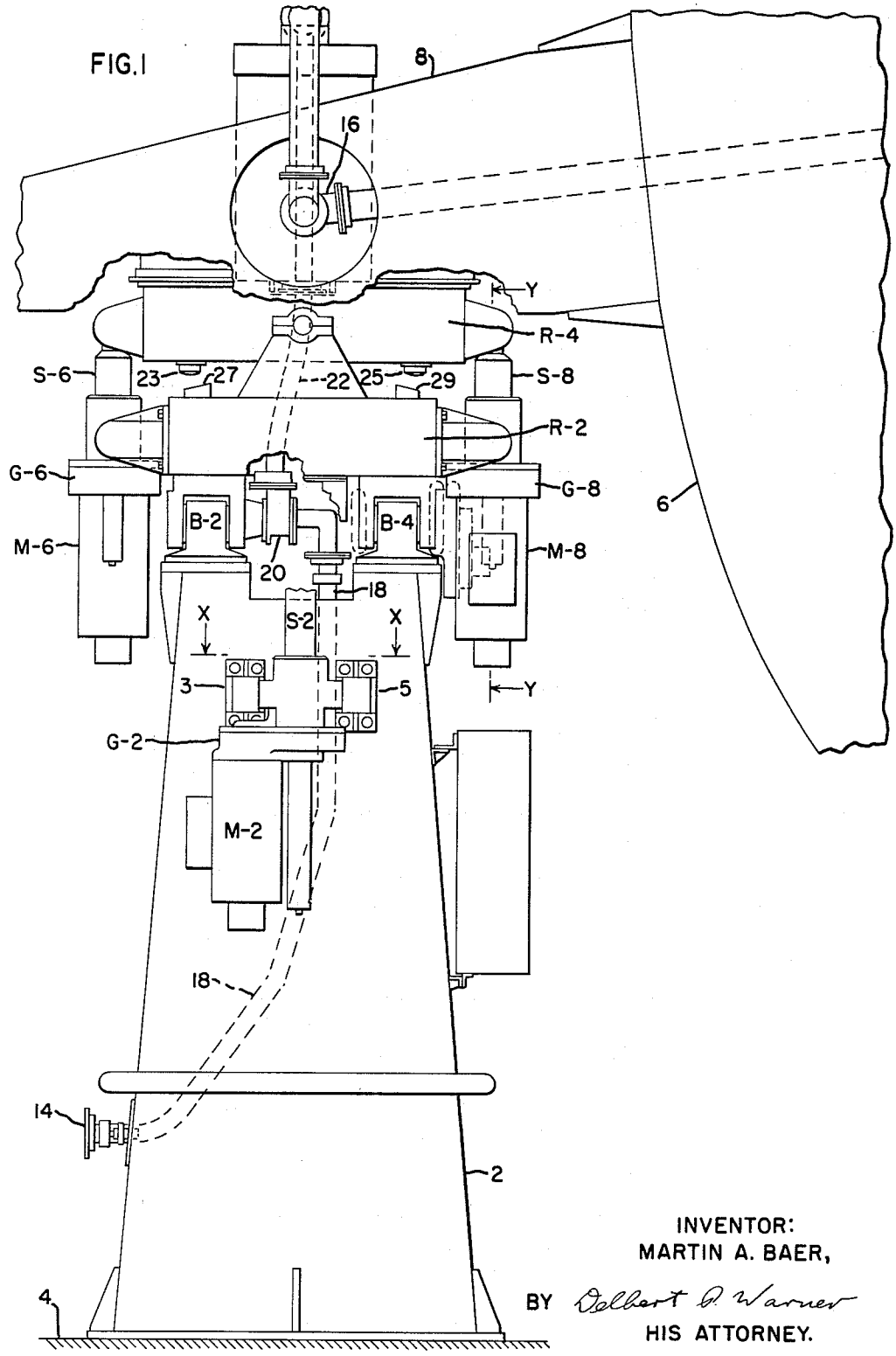
Nov. 16, 1965 M. A. BAER 3,218,015

GIMBAL CONFIGURATION FOR A STABLE BASE

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FIG. 1



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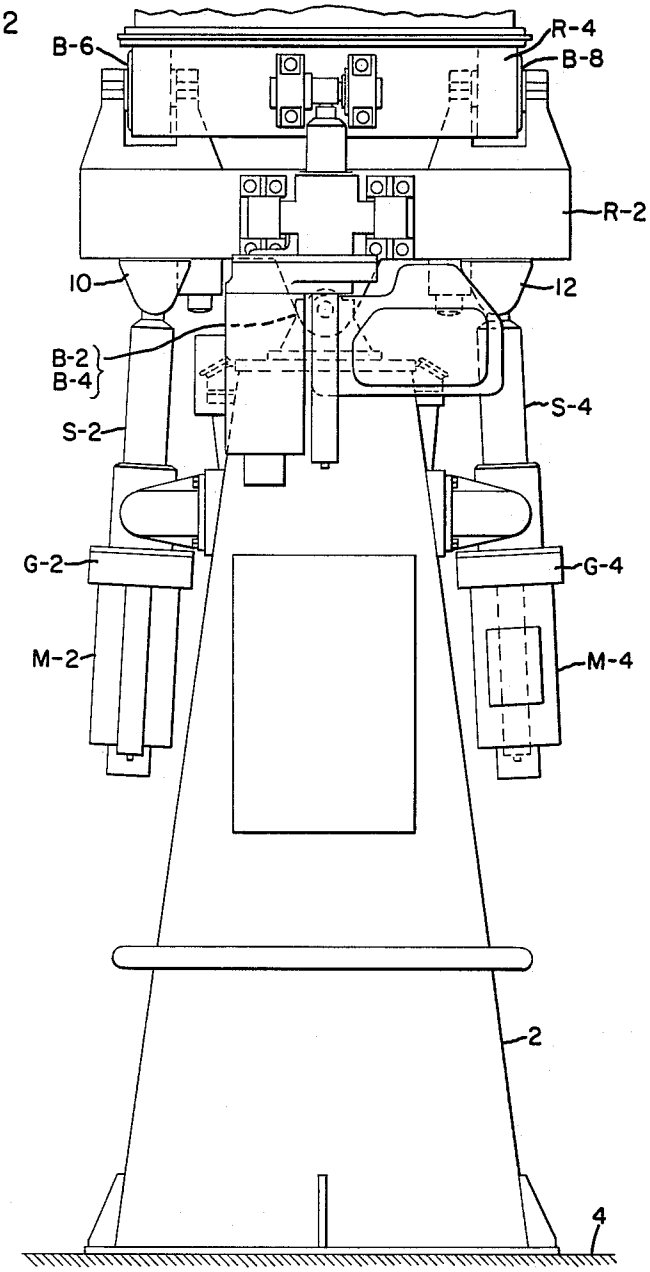
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GIMBAL CONFIGURATION FOR A STABLE BASE

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FIG.2



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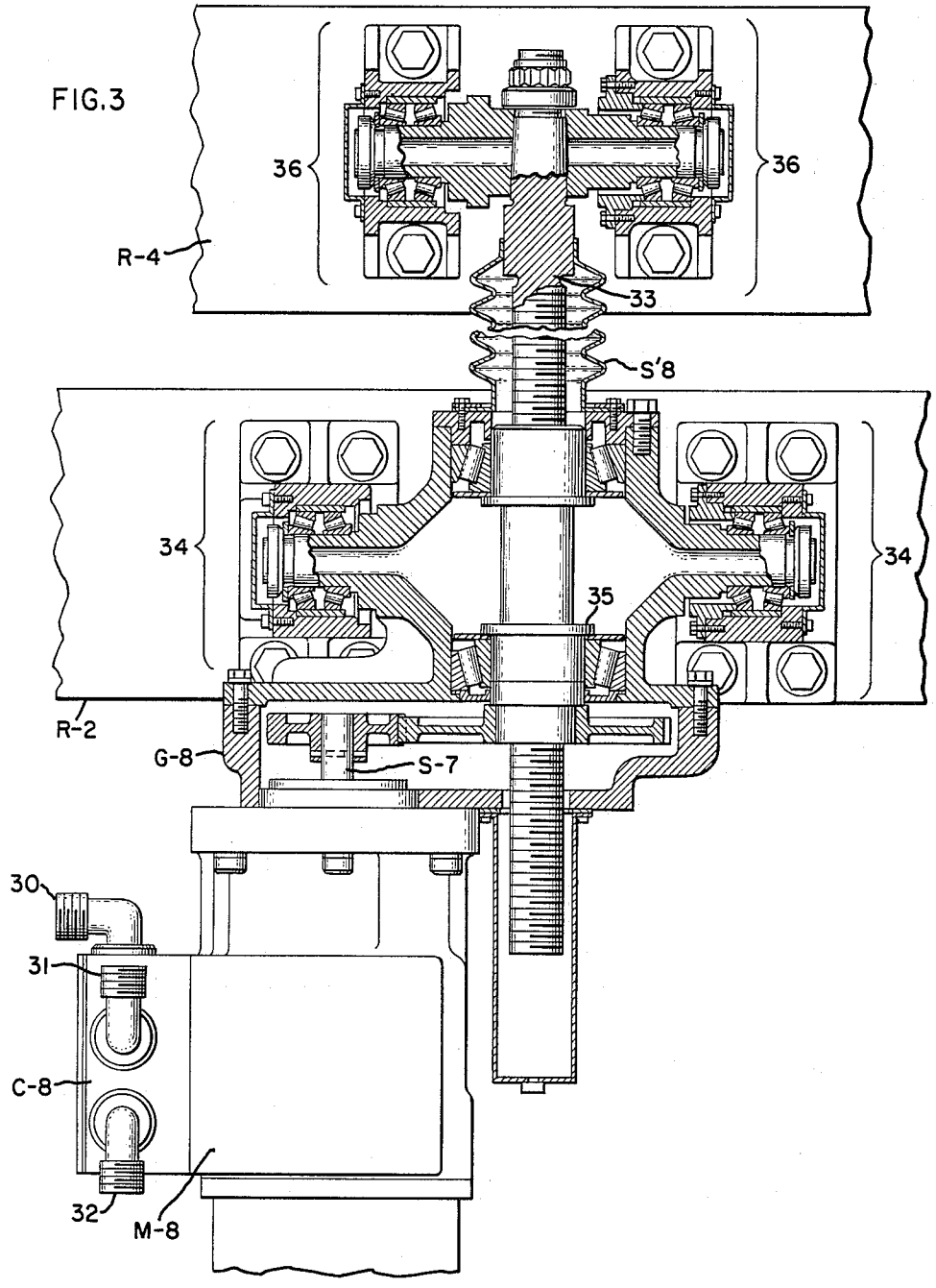
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FIG.3



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GIMBAL CONFIGURATION FOR A STABLE BASE

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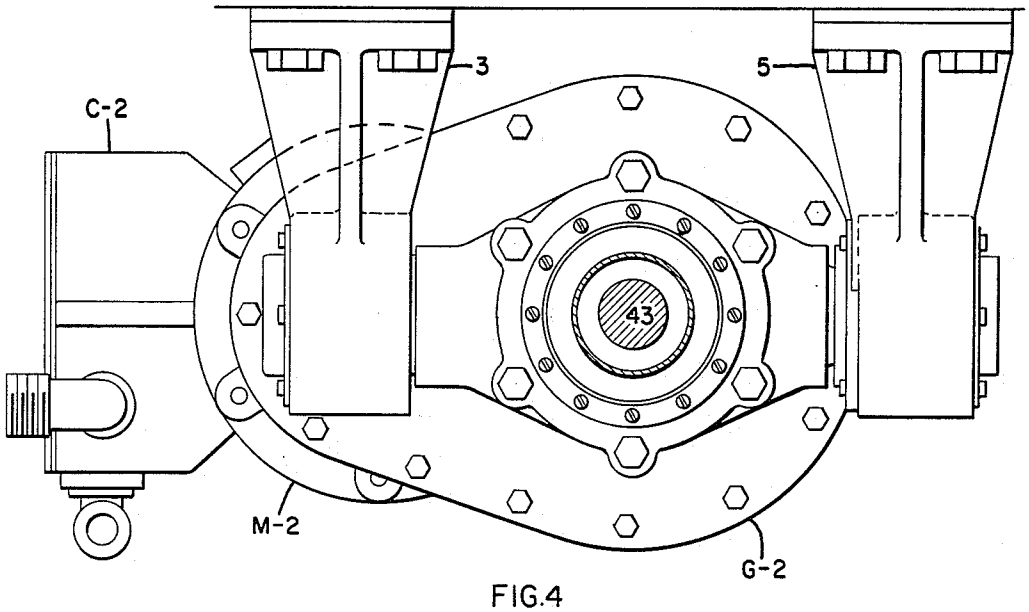


FIG.4

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United States Patent Office 3,218,015 Patented Nov. 16, 1965

3,218,015

GIMBAL CONFIGURATION FOR A STABLE BASE

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Filed Apr. 22, 1963, Ser. No. 274,766
1 Claim. (Cl. 248—184)

This invention relates to platforms which are supported by unstable objects such as ships but which are actively maintained in stable attitudes relative to the ground. In particular, the invention relates to improved gimbals and supporting structures to provide stability for relatively massive structures which may be oscillated about an axis.

The prior art platforms for providing a stable base with respect to the earth under unstable conditions, such as may be found on a rolling and pitching ship, include gimbals which have their axes in a common plane. Such devices afford a structure which can be rotated about two sets of axes at right angles to each other and can be precisely controlled to provide stability about each of the axes to compensate for motion such as pitch and roll. However, such concentrically disposed gimbals tend to be massive if they are heavily loaded and are subjected, because of their size and the great magnitude of their mass and imposed loads, to excessive bending moments and other forces. Such massive gimbals pose a problem (of support) on such structures as the masts of ships where they have been used to stabilize radar antennnas. In addition to being excessively bulky and heavy, such prior art devices have required relatively large driving motors and power supplies, thereby aggravating the already stringent space and weight requirements on shipboard as well as complicating the problems of supply because of their need for large spare parts and extra fuel. Furthermore, the prior art devices have required the use of excessively complex waveguide rotary joints and other components wherever they have been used in radar antennas. In addition, if there is a structure above the upper gimbal ring, concentric gimbals are limited in their excursions by the lower ring.

It is a primary object therefore of this invention to provide an improved platform which may be stabilized about pitch and roll axes.

It is a further object of this invention to provide a stable platform having higher mechanical resonance due to the elimination or at least minimization of backlash and structural bending.

It is another object of this invention to provide a stable platform to support an antenna and at the same time reduce the complexity of the waveguide runs, bends and rotary joints.

It is still another object of this invention to provide a safer mechanical drive system for stable platforms.

It is still a further object of this invention to provide an improved stable platform having a reduced need for bulky and heavy components.

It is yet another object of this invention to provide improved stable platforms using identical drive components for all motions.

It is still another object of this invention to match the platform (load) inertia to the prime mover inertia in order to reduce the torque requirements on the prime mover.

The foregoing objects and others ancillary thereto preferably may be accomplished by actuating a roll gimbal ring relative to ground and a pitch gimbal ring relative to the roll gimbal ring. In order to provide this motion, the two gimbal rings are supported in a novel way—the first by its axis on a set of pillow blocks and the second by its axis on the first. The first gimbal is then actuated about its axis to provide roll motion relative to the ground

(or more commonly to remain stationary relative to the ground while the support rolls) and the second gimbal ring is actuated about its axis to provide pitch motion relative to the first (or to maintain a horizontal attiude while is supports undergo pitching motion). This construction assures that the two gimbal rings working in concert in response to appropriate signals will constitute a platform which will maintain a stable relationship to the horizon. This stable relationship will be maintained by the ship gimbals even on a ship or other vehicle which is pitching and rolling. This construction also makes it possible to build a simpler and stronger platform while decreasing the weight relative to the prior art devices. In addition, it provides for more nearly direct connections of the waveguide and data transducers from a transmitter through the gimbal rings to the antenna.

For a fuller understanding of the nature and objects of the invention reference should be had to the following detailed description taken in connection with the accompanying drawings, in which:

FIG. 1 is a view of a preferred embodiment of the invention showing certain relationships between the invention and various associated components including a mast and an antenna,

FIG. 2 is another view of the invention and various associated components showing the invention from a different viewpoint,

FIG. 3 is a partial section of the invention taken along the lines Y—Y of FIG. 1,

FIG. 4 is a partial section taken along the lines X—X of FIG. 1.

Turning now to FIG. 1, we find a side view of an antenna and mast, or tower, such as might be found on shipboard. As seen from the viewpoint of FIG. 1, that portion of the invention relating to control of motion of lesser magnitude, which will generally be pitch on shipboard, is shown most clearly. The control of roll will be most clearly evidenced by the view of FIG. 2. As shown in FIG. 1, a tower at 2 is supported on a base at 4 and, it will be recognized, should be rigidly secured to the base at 4 where the base 4 may be the deck of the ship or the mounting of a mast even larger than the tower or mast illustrated at 2. It will be recognized that by securing the tower on the fittings of the ship it will move in pitch and roll along with the ship. The ultimate purpose of the tower 2, of course, is to support a large radar antenna 6 which in turn is supported on a boom or arm 8 with the boom or arm 8 secured in some fashion to the tower 2. In order to isolate the antenna 6 from fthe tower 2 the present invention is interposed as a connection between the boom 8 and the tower 2 so that as the tower 2 moves in response to pitch and roll of the ship, the boom 8 and antenna 6 can be isolated from that motion.

The invention isolates the respective motion of the tower 2 and the antenna 6 by use of two gimbal rings shown at R–2 and R–4 where the lower ring R–2 may be used in compensating for roll motion and the upper ring R–4 may be used in compensating for pitch motion. The lower gimbal ring R–2 is supported on a tower 2 by pillow blocks and bearings at B–2 and B–4 so that the antenna static weight is directly supported through these pillow blocks by the tower 2. In addition to this principal support through the pillow blocks, the stabilizing moments are supplied through the two drives at G–2 and G–4 acting as a force couple on opposite sides of the gimbal ring R–2 on each side of the tower 2 with appropriate drive motors at M–2 and M–4 (FIG. 2) and with appropriate mechanical couplings through the housings G–2 and G–4 to separate ball screws at S–2 and S–4. It will be recognized that hydraulic pistons and cylinders could be used to control the attitude of the

gimbal ring to the fixed trunnions shown at 10 and 12 in FIG. 2. The actual control of the motors or hydraulic actuators will be provided by signals from a gyroscope, a stable element, or other device which can sense the positioning of the ship. It will be recognized that such signals will normally be available and that their supply is a matter outside the scope of the present invention.

With stability about one axis assured by operation of the gimbal ring R–2, it then remains necessary only to stabilize the motion about a second axis perpendicular to the first and in a plane parallel to the first axis in order to provide a platform which will remain stable relative to the earth at all times. In order to effectuate this control about a second axis the gimbal ring R–4 is employed, as previously indicated. The gimbal ring R–4 is supported at two pivots corresponding to two points along an axis about which it is designed to rotate. The support pivots are represented by bearings at B–6 and B–8, FIG. 2, which bear all of the static weight of the antenna 6 which is transmitted directly to the gimbal ring R–2 and from there to the tower 2. The moments required to stabilize the pitch gimbal ring R–4 are supplied by the drives M–6; G–6; S–6 and M–8; G–8; S–8 acting as a force couple on opposite sides of the gimbal sides of the gimbal ring R–4. This arrangement is identical in principal to that used in stabilizing the gimbal ring R–2. The elements S–6 and S–8, will in a preferred embodiment be ball bearing screws which in turn will be controlled by gear trains enclosed in housings G–6 and G–8 which are controlled by motors M–6 and M–8. The motors M–6 and M–8 are made responsive to control signals from a gyroscope or stable element or other sensing and signal transmitting device.

From the foregoing it can be ascertained that a relatively compact and strong new mode of supporting and dynamically stabilizing large structures has been devised. It is thus clear that the main or static loads are transmitted directly from gimbal ring R–4 to gimbal ring R–2 and to tower 2 through B–6 and B–8; and B–2 and B–4, while the moment, or stabilizing loads are resolved into force couples though the pitch and roll drives. This eliminates practically all bending loads at both gimbal rings. A more direct and more firm support than this is hardly possible, for the conditions which must be met in the foreseeable environments, with the materials which are available for construction. Less rigid requirements will permit the use of only one drive for each motion rather than the two shown.

In addition, the present invention makes it possible to provide an improved rotary joint and simplified waveguide runs and bends through the stable base to the antenna. This improvement is clearly shown between the microwave coupler at 14 at the base of the tower and the coupler at 16 which connects to the antenna 6. The dashed lines 18 represent a fixed waveguide which is coupled to a single rotary joint at 20 and from there to the flexible waveguide 22 and then to the coupler 16. It will be recognized that the single rotary joint 20 is intended to permit much of the roll motion between the gimbal ring R–2 and the tower while the flexible waveguide permits pitch motion.

FIG. 3 represents a partial section taken along the line Y—Y in FIG. 1 to illustrate in some detail the particular drive mechanisms used in a preferred embodiment of the invention. In this figure a motor is shown in the housing M–8 fastened to which is a housing C–8 through which outlets 30, 31 and 32 provide the electrical power and control signals for the motor. The shaft S–7 of the motor drives a single reduction gear train which, in turn, rotates the ball screw nut 35 which causes the ball screw 33 to move vertically. The ball screw is a commercial ball bearing screw assembly such as is made by Saginaw Steering Gear Division of the General Motors Corporation and therefore is not described in detail herein. A flexible and expandable corrugated housing

is shown as S'–8 instead of a solid housing as shown at S–8 in FIG. 1. The trunnions indicated by the brackets 34 provide a firm support and pivot for the ball screw and drive assembly by the gimbal ring R–2. The trunnion assembly 36 provides a similar strong mechanical support and pivot to the gimbal ring R–4. It will be appreciated that the construction shown in FIG. 3 will provide a firm positive interconnection between the driving forces supplied by the motor M–8 when they are applied between the roll gimbal ring R–2 and the pitch gimbal R–4 and will effectively adjust the distance between the two gimbal rings in accordance with the signal supplied to the motor M–8. The use of a ball screw in this fashion will virtually eliminate backlash so that a single drive mechanism at FIG. 3 could be used to provide control of the spacing and hence the angle between the two gimbal rings. However, by using two complete drive assemblies on opposite sides of a pivot axis as is done in FIG. 1 the backlash is minimized. By connecting the two D.C. motors in series a slight difference in their instantaneous speeds will exist and cause a small difference in output torques which is utilized in taking up backlash.

Further details relating to the construction of the embodiment of the invention illustrated in FIG. 1 may be gleaned from a review of FIG. 4 which is a view of the portion of FIG. 1 taken along a plane indicated by the lines X—X. Viewed from above in this fashion it will be seen that the motor M–2 is partially hidden behind the gear train housing G–2 which will couple to a ball bearing screw which is identified as 43 and which of course supplies the drive for the gimbal ring R–2 in FIG. 1. In FIG. 4 trunnions are shown at 3 and 5 which correspond to like numbered trunnions in FIG. 1 and which, of course, are like the support assemblies 34 and 36 in FIG. 3. Coupled to the houings M–2 in FIG. 4 is shown a housing C–2 which connects the motor to a power source and a control signal as was explained previously with respect to the housing C–8 (which may be identical) in FIG. 3.

A number of details of construction of a preferred embodiment of the present invention have been illustrated in the figures but have not been expressly described in the written disclosure. This procedure has been followed, since it is felt that a great many details may be omitted from the description where their function is obvious from the figures. This is particularly true with respect to the various nut heads and plates which are shown simply to reveal how the components are held together. Other components such as the buffers 23, 25, 27 and 29 would serve as shock absorbers for absorbing the energy stored in the gimbal rings when the excursion limits are reached. It will be recognized also that the assemblies shown in FIG. 3 and FIG. 4 represent four identical assemblies although each of them could be different if desired.

Although the invention has been described with respect to certain specific embodiments, it will be appreciated that many modifications and changes may be made by those skilled in the art without departing from the spirit of my invention. In particular, the invention has utility as a means of imparting motion to otherwise stationary apparatus fixed on land. I intend, therefore, by the appended claim to cover all such modifications and changes as fall within the true spirit and scope of my invention.

What I claim and desire to secure by Letters Patent of the United States is:

In a platform for providing a stable base for relatively heavy loads, means comprising:

a first gimbal ring supported by a first set of bearings located directly beneath the gimbal ring in a manner such that all loads on the gimbal ring are transmitted directly through the ring to the bearings, said first set of bearings permitting rotation of said

first gimbal ring about an axis through said bearings,

a second gimbal ring of substantially the same size as said first gimbal ring and supported by a second set of bearings located directly above the first gimbal ring, said second set of bearings being supported by said first gimbal ring in a manner such that all loads on the second gimbal ring are transmitted directly through the second gimbal ring and the second set of bearings to the first gimbal ring,

said first and second gimbal rings being axially spaced to permit rotation of said second gimbal ring about an axis through said second set of bearings, where the axis through said second set of bearings is located at all times substantially at right angles to the axis through said first set of bearings and in a separate plane,

and first and second linear actuators coupled to said first and second gimbal rings, respectively, to transfer linear motion of said actuators to rotational motion of said first and second gimbal rings about their respective axes.

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