or the scope of the claims.

We claim:

1. In an antenna system having a mount, a large-diameter reflector rotatably supported relative to said mount, and comprising:

(*a*) A main ring beam means,

(*b*) Trunnion beam means secured in chordal relation to said main ring beam means and rotatably connecting the reflector to the antenna system amount,

(*c*) Other ring beam means concentrically located radially outwardly and radially inwardly relative to said main ring beam means and connected thereto,

(*d*) Reflector panel members arranged to form a parabolic reflecting surface which is radially coextensive with said other ring beam means,

(*e*) Tensioning means joining said reflector panel members into a unitary thin-walled shell assembly stressed in hoop compression, and

(*f*) Connector means fastened to said shell assembly and to said main ring beam means,

said tensioning means and said connector means serving to carry substantially the entire weight of said reflector panel members to said main ring beam means in by-pass relation to said other ring beam means when the reflector is in a horizontal position.

2. The invention defined by claim 1, wherein shear connector means are fastened to said shell assembly and to said trunnion beam means, said shear connector means serving to carry substantially the entire weight of said reflector panel members to said trunnion beam means when the reflector is rotated to a vertical position.

3. The invention defined by claim 1, wherein other connector means are fastened to said shell assembly and to said other ring beam means, said other connector means substantially restricting adjacent portions of said shell assembly from movement relative to said other ring beam means only in directions generally parallel to the axis of symmetry of the reflector.

4. The invention defined by claim 1, wherein a secondary reflector is provided in spaced-apart relation to said shell assembly and is supported by elongated strut members, one end of each of said strut members being connected to the large-diameter reflector adjacent said main ring beam means.

5. In an antenna system having a mount, a large-diameter reflector rotatably supported relative to said mount, and comprising:

(*a*) A unitary shell having a parabolic reflecting surface and essentially comprised of parabolic reflector panels joined together in hoop compression,

(*b*) A main ring beam means located concentrically with respect to said unitary shell and at a mid-way position in the radial extent of said unitary shell reflecting surface,

(*c*) First connector means which are fastened to said unitary shell and to said main ring beam means, which transfer substantially the entire weight of said unitary shell into said main ring beam means when the reflector is in a generally horizontal position, and which permit portions of said unitary shell to move relative to said main ring beam means in directions generally normal to the reflector radio frequency axis when the reflector is rotated to a generally vertical position,

(*d*) Other ring beam means supported by and located radially outwardly and radially inwardly relative to said main ring beam means and each comprised of spaced-apart tubular upper and lower cap members which constitute chords of a circle, circumferentially spaced-apart tubular strut members connected to said upper and lower cap members to maintain said cap members in spaced-apart relation with respect to each other along a direction parallel to the reflector radio frequency axis, and tension means connected to said upper and lower cap members intermediate said strut members to place all of said members in each of said other ring beam means in compression loading, and

(*e*) Second connector means fastened to said unitary shell and to each of said other ring beam means adjacent said upper cap members,

said other ring beam means and said second connector means restricting movement of adjacent portions of said unitary shell in directions parallel to the reflector radio frequency axis when such portions move relative to said other ring beam means in directions generally normal to the reflector radio frequency axis as the reflector is rotated to a vertical position.

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