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J. R. BARBER
ANTENNA STRUCTURE

3,233,475

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3 Sheets-Sheet 1

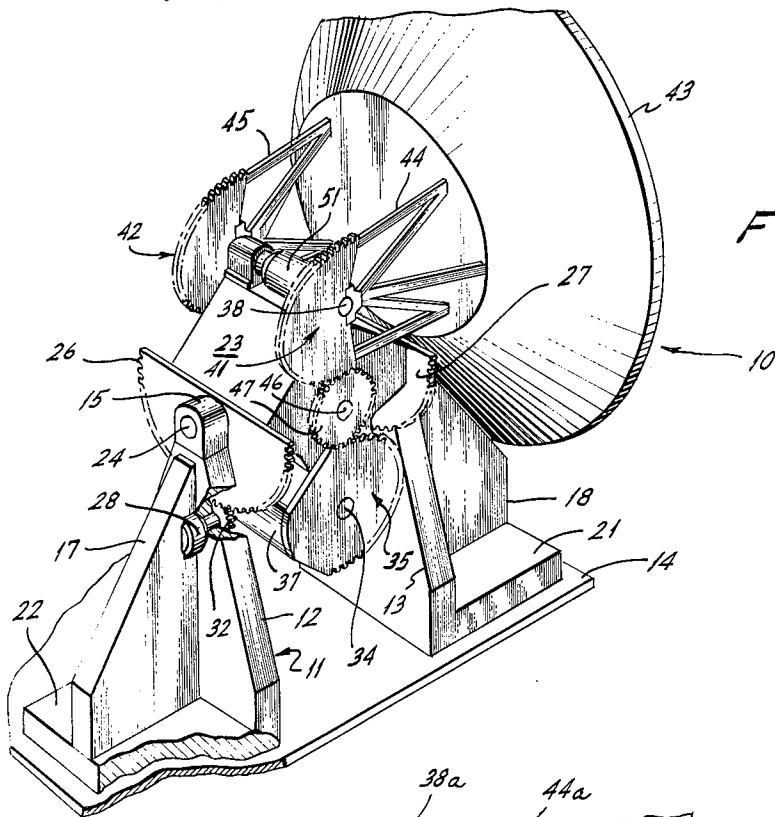


FIG. 1.

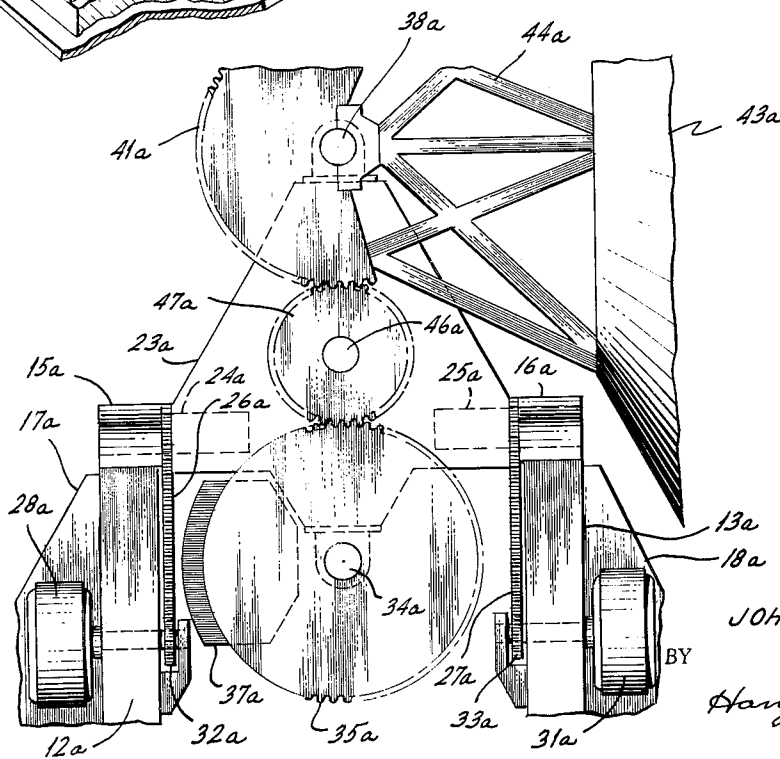


FIG. 4.

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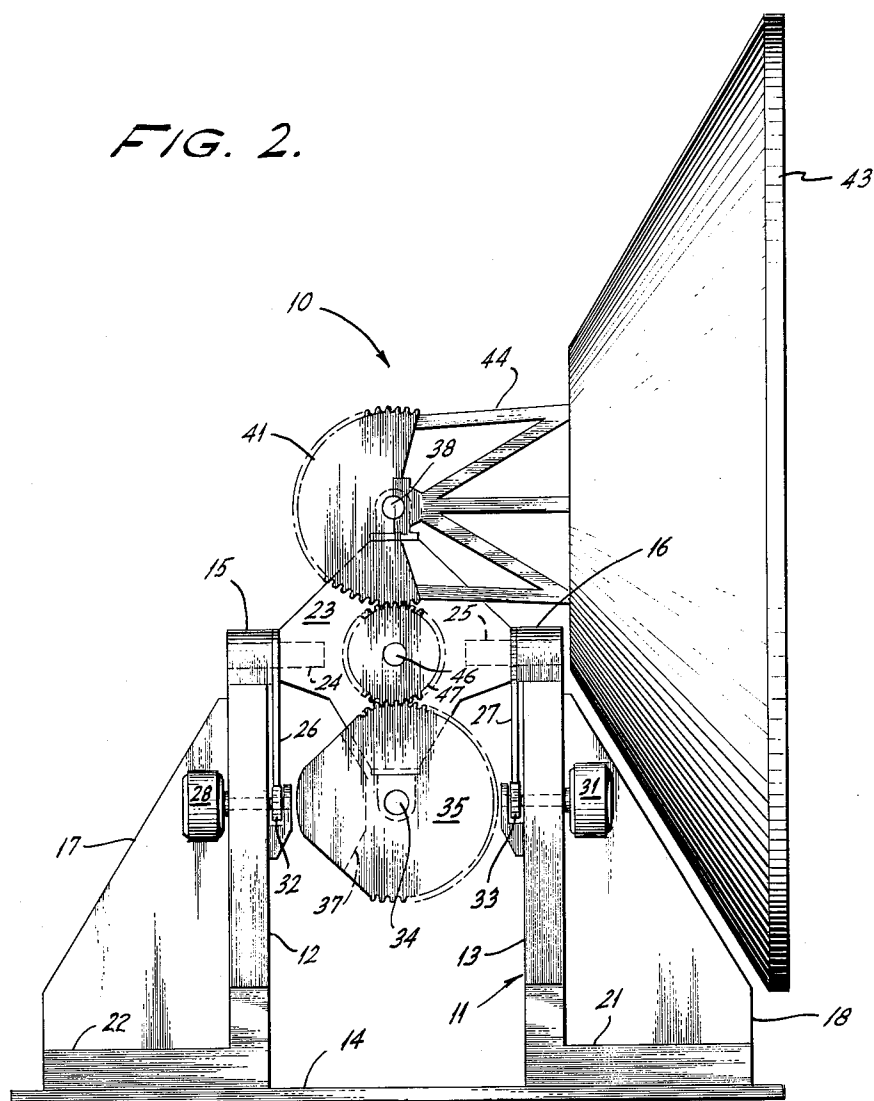
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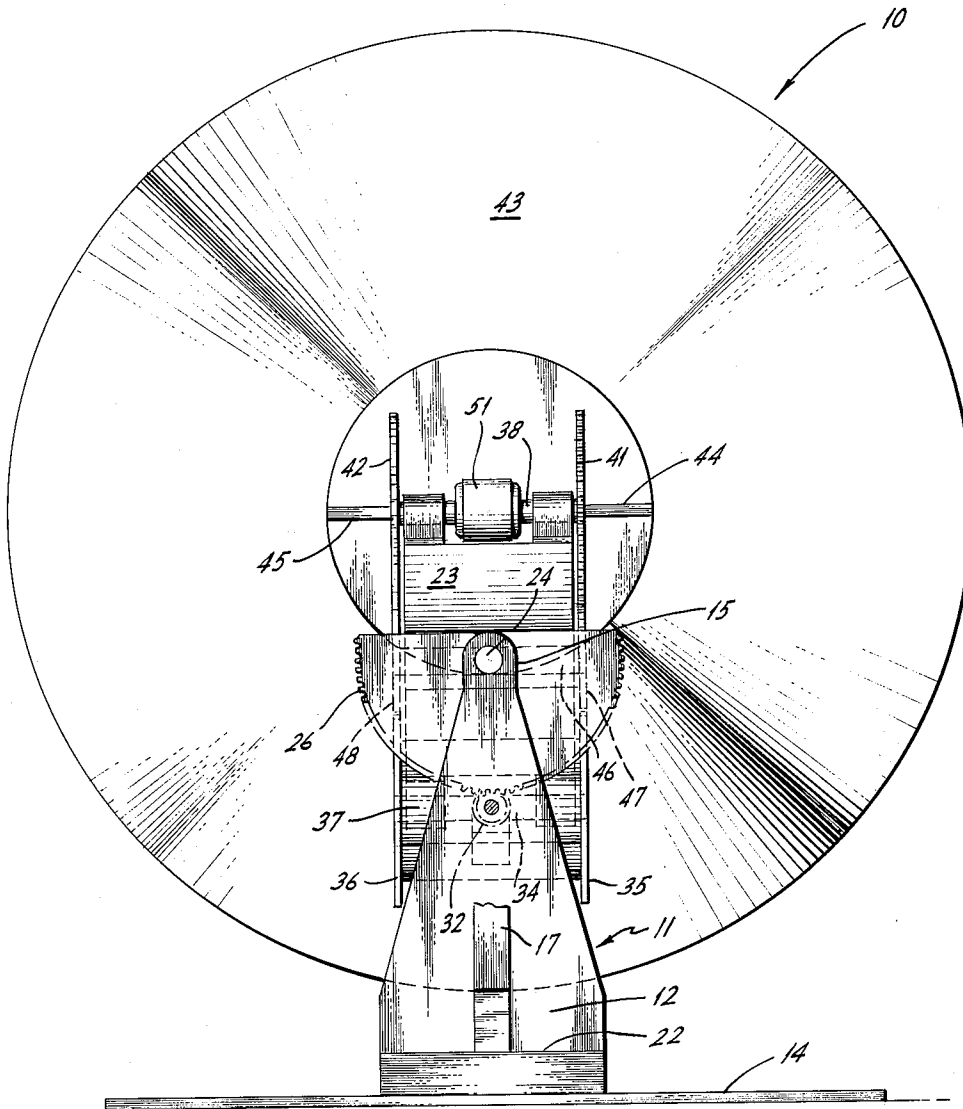


FIG. 3.

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ANTENNA STRUCTURE

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11 Claims. (Cl. 74-90)

This invention relates to antenna structure, and more particularly to base or pedestal means constructed and arranged to support relatively large antennas, or similar massive structures, for pivotal movements about a plurality of axes.

The invention is specifically concerned with improvements in counterbalancing apparatus associated with movable generally dish-shaped, or parabolic, antenna structure and accommodating multi-axis pivotal movement of the latter.

In pivotally movable antenna structure wherein a massive antenna is moved about a pair of axes, either intersecting or non-intersecting, counterbalancing means, comprising counterweights, have posed problems due to structural interference between the counterweights and the pedestal structures. Such interference prevents desired full-hemispherical sky coverage and therefore limits the effectiveness of the antenna structure.

It is an objective of this invention to provide improved two-axis, counterbalanced support means for pivotally movable antenna structure, which means affords full hemispherical sky coverage by the antenna.

It is a further objective of the invention to provide counterbalancing means for a pivotally movable massive parabolic antenna, which means, in carrying out its function, is movable in paths which preclude interference thereof with fixed structure, thereby ensuring pivotal movement of the massive antenna to any of its positions.

In achievement for the foregoing and other objectives, the invention comprises, in support means for a massive structure: bearing means; yoke means mounted for pivotal movements upon said bearing means; a massive structure mounted for pivotal movements upon said yoke means, about a first axis disposed above and extending transversely of the axis of said bearing means; counterweight means mounted for pivotal movements upon said yoke means about a second axis disposed below said bearing means and extending parallel to said first axis about which said massive structure is pivotal; linkage means, preferably including an idler gear connection, so disposed between said massive structure and said counterweight means as to interconnect the same for movements corresponding to the movements of said structure and in sense opposite thereto, whereby to cause said counterweight means statically to balance said massive structure in any of its positions of movement, either about the axis of said bearing means or about said first axis.

It will be appreciated, therefore, from what follows that the above-described system of linkages achieves, effective counterbalance and a high degree of mobility of the antenna, as well as full-hemispherical sky coverage by the latter.

The foregoing as well as other features and objectives of the invention will be more clearly understood from a consideration of the following description, taken in light of the accompanying drawings in which:

FIGURE 1 is a perspective showing, on a greatly reduced scale, of antenna structure embodying the invention;

FIGURE 2 is a slightly enlarged elevational showing of apparatus illustrated in FIGURE 1, as seen from the side;

FIGURE 3 is an elevational showing, with a part broken away, of apparatus illustrated in FIGURE 2 as seen from the rear; and

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FIGURE 4 is a fragmentary showing, similar to that of FIGURE 2, of a slightly modified mechanical linkage system embodying the invention.

With reference to FIGURES 1, 2 and 3 of the drawings, the antenna structure 10 comprises pedestal means 11 defined by a pair of vertically extending standards 12 and 13 mounted upon suitable base structure 14. Standards 12 and 13, as viewed in FIGURE 3, are generally triangularly shaped and each has at its apex a bearing 15 and 16, respectively. The bearings are axially aligned with one another and, by way of example, extend generally horizontally in a direction transverse the major planes of the confronting standards. Standards 12 and 13 further include brace portions 17 and 18 and base portions 21 and 22, respectively. As will be described later, it is contemplated that for certain applications the axis of bearings 15 and 16 may extend with angularity as respects the horizontal.

Means defining a frame or yoke 23 is rotatably journaled by stub shafts 24 and 25 within said bearings 15 and 16, respectively. A pair of sector gears 26 and 27 are affixed to yoke 23 and are concentric with the common axis of journals or stub shafts 24 and 25. As best seen in FIGURE 2, motors 28 and 31 are carried by standards 12 and 13, the shafts of which motors are disposed in horizontal axial alignment and have pinions 32 and 33 at the respective ends thereof. Pinions 32 and 33 mesh with sector gears 26 and 27, respectively, the construction and arrangement being such that motors 28 and 31, when energized simultaneously, will rotate yoke 23 about the horizontal axis provided by journals 24 and 25 within bearings 15 and 16. Preferably, a pair of motors are used in order to avoid undue loading thereof as well as to minimize deformation of elements making up the linkage system due to unsymmetrical application of torsional forces thereto, as may arise from using a single motor.

A rotatable shaft 34 supported by frame or yoke 23 extends along a horizontal axis disposed below the axis of journals 24 and 25, and further extends perpendicular to the axis of the journals. A pair of sector gears 35 and 36 are carried by shaft 34, one at each end thereof. A massive counterweight 37 is suspended between opposed sections of sector gears 35 and 36 substantially parallel to the axis of shaft 34 and has its center of gravity disposed to the side of the latter opposite the teeth portions of the gears.

Another rotatable shaft 38 is supported by yoke 23, and has its axis disposed above the axis of journals 24 and 25 and extending substantially parallel to the axis of lower shaft 34. Upper shaft 38 carries a pair of spaced sector gears 41 and 42, one at each end thereof.

A massive antenna 43, the interior dish surface of which is parabolic, is supported upon sector gears 41 and 42 by suitable truss means 44, 45, and has its center of gravity positioned to the side of the latter sector gears opposite the shaft 38 and the massive counterweight 37. The antenna is frequently very large, for example it may be sixty to eighty or more feet in diameter.

A third rotatable shaft 46 carried by yoke 23 extends parallel to and is disposed intermediate shafts 34 and 38. A pair of spaced pinions 47 and 48 are carried by ends of the shaft 46 and are meshed with upper and lower sector gears 41, 35 and 42, 36. A motor 51 carried by yoke 23 is illustrated as being adapted, by way of example, to drive shaft 38 to provide for pivotal elevational movements of the antenna about the axis of shaft 38. However, it will be understood that this drive motor may be coupled directly with shaft 46 whereby drive of the antenna will be through pinions 47 and 48. In driving the antenna with shaft 38, sector gears 41, 42 drive pinions or idler gears 47, 48, which in turn

drive sector gears 35, 36, thereby moving the attached counterweight 37 in correspondingly opposite direction as respects the antenna movements. For example, as the antenna pivots upwardly about the axis defined by shaft 38, the counterweight pivots downwardly about the axis of shaft 34, and conversely, as the antenna pivots downwardly the counterweight pivots upwardly.

The construction and arrangement is such that the weight of the antenna 43 is translated into a tangential force through sector gears 41, 42 tending to rotate pinions 47 and 48 in one direction, while counterweight 37 exerts a tangential force through sector gears 35, 36 tending to rotate pinions 47 and 48 in the opposite direction. The counterweight therefore statically balances antenna 43 about the axis of shaft 38 through the linkage comprising pinions 47, 48 and sector gears 41, 42, and 35, 36.

Also antenna 43, pinions 47, 48, their associated sector gears, and counterweight 37, are pivotally movable by motors 28 and 31 which drive pinions 32, 33 and sector gears 26, 27 meshed therewith about the horizontal axis provided by bearings 15, 16. Thus, the same counterweight is disposed and adapted to balance the antenna about the axis of the bearings 15 and 16, and moves freely in the unobstructed space between standards 12 and 13.

Respective pivotal movements of antenna 43 about the axis of bearings 15, 16 and about the axis of shaft 38 are achieved by known programming means for coordinating energization of motors 28, 31 and 51 and adapted to cause the antenna to track a desired azimuthal and elevational path.

In the embodiment of the invention illustrated in FIGURES 1, 2 and 3 the axes of shaft 46 and of the coaxial stub shafts or journals 24 and 25 are seen to intersect. However, it will be appreciated that it may be necessary in some instances, in establishing balance of a system embodying the invention, to space the axis of shaft 46 above the axes of coaxial stub shafts 24, 25. This latter, modified construction is illustrated in FIGURE 4, in which elements of the modified mounting structure are identified by the same reference numerals as are used in connection with the embodiment illustrated in FIGURES 1, 2 and 3, but with the suffix *a* appended thereto.

It will be appreciated therefore that due to the symmetry of the elements of the linkages and of the counterweight, the antenna structure in any of its positions is statically balanced about a pair of non-intersecting axes. Also, the counterweight and linkage combination advantageously does not interfere with the fixed support-structure, so that full-hemispherical sky coverage is attainable.

It should be understood that the disclosed counterbalance linkage need not be limited to use in combination with massive antenna structure, but may also be used in combination with similarly movable massive structures requiring counterbalance.

Further it will be understood that the antenna structure can be used in applications where the axis defined by bearings 15 and 16 is not horizontal. Such an arrangement may be desirable when the antenna is used as a radio telescope.

I claim:

1. In support means for a massive structure; frame means mounted for pivotal movements about a horizontal axis; massive structure mounted for pivotal movements upon said frame means about a first axis disposed above and extending transversely of the recited horizontal axis about which said frame means is pivotal; counterweight means mounted for pivotal movements upon said frame means about a second axis disposed below said horizontal axis and extending parallel to said first axis about which said massive structure is pivotal; and linkage means including an idler gear connection so disposed between said massive structure and said

counterweight means as to interconnect the same for movements corresponding to the movements of said structure and in sense opposite thereto, whereby to provide for static balance of said massive structure by said counterweight means in any positions of movement about said horizontal axis or about said first axis.

2. In support means for a massive structure: bearing means having a substantially horizontal axis; frame means mounted for pivotal movements upon said bearing means; a massive structure mounted for pivotal movements upon said frame means about a first axis disposed above and extending transversely of the axis of said bearing means; counterweight means mounted for pivotal movements upon said frame means about a second axis disposed below said bearing means and extending parallel to said first axis about which said massive structure is pivotal; and linkage means including an idler gear connection so disposed between said massive structure and said counterweight means as to interconnect the same for movements corresponding to the movements of said structure and in sense opposite thereto, whereby to provide for static balance of said massive structure in any of its positions of movement about the axis of said bearing means or about said first axis.

3. Antenna support structure, comprising: bearing means; yoke means including journal means providing pivotal support thereof upon said bearing means; antenna structure mounted upon said yoke means for pivotal movement about a first axis disposed above and extending transversely of the axis of said journal and bearing means; counterweight means mounted for pivotal movement upon said yoke means about a second axis disposed below said journal and bearing means and extending parallel to said first axis about which said antenna structure is pivotal; and a linkage comprising idler gear means interconnecting said antenna structure and said counterweight means and arranged to effect correspondingly opposite rotational movements of said antenna structure and said counterweight means, whereby to provide for static balance of said antenna structure in any of its positions of pivotal movement, either about the axis of said journal and bearing means or about said first axis.

4. Antenna support structure, comprising: antenna structure mounted for pivotal movement about a first axis; counterweight means mounted for pivotal movement about a second axis disposed below said first axis and extending parallel to the same; and a linkage comprising idler gear means interconnecting said antenna structure and said counterweight means and arranged to provide opposite movements thereof corresponding to the movements of said antenna structure, whereby to provide for static balance of said antenna structure by said counterweight means in any of its positions of movement.

5. Antenna support structure according to claim 4, and further including frame means provided with journal means and supporting said antenna structure and said counterweight means for the recited pivotal movements; bearing means supporting said frame means through said journal means for pivotal movements about an axis extending transversely of and disposed below said first axis, said bearing and journal means further being disposed above said second axis, the construction and arrangement being such that said counterweight means further statically balances said antenna structure in any of its positions of rotational movement with said frame means about said bearing means.

6. Support apparatus for a massive structure, comprising: means defining a pedestal; a pair of spaced, axially aligned bearings carried by said pedestal; means defining a yoke disposed between said bearings and having journals provided for rotatable support thereof within said bearings; a pair of first sector gears concentric with the axis of said yoke defined by said journals and bearings; first pinion means meshing with each said first sector gears; first

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motor means for rotating each said first pinion means whereby to drive said first sector gears and rotate said yoke within said bearings; a first rotatable shaft supported by said yoke, disposed below the axis of said bearings and journals, and having its axis extending transversely of the axis of said bearings and journals; a pair of spaced second sector gears carried by said first shaft, one gear at each end thereof; a massive counterweight suspended between opposed sections of said second sector gears, and having its center of gravity disposed to one side of teeth portions of the latter; a rotatable second shaft supported by said yoke, disposed above the axis of said bearings and journals and having its axis disposed substantially parallel to the axis of said first shaft; a pair of spaced third sector gears carried by said second shaft, one gear at each end thereof; a massive structure supported by opposed sections of said third sector gears and having its center of gravity disposed to the side thereof opposite teeth portions of the latter and the center of gravity of said massive counterweight; a third rotatable shaft carried by said yoke parallel to and intermediate said first and second shafts; a pair of spaced second pinions carried by opposite ends of said third shaft, each second pinion intermeshed with a recited second and third sector gear; and second motor means for driving one of said shafts, the construction and arrangement being such that the structure is rotatably movable about the said second shaft, by energizing the second motor means to cause the second pinions to rotate the third sector gears, and concurrently with movement of the structure, the second sector gears are rotated in a direction opposite to movement of the structure whereby the counterweight is moved to positions providing for static counterbalance of the structure, and said structure further is pivotally movable about said journals, to either side of center, by energization of said first motor means, said counterweight and portion of the yoke below said journals and bearings being disposed and adapted statically to counterbalance said structure in said last recited movements.

7. Apparatus according to claim 4 and characterized in that said massive structure comprises directional antenna means, and the recited pivotal support thereof achieves full-hemispherical sky coverage by said antenna means.

8. Support apparatus for a massive structure, comprising: means defining a pedestal; means defining a yoke supported for pivotal movements about a substantially horizontal axis extending between spaced, axially aligned portions of said pedestal; a first pair of gears concentric with the recited horizontal axis about which said yoke is pivotal; a first pair of pinion means meshing with each gear of said first pair of gears; first motor means for rotating said first pair of pinion means to drive said first pair of gears whereby to rotate said yoke about said horizontal axis; a first rotatable shaft supported by said yoke, disposed below said horizontal axis, and having its axis horizontal and extending perpendicular to said horizontal axis; a second pair of spaced gears carried by said first shaft, one gear at each end thereof; a massive counterweight suspended between opposed sections of each of said second pair of gears and having its center of gravity disposed to one side of the axis of said first shaft; a rotatable second shaft supported by said yoke, disposed above said horizontal axis about which said yoke is pivotal and having its axis disposed substantially parallel to the axis of said first shaft; a third pair of spaced gears carried by said second shaft, one gear at each end thereof; a massive structure supported by opposed sections of each gear of said third pair of gears and having its center of gravity disposed to the side thereof opposite the center of gravity of said massive counterweight; a third rotatable

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shaft carried by said yoke parallel to and intermediate said first and second shafts; a second pair of spaced pinions carried by opposite ends of said third shaft, each last recited pinion intermeshed with gears of the recited second and third pair; and second motor means for driving said shafts, the construction and arrangement being such that the structure is rotatably movable about the said second shaft, by energizing the second motor means to cause the second pair of pinions to rotate the third pair of gears, and concurrently with movement of the structure, the second pair of gears are rotated in a direction opposite to movement of the structure whereby the counterweight is moved to positions providing for static counterbalance of the structure, and said structure further is pivotally movable about the recited horizontal axis of said yoke, by energization of said first motor means, said counterweight and portion of said yoke below said horizontal axis being disposed and adapted statically to counterbalance said structure in said last recited movements.

9. Antenna support structure, comprising: antenna structure mounted for pivotal movement about a first axis; counterweight means mounted for pivotal movement about a second axis spaced from and extending parallel to said first axis; and a linkage comprising idler gear means interconnecting said antenna structure and said counterweight means and arranged to provide opposite movements thereof corresponding to the movements of said antenna structure, whereby to provide for static balance of said antenna structure by said counterweight means in any of its positions of movement.

10. Antenna support structure according to claim 9, and further including frame means provided with journal means and supporting said antenna structure and said counterweight means for the recited pivotal movements; bearing means supporting said frame means through said journal means for pivotal movements about an axis extending transversely of and disposed intermediate said first axis and said second axis, the construction and arrangement being such that said counterweight means further statically balances said antenna structure in any of its positions of rotational movement with said frame means about said bearing means.

11. In support means for a massive structure: frame means mounted for pivotal movements about a first axis; massive structure mounted for pivotal movements upon said frame means about a second axis disposed to one side of and extending transversely of the recited first axis about which said frame means is pivotal; counterweight means mounted for pivotal movements upon said frame means about a third axis disposed to a side of said first axis opposite and extending parallel to said second axis about which said massive structure is pivotal; and linkage means including an idler gear connection so disposed between said massive structure and said counterweight means as to interconnect the same for movements corresponding to the movements of said structure and in sense opposite thereto, whereby to provide for static balance of said massive structure by said counterweight means in any positions of movement about said first axis or about said second axis.

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