



## NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

WASHINGTON, D.C. 20546

JUN 21 1974

REPLY TO  
ATTN OF: GP

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

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

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

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

The following information is provided:

U.S. Patent No. : 3,814,350

Government or  
Corporate Employee : McDonnell Douglas Corp.  
Huntington Beach, CA

Supplementary Corporate  
Source (if applicable) : \_\_\_\_\_

NASA Patent Case No. : MFS- 21,680-1 +  
21,681-1

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

YES  NO

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

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Enclosure

[54] THRUST-ISOLATING MOUNTING

3,709,163 1/1973 Smedley et al. .... 108/53

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[22] Filed: Mar. 21, 1973

[57] ABSTRACT

[21] Appl. No.: 343,607

A supporting frame for a load, such as one or more telescopes, is isolated from all multi-gravitational forces, which will be developed within that load as that load is propelled into space, by using a shroud to fully and solidly hold that load until that load has been propelled into space. Thereafter, that shroud will be jettisoned; and then supports which are on, and which are movable with, that load will have surfaces thereon moved into supporting engagement with complementary surfaces on that supporting frame to enable that supporting frame and those supports to fully and solidly hold that load.

[52] U.S. Cl. .... 244/1 SS, 248/16, 248/23

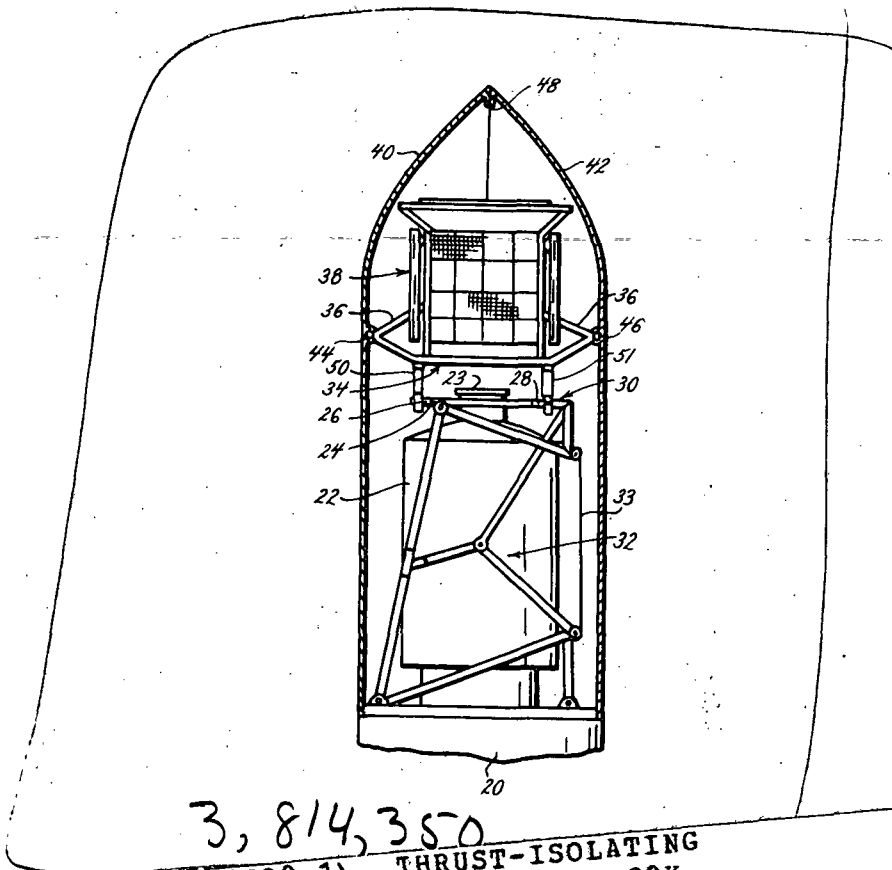
[51] Int. Cl. .... B64g 1/10

[58] Field of Search ..... 244/1 SS, 1 R; 108/53; 248/16, 23, 24; 350/8

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13 Claims, 6 Drawing Figures



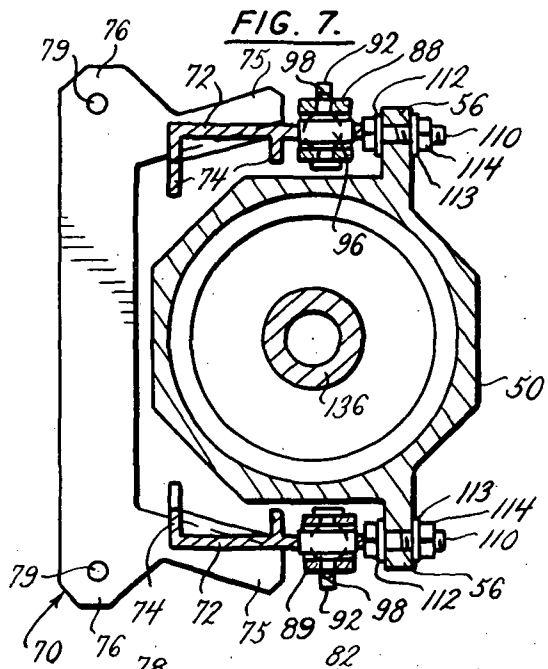
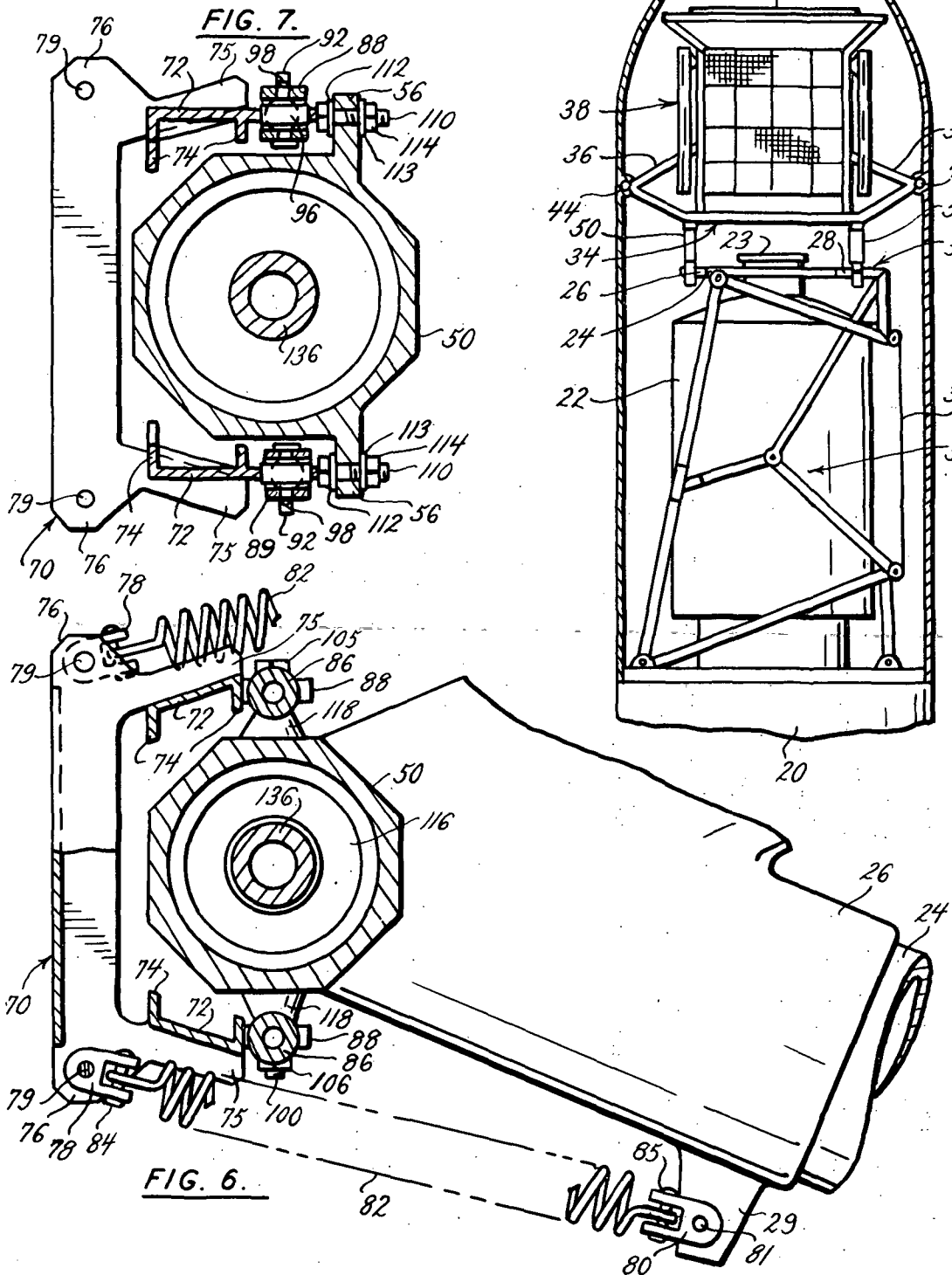
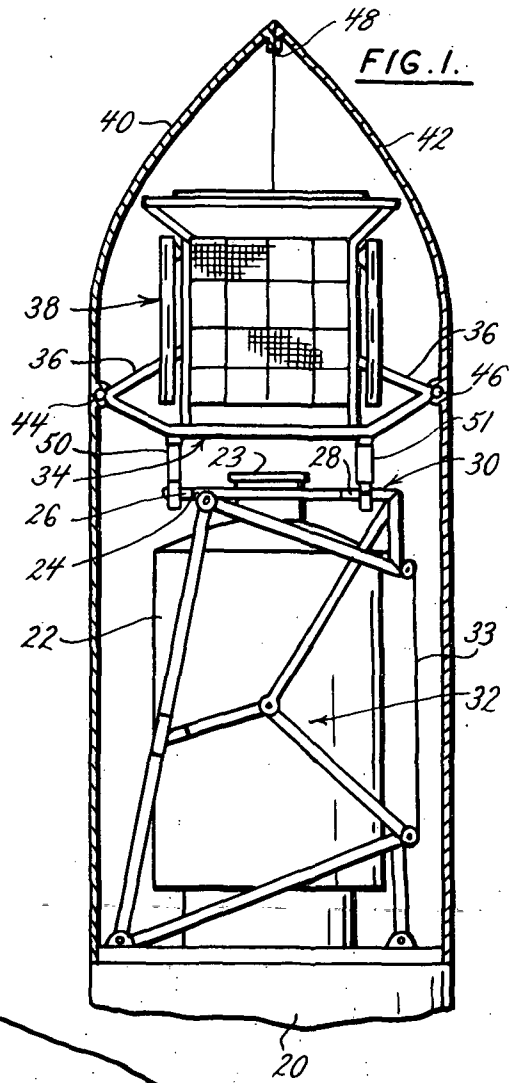
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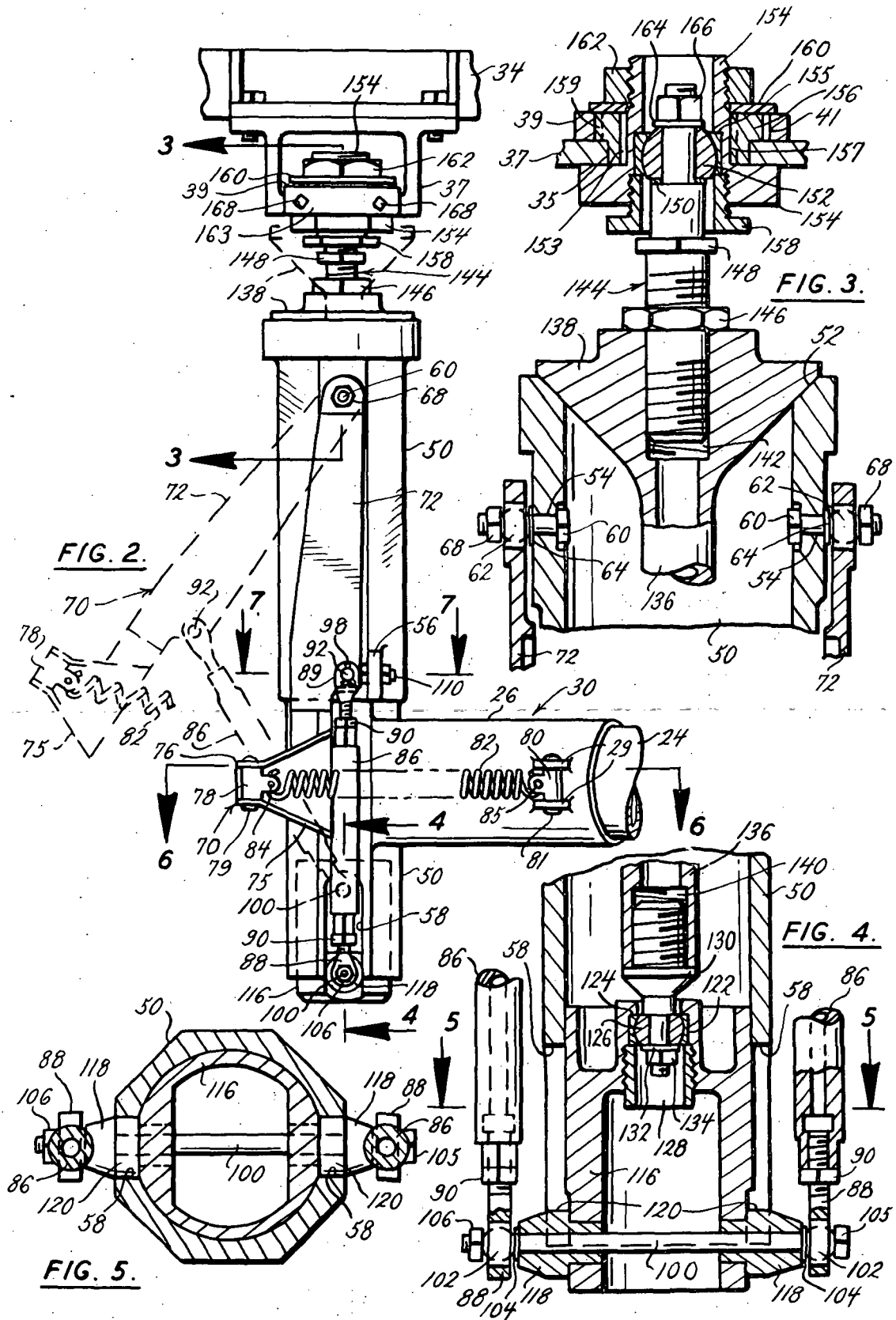
(NASA-Case-MFS-21680-1) THRUST-ISOLATING MOUNTING Patent (NASA) 11 P CSCL 20K

N74-27397

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## THRUST-ISOLATING MOUNTING

## ORIGIN OF THE INVENTION

The invention described herein was made in the performance of work under a NASA contract and is subject to the provisions of Section 305 of the National Aeronautics and Space Act of 1958, Public Law 85-568 (72 Stat. 435, 42 USC 2457).

This invention relates to improvements in mountings. More particularly, this invention relates to improvements in mountings which can isolate supporting frames for loads from forces on, or applied by, those loads.

It is, therefore, an object of the present invention to provide an improved mounting which can isolate a supporting frame for a load from forces on, or applied by, that load.

A supporting frame, that is intended to support a load such as one or more telescopes after that frame and its load have been propelled into space, is mounted on a vehicle which can propel that frame and its load into space. A plurality of supports are secured to, and movable with, that load; and those supports and that frame have interacting surfaces thereon which can coact to enable that frame to fully and solidly hold those supports, and thereby enable that frame to fully and solidly hold that load. That supporting frame must be relieved of all thrust-induced forces which are developed within that load during the time that vehicle propels that frame and that load into space; and a shroud, which initially is fixedly secured to that vehicle and to that load, will fully relieve that supporting frame of those thrust-induced forces until that vehicle has reached its scheduled position in space. When that vehicle reaches that scheduled position, that shroud will be separated from the load and from the vehicle and will be jettisoned; and thereafter the interacting surfaces on the supports and on the supporting frame will coact to guide that load into a position relative to that supporting frame wherein that supporting frame will fully and solidly hold that load. In that way, the supporting frame can be designed and constructed so it is relatively light in weight, because it need only support the normal weight of the load during testing of that supporting frame and load prior to the mounting of that load on the vehicle, and because that load will be essentially weight-less after that supporting frame and load have been propelled into space. It is, therefore, an object of the present invention to provide a supporting frame which can be mounted on a vehicle, to provide supports which are secured to and movable with a load that eventually must be fully and solidly held by that supporting frame, to provide interacting surfaces on those supports and on that supporting frame which can enable that supporting frame to fully and solidly hold those supports and thereby enable that supporting frame to fully and solidly hold that load, and to provide a supporting structure which is initially secured to that vehicle and to that load to initially hold those interacting surfaces apart and thereby effectively isolate that supporting frame from any thrust-induced forces which develop within that load.

The interacting surfaces on the supports and on the supporting frame are self-aligning, so that the load will move into precisely aligned relationship with that supporting frame as those interacting surfaces move into

engagement with each other. In that way, the center of mass of the load can be moved into a precisely-predictable position relative to that supporting frame. It is, therefore, an object of the present invention to provide self-aligning, interacting surfaces between a supporting frame and a load which is initially isolated from that supporting frame.

Other and further objects and advantages of the present invention should become apparent from an examination of the drawing and accompanying description.

In the drawing and accompanying description a preferred embodiment of the present invention is shown and described but it is to be understood that the drawing and accompanying description are for the purpose of illustration only and do not limit the invention and that the invention will be defined by the appended claims.

## BRIEF DESCRIPTION OF THE DRAWING

In the drawing,

FIG. 1 is a partially-sectioned, side elevational view of the upper part of a space vehicle on which the thrust-isolating mounting of the present invention is supported,

FIG. 2 is a side elevational view, on a larger scale, of one corner of the thrust-isolating mounting of the present invention,

FIG. 3 is a sectional view, on a still larger scale, through the upper portion of the structure shown in FIG. 2, and it is taken along the plane indicated by the line 3-3 of FIG. 2,

FIG. 4 is a sectional view, on the scale of FIG. 3, through the lower portion of the structure shown in FIG. 2, and it is taken along the plane indicated by the line 4-4 of FIG. 2,

FIG. 5 is a sectional view, on the scale of FIG. 3, through the structure shown in FIG. 4, and it is taken along the plane indicated by the line 5-5 in FIG. 4,

FIG. 6 is a sectional view, on the scale of FIG. 3, through the lower portion of the structure shown in FIG. 2, and it is taken along the plane indicated by the line 6-6 in FIG. 2, and

FIG. 7 is another sectional view through the lower portion of the structure shown in FIG. 2, and it is taken along the plane indicated by the line 7-7 in FIG. 2.

## DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to the drawing in detail, the numeral 20 denotes a vehicle which is designed so it can be propelled into orbit about the earth or some other large body in space; and one such vehicle is known to the public as the "Skylab." The numeral 22 denotes a docking adapter which is secured to the forward end of the vehicle 20; and that docking adapter will releasably receive and hold vehicles which are used to transport astronauts to and from the earth. The numeral 24 denotes a length of tubing which has one end thereof fixedly connected to a corner bracket 26, and which has the other end thereof fixedly connected to a second corner bracket 28. The length of tubing plus similar lengths of tubing, not shown, and those corner brackets plus at least one other similar corner bracket, not shown, constitute a rigid supporting frame 30 which partially surrounds the entrance 23 of the docking adapter 22. The length 24 of tubing and the similar lengths of tubing,

not shown, and the corner brackets 26 and 28 and the similar corner brackets, not shown, will be made of relatively light-weight but sturdy metal to enable them to constitute a rigid supporting frame which is relatively light in weight. Each corner bracket has two sockets therein to accommodate the adjacent ends of two of the lengths of tubing. The corner bracket 26 has a pair of ears 29 adjacent the socket therein which accommodates one end of the length 24 of tubing; and that bracket has a similar pair of ears, not shown, adjacent the socket therein which accommodates the end of a second length of tubing, not shown. Each of the ears 29 has an opening therein, and the openings in each pair of ears are in alignment with each other.

The numeral 32 generally denotes a linkage which is made of lengths of tubing that are suitably connected to the vehicle 20, to each other, and to the rigid supporting frame 30. The lengths of tubing of the linkage 32 are made of light weight but strong metal, so that linkage can be sturdy and rugged but relatively light in weight. That linkage has a number of pivots therein so that linkage is capable of rotating the rigid supporting frame 30 from the position shown in FIG. 1 to a position wherein that frame is disposed to the right of the geometric axis of the vehicle 20 and is displaced ninety° from the position shown in FIG. 1. The rigid supporting frame 30 is generally V-shaped in plan view, and it has the open throat thereof at the left-hand end thereof in FIG. 1, so that rigid supporting frame can be pivoted to the right and downwardly without striking the entrance 23 or any part of the forward end of the docking adapter 22. A cable 33 is guided by a number of pulleys, and it is connected to an appropriate portion of the linkage 32 and to a suitable motor-driven sheave. Rotation of that motor-driven sheave will cause that cable to actuate the linkage 32, and will thereby effect shifting of the rigid supporting frame 30 from the position shown by FIG. 1 to the position wherein that rigid supporting frame is disposed to the right of the axis of the vehicle 20 and is displaced 90° from the position shown by FIG. 1.

The numeral 34 generally denotes a light-weight but sturdy framework which underlies and supports a load that is generally denoted by the numeral 38. Although various loads could be supported by the framework 34, the load which will be supported by that framework on the Skylab will include several telescopes and the guiding and stabilization apparatus for those telescopes. That load also will include light-sensitive panels which are referred to as solar batteries plus the equipment needed to move those light-sensitive panels into extended position. Brackets 37 of generally U-shaped cross section are rigidly secured to, and extend downwardly from, the framework 34; and one of those U-shaped brackets is shown in detail in FIGS. 2 and 3. As shown particularly by FIG. 3, that U-shaped bracket has an opening 35 in the closed end thereof.

The numerals 40 and 42 denote two sections of a plural-section shroud which is secured to, and which extends forwardly from the forward end of the vehicle 20. As shown particularly by FIG. 1, that shroud encloses the docking adapter 22, the entrance 23 for that docking adapter, the linkage 32, the rigid supporting frame 30, the framework 34, and the load 38. In doing so, that shroud protects those various elements from the degradation which they might experience if they were not enclosed as the vehicle 20 was propelled into orbit. The

vehicle 20, the docking adapter 22, the entrance 23, the rigid supporting frame 30, the linkage 32, the framework 34, the load 38, and the plural-section shroud are not, per se, parts of the present invention.

The framework 34 has extensions 36 which incline outwardly and upwardly to separation joints 44 and 46 that are located at the inner surfaces of the sections 40 and 42 of the shroud; and those extensions then incline upwardly and inwardly to the load 38. The lower ends of the extensions 36 are rigidly secured to the framework 34, the upper ends of those extensions are rigidly secured to the load 38, and the separation joints 44 and 46 rigidly secure those extensions to the plural-section shroud. Those extensions are light-weight but sturdy; and, as long as the separation joints 44 and 46 are intact, those extensions will rigidly secure the load 38 and the framework 34 to that plural-section shroud, and hence to the vehicle 20. The numeral 48 denotes a separation joint which is located at the forward end of the plural section shroud, and which helps hold the sections of that shroud in assembled relation. The separation joints 44, 46 and 48 can be of standard and usual design; and they usually will be pyrotechnic-type separation joints. As long as the separation joints 44, 46 and 48 are intact, the plural-section shroud will be fixedly secured to, and will be fully supported by, the forward end of the vehicle 20; and the separation joints 44 and 46 and the extensions 36 will enable that plural-section shroud to fully and solidly hold the load 38 and the framework 34.

The numeral 50 denotes a post-like member which is tubular in form and which is rigidly secured to the corner bracket 26. An essentially-identical post-like member 51 is rigidly secured to the corner bracket 28; and at least one other essentially-identical post-like member, not shown, will be secured to a further corner bracket of the rigid frame 30. An internal frusto-conical seat 52 is provided at the upper end of the post-like member 50, as shown particularly by FIG. 3. Aligned openings 54 are provided in the post-like member 50 a short distance below the upper end of that post-like member, as shown by FIG. 3. Ears 56 extend outwardly from the post-like member 50, as shown particularly by FIGS. 2 and 7; and those ears are parallel to each other and are located short distances above the corner bracket 26, as shown particularly by FIG. 2. Each of those ears has a horizontally-directed opening therethrough, as shown particularly by FIG. 7. The post-like member 50 has wide, vertically-directed slots 58 at opposite sides of the lower end thereof, as shown particularly by FIGS. 2, 4 and 5. The post-like member 50 will be rigidly secured to the corner bracket 26. In one preferred embodiment of the present invention, the lower part of the post-like member 50 is cast or otherwise made integral with the corner bracket 26; and the upper part of that post-like member is bolted to that corner bracket.

The numeral 60 denotes pivot-like bolts which are disposed within the openings 54 in the post-like member 50; and those bolts have the heads thereof located with enlarged inner ends of those openings, as shown particularly by FIG. 3. Spherical bearings 62, each of which includes an inner annulus with a generally spherical exterior and an outer annulus with a generally spherical interior, are telescoped over the outer ends of the bolts 60. Washers 64 are interposed between the

spherical thrust bearings 62 and the adjacent portions of the outer surface of the post-like member 50.

The numeral 70 denotes a large U-shaped bracket with arms 72 that are equipped with elongated ribs 74 at the inner surfaces thereof; and those arms are spaced far enough apart to enable them to be disposed at opposite sides of the post-like member 50. Openings in the upper ends of those arms accommodate the spherical bearings 62 that are telescoped over the outer ends of the bolts 60; and nuts 68 are threaded onto the outer ends of those bolts to hold the large U-shaped bracket 70 in assembled relation with the post-like member 50. The closed portion of the large U-shaped bracket 70 is channel-shaped, as indicated by FIG. 6; and that closed portion has frusto-triangular wings 75 at the opposite ends thereof which strongly and rigidly support the arms 72. Pairs of ears 76 are provided at the opposite ends of the closed portion of the large U-shaped bracket 70, and each of those ears has an opening therein, as shown particularly by FIG. 7. The opening in the ears 76 are in alignment with each other to enable those openings to accommodate pivots 79 for connectors 78. As shown particularly by FIG. 6, those connectors are generally clevis-like in configuration. Generally similar connectors 80 are pivotally secured to the ears 29 on the corner bracket 26 by pivots 81, as shown particularly by FIGS. 2 and 6. A helical extension spring 82 has one end thereof secured to the connector 78 adjacent the bottom of FIG. 6 by pin 84; and it has the other end thereof secured to the connector 80 by a pin 85. A second helical extension spring 82 has one end thereof secured to the other connector 78 in FIG. 6, and it has the other end thereof secured to a connector, not shown, which will be identical to the connector 80. Those helical extension springs will strongly bias the large U-shaped bracket 70 toward the solid-line position shown in FIG. 2; but those helical extension springs can yield to permit that large U-shaped bracket to be moved to the dotted-line position shown in FIG. 2.

The numeral 86 denotes turnbuckles which are disposed at opposite sides of the post-like member 50; and each of those turnbuckles has a standard eye bolt 88 at the lower end thereof, has a clevis-like eye bolt 89 at the upper end thereof, and has two nuts 90. After the clevis-like eye bolts 89 are threaded into the internally-threaded lower ends of the tubular portions of the turnbuckles 86, the lower nuts 90 will lock those clevis-like eye bolts in any desired positions relative to those tubular portions. After the eye bolts 88 are threaded into the internally-threaded upper ends of the tubular portions of the turnbuckles 86, the upper nuts 90 will lock those eye bolts in any desired positions relative to those tubular portions. Pivots 92 are disposed within openings in the arms 72 of the large U-shaped bracket 70; and those openings are spaced short distances about the level of the closed portion of that large U-shaped bracket. The heads of those pivots abut the inner faces of those arms, and the shanks of those pivots project outwardly beyond the outer faces of those arms. A spherical bearing 96 is telescoped over the shank of each of the pivots 92; and that spherical bearing has the inner annulus thereof engaging that pivot, and has the outer annulus thereof engaging the clevis-like eye bolt 89. Cotter pins 98 are passed through openings in the outer ends of the shanks of the pivots 92 to maintain the clevis-like eye bolts 89 at the upper ends of the

turnbuckles 86 in assembled relation with the arms 72 of the large U-shaped bracket 70. If desired, washers could be disposed at either or both sides of the spherical bearings 96.

The numeral 116 denotes a piston-like slide which is telescoped within the lower ends of the post-like member 50; and that slide can reciprocate axially of that post-like member. That slide has bosses 118 extending outwardly from the opposite sides thereof, as shown particularly by FIGS. 4 and 5; and each of those bosses has a frusto-conical portion and a cylindrical portion 120. The opposite sides of the cylindrical portions 120 slidably engage the opposite faces of the slots 58 in the lower end of the post-like member 50 to prevent circumferential movement, while permitting axial movement of the slide 116 relative to the post-like member 50. An elongated bolt 100 extends through aligned openings in the bosses 118 and in the adjacent portions of the slide 116; and the opposite ends of that elongated bolt are encircled by washers 104 and spherical bearings 102. A nut 106 is threaded on the threaded end of the elongated bolt 100. The inner annuli of the spherical bearings 102 directly engage the elongated bolt 100, and the outer annuli of those spherical bearings directly engage the eye bolts 88 at the lower ends of the turnbuckles 86. The turnbuckles 86, the eyebolts 88 and 89, the pivots 92, and the elongated bolt 100 secure the piston-like slide 116 to the arms 72 of the large U-shaped bracket 70 while permitting rotation of that large U-shaped bracket relative to that slide.

The numeral 110 denotes stops, which can be bolts, that are disposed within the openings in the ears 56 at the opposite sides of the post-like member 50. Shim washers 112 are located at the inner faces of the ears 56 and further washers 113 are located at the outer faces of those ears, as shown particularly by FIG. 7; and nuts 114 are used to hold those washers and those stops in assembled relation with those ears. The stops 110 are in the paths of the right-hand edges of the arms 72 of the large U-shaped bracket 70, as shown particularly by FIG. 7; and hence those stops limit the extent to which that large U-shaped bracket can be rotated in the counterclockwise direction in FIG. 2. When the large U-shaped bracket 70 is in the solid-line position shown by FIG. 2, the right-hand edges of the arms 72 will be held in engagement with the stops 110 by the helical extension springs 82. It should be noted that when the larger U-shaped bracket 70 is in the dotted-line position of FIG. 2, the common axis of the pivots 92 is located to the left of a straight line which could be drawn between the common axis of the pivot-like bolts 60 and the axis of the elongated bolt 100. However, when that large U-shaped bracket is in the solid-line position of FIG. 2, the common axis of the pivots 92 is located to the right of that straight line; and hence it should be apparent that the large U-shaped bracket 70 and the turnbuckles 86 constitute components of an over-center linkage. Because the Young's moduli, of the various alloys of which the post-like member 50, the large U-shaped bracket 70, of turnbuckles 86, and the slide 116 are made, are relatively high, those various elements will be strongly resistant to compressive and tensile forces. Consequently, the common axis of the pivots 92 must, whenever those pivots are in the solid-line position of FIG. 2, be close to the straight line between the common axis of the pivot-like bolts 60 and the axis of the elongated bolt 100.

The piston-like slide 116 has a cylindrical recess 122 in the upper end thereof; and that recess has an annular shoulder 124 at the upper end thereof. A spherical thrust bearing 126 has the outer annulus thereof disposed within the cylindrical recess 122; and an externally-threaded nut 128 is threaded into the internally-threaded lower end of the cylindrical recess 122 to lock the outer annulus of that spherical thrust bearing in position within that recess.

The numeral 130 denotes an end fitting which has a relatively-large threaded upper end, a smaller-diameter stepped lower end, and a frusto-conical intermediate portion. One of the stepped diameters of the lower end of the end fitting 130 passes through the inner annulus of the spherical thrust bearing 126; and a washer 132 surrounds the threaded smallest stepped diameter of that end fitting. A nut 134 presses that washer against the inner annulus of the spherical thrust bearing 126.

The numeral 136 denotes a tubular connector or strut which has a frusto-conical upper end 138, as shown by FIGS. 2 and 3. The angle of generation of that frusto-conical upper end is the same as the angle of generation of the frusto-conical seat 52 in the upper end of the post-like member 50; and hence the frusto-conical upper end 138 can provide a precise guiding and centering action as that frusto-conical upper end moves into engagement with the frusto-conical seat 52. A threaded socket 140 in the lower end of the tubular connector 136 accommodates the large-diameter threaded upper end of the end fitting 130, as shown particularly by FIG. 4. A threaded socket 142 in the upper end of the tubular connector 136 accommodates the large diameter threaded lower end of an end fitting 144, as shown by FIG. 3. A lock nut 146 can secure that end fitting in any desired position relative to the tubular member 136. The end fitting 144 has a wrench-receiving surface 148 intermediate the upper and lower ends thereof; and that fitting has a stepped-diameter upper end. The intermediate stepped diameter of that stepped-diameter upper end passes upwardly through a washer 150, through the inner annulus of a spherical thrust bearing 152, and then through a washer 164 to receive a nut 166. That nut and those washers will hold the inner annulus of that spherical thrust bearing in engagement with the end fitting 144.

An internally and externally threaded sleeve 154 has axially-directed splines 153 at an intermediate portion of the exterior surface thereof, it has an annular shoulder 155 at an intermediate portion of the interior surface thereof, and it has the internal thread thereof located a short distance below that shoulder. The splines 153 are eccentric of the geometric axes of the internally and externally threaded sleeve 154 and of the shoulder 155. That shoulder accommodates the upper edge of the outer annulus of the spherical thrust bearing 152; and an externally-threaded nut 158 abuts the lower edge of the outer annulus of that spherical thrust bearing. The external thread on the externally-threaded nut 158 mates with the internal thread of the internally and externally threaded sleeve 154 to enable that externally-threaded nut and the shoulder 155 to fixedly secure the outer annulus of the spherical thrust bearing 152 to the internally and externally threaded sleeve 154. A shouldered sleeve 156 has axially-directed external splines 159 on the shoulder thereof which mesh with axially-directed splines 41 that define

an opening in a plate 29; and that plate overlies the closed end of the U-shaped bracket 37, as indicated by FIGS. 2 and 3. That plate has downwardly-directed flanges 163 at the opposite ends thereof which extend down into register with the closed end of that U-shaped bracket; and set screws 168 through openings in those downwardly-extending flanges to bear against that closed end and thereby rigidly secure that plate to that bracket. The exterior of the smaller-diameter lower portion of the shouldered sleeve 156 is smooth and is rotatably disposed within the opening 35 in the closed end of the U-shaped bracket 37. The shouldered sleeve 156 has axially-directed splines 157 at the interior surface thereof which mate with the axially-directed splines 153 at the exterior of the internally and externally threaded sleeve 154.

The external splines 159 on the shoulder of the shouldered sleeve 156 are eccentric of the exterior of the smaller-diameter lower portion of that shouldered sleeve; and the splines 153 on the internally and externally threaded sleeve 154 are eccentric of the annular shoulder 155 within that internally and externally threaded sleeve. The eccentricity of the splines 159 is preferably equal to the eccentricity of the splines 153; and, by setting the shouldered sleeve 156 and the internally and externally threaded sleeve 154 so the eccentricities thereof offset each other, it is possible to make the axis of the end fitting 144 precisely concentric with the opening 35 in the closed end of the U-shaped bracket 37. By setting that shouldered sleeve and that internally and externally threaded sleeve so the eccentricities thereof are additive, it is possible to displace the axis of the end fitting 144 from the axis of the opening 35 by a distance equal to twice the eccentricity of the splines 159 on the shouldered sleeve 156. By setting the shouldered sleeve 156 and the internally and externally threaded sleeve 154 in various relative circumferential positions, it is possible to displace the axis of the end fitting 144 from the axis of the opening 35 by various desired distances. A washer 160 overlies the upper surface of the plate 39 and also overlies the upper surface of the shouldered sleeve 156. A nut 162 is threaded onto the upper end of the internally and externally threaded sleeves 154; and that nut bears against the washer 160. In assembling the plate 39 with the U-shaped bracket 37 and the end fitting 144, it is preferable to set the splines 157 of the shouldered sleeve 156 in engagement with the appropriate splines 153 on the internally and externally threaded sleeve 154, to telescope the splines 41 of the plate 39 over the splines 159 on the shoulder of that shouldered sleeve, to telescope the washer 160 over the upper end of that internally and externally threaded sleeve, and then thread the nut 162 onto the external thread of that internally and externally threaded sleeve.

It will be noted that the upper end of the tubular connector 136 is connected to the framework 34 while the lower end of that tubular connector is secured to the piston-like slide 116. The lock nut 146 on the large diameter threaded end of the end fitting 144 can be set at different positions along the length of that threaded end to adjust the distance between the closed end of the U-shaped bracket 37 and the frusto-conical surface 138 on the tubular connector 136. The shouldered sleeve 156 can be set in different circumferential positions relative to the internally and externally threaded sleeve 154 to adjust the position of the axis of that tu-



bular connector relative to the opening 35 in that U-shaped bracket. In this way, it is possible to shift the upper end of the tubular connector 136 longitudinally, laterally, or both longitudinally and laterally relative to the U-shaped bracket 37 of the framework 34.

The nuts 90 adjacent the eye bolts 89 and the nuts 90 adjacent the eye bolts 88 of the turnbuckles 86 can be set to adjust the effective distances, between the pivot-like bolts 60 and the elongated bolt 100, when the large U-shaped bracket 70 and the turnbuckles 86 are in the solid-line positions of FIG. 2. Those effective distances will preferably be set so that large U-shaped brackets can coact with those turnbuckles, with the piston-like slide 116, and with the tubular connector 136 to hold the frusto-conical upper end 138 of that tubular connector in intimate engagement with the frusto-conical seat 52 in the upper end of the post-like member 50 whenever that large U-shaped bracket and those turnbuckles and that piston-like slide are in the solid-line positions shown by FIG. 2. As the large U-shaped bracket 72, the turnbuckles 86 and the piston-like slide 116 approach the solid-line positions of FIG. 2, the frusto-conical upper end 138 of the tubular connector 136 will coact with the frusto-conical seat 52 to precisely align the U-shaped bracket 37 with the post-like member 50; and then, as that large U-shaped bracket and those turnbuckles move into the over-center positions shown by solid lines in FIG. 2, that U-shaped bracket and those turnbuckles will have compressive and bending forces developed within them, while the piston-like slide 116 and the tubular connector 136 will have tensile forces developed within them. Those various forces will coact to hold the frusto-conical upper end 138 of the tubular connector 136 in very intimate engagement with the frusto-conical seat 52 in the upper end of the post-like member 50.

When the plural-section shroud is assembled with the vehicle 20; the separation joints 44 and 46 and the extensions 36 of the framework 34 will solidly lock the load 38 and that framework to that shroud. At such time, the upper end of the tubular connector 136 will be spaced a finite distance above the upper end of the post-like member 50, as indicated by dotted lines in FIG. 2; and the U-shaped bracket 37, the plate 39, and the framework 34 will be spaced corresponding finite distances above the solid-line positions shown for those elements in FIG. 2. Also, at such time, the large U-shaped bracket 70 and the turnbuckles 86 will be in the dotted-line positions of FIG. 2. Consequently, at such time the only connection between the framework 34 and the rigid frame 30 will be the sliding engagement between the piston-like slide 116 and the post-like member 50, and the similar sliding engagements between the other piston-like slides and the other post-like members of the thrust-isolating mounting of the present invention. Those various sliding engagements will be incapable of transmitting any appreciable axially-directed forces from the tubular connectors 136 to the post-like members 50; and hence the rigid frame 30 will be effectively isolated from any thrust-induced forces which could be developed within the framework 34 and the load 38. This is important, because it makes it possible to design the linkage 32 so it is a small and acceptable proportion of the total pay load which must be propelled into space. If that linkage was not isolated

vehicle 20 was propelled into space, that linkage would have to be made so sturdy and strong that its weight would constitute an unacceptable percentage of the total pay load which had to be propelled into space.

Once the vehicle 20 is in orbit, the load 38 and the framework 34 will become essentially weight-less; and the supporting frame 30 will be fully capable of providing full and solid support for the framework 34 and the load 38. As a result, after the vehicle 20 has attained a predetermined orbit in space, the separation joints 44, 46, and 48, and any other separation joints which secure the plural-section shroud to that vehicle, will be actuated to jettison that shroud. As the separation joints 44 and 46 cause the sections of the plural-section shroud to separate from the extensions 36 of the framework 34, the restorative forces within the helical extension springs 82 would force the large U-shaped bracket 70 to rotate from the dotted-line position to the solid-line position in FIG. 2. As that large U-shaped bracket so rotates, the turnbuckles 86 will move from the dotted-line to the solid-line positions in FIG. 2, and thus will force the piston-like slide 116 to move downwardly to the position shown in FIGS. 3 and 4. As that piston-like slide so moves, it will pull the tubular connector 136 downwardly, and thus will cause the frusto-conical upper end 138 of that tubular connector to approach, and move into engagement with, the frusto-conical seat 52 in the upper end of the post-like member 50. That frusto-conical upper end will coact with that frusto-conical seat to automatically and precisely align the corresponding corners of the framework 34 and of the rigid supporting frame 30. The tubular connectors 136 and the post-like members 50 adjacent the other corners of the framework 34 and of the rigid supporting frame 30 will provide corresponding precise alignment of those other corners. The tubular connectors 136 and the post-like members 50 at the various corners of the framework 34 and of the rigid supporting frame 30 also provide such intimate engagement between them that the rigid supporting frame 30 will be able to solidly and fully support the framework 34 and the load 38. Even when the large U-shaped bracket 70 and the turnbuckles 86 are in the solid-line positions of FIG. 2, the helical extension springs 82 will have powerful restorative forces within them. Those restorative forces will enable those helical extension springs, the large U-shaped bracket 70, the turnbuckles 86, the piston-like slide 116 and the tubular connector 136 to continuously hold the frusto-conical upper end 138 of that tubular connector in precisely centered relation with the frusto-conical seat 52 at the upper end of the post-like member 50. Consequently, the load 38, which was supported by the plural-section shroud during the propelling of the vehicle 20 into space, will thereafter be solidly and fully held by the rigid supporting frame 30.

After the rigid framework 34, and hence the load 38, have been moved into solid engagement with the rigid supporting frame 30, the linkage 32 can be actuated to effect rotation of that rigid supporting frame from the position shown by FIG. 1 to a position where that rigid supporting frame is located at the right of the axis of the vehicle 20 and is displaced 90° from the position shown by FIG. 1. As that linkage rotates that rigid supporting frame, that rigid supporting frame will cause the framework 34 and the load 38 to rotate to the right of the axis of the vehicle 20 and to positions at 90° to the positions which they occupy in FIG. 1. Thereafter,

the entrance 23 of the docking adapter 22 will be exposed; and hence vehicles can engage that docking adapter so astronauts will be able to freely enter and leave the vehicle 20.

The spherical thrust bearings 152, at the various corners of the framework 34, perform dual functions. Specifically, those spherical thrust bearings hold the framework 34 at fixed positions axially of the tubular connectors 136 while permitting limited variations to be made in the angles between the axes of those tubular connectors and the axis of the vehicle 20. The various spherical bearings 62, 96, 102 and 126 also perform dual functions. Thus, the spherical bearings 62 permit relative rotation between the large U-shaped bracket 70 and the post-like member 50 while accommodating slight departures of the arms 72 of that large U-shaped bracket from lines at right angles to the common axis of the pivot-like bolts 60, the spherical bearings 96 permit relative rotation between the turnbuckles 86 and that large U-shaped bracket while accommodating slight misalignments of those turnbuckles and the arms 72 of that large U-shaped bracket, the spherical bearings 102 permit relative rotation between the turnbuckles 86 and the piston-like slide 116 while accommodating slight departures of those turnbuckles from lines at right angles to the axis of the elongated bolt 100, and the spherical thrust bearing 126 holds that piston-like slide at a fixed position axially of the tubular connector 136 while permitting limited variations to be made in the angles between the axes of that piston-like slide and of that tubular connector. As a result, it is a simple and easy matter to assemble the framework 34 with the rigid support frame 30.

Whenever the tubular connector 136 is in the dotted-line position of FIG. 2, the stem of that tubular connector is so located that at least two inches of spherical motion of the geometric center of the spherical thrust bearing 152 can be accommodated and still have clearance between the stem and frusto-conical upper end of that tubular connector and the confronting portion of the post-like member 50. This provides 360° of lateral freedom as well as 360° in-plane freedom for the upper end of the tubular connector 136; and this means that any point on the upper end of that tubular connector could be moved upwardly, downwardly, and from side to side, within a spherical space having a radius of two inches, without striking any part of the post-like member 50. As a result, no anticipated misalignment of the plural-section shroud, of the linkage 32, of the rigid supporting frame 30 or of the framework 34 could cause the tubular connector 136 to transmit thrust-induced forces from the load 38 to the rigid supporting frame 30.

The thrust-isolating mounting of the present invention could be used to safely transport delicate instruments on the earth, and then solidly and fully support those instruments. Similarly, that thrust-isolating mounting could be used to safely transport other delicate objects or loads on the earth, and then solidly and fully support those objects or loads.

Whereas the drawing and accompanying description have shown and described a preferred embodiment of the present invention, it should be apparent to those skilled in the art that various changes may be made in the form of the invention without affecting the scope thereof.

What I claim is:

1. A mounting for a load which comprises a frame; a support which is secured to said load and which is movable with said load relative to said frame; interacting surfaces on said support and on said frame which can engage each other to enable said frame to fully and solidly hold said support and thereby enable said frame and said support to fully and solidly hold said load, said interacting surfaces on said support and on said frame being separable from each other to relieve said frame of forces due to said load; and means to which said load can be selectively connected, to selectively hold said load and said support in positions wherein said interacting surfaces are separated from each other, and from which said load can be selectively disconnected, to selectively permit said load and said support to move to other positions wherein said interacting surfaces engage each other to enable said frame to fully and solidly hold said support, and load being fully and solidly held by said means as long as said interacting surfaces are kept separated from each other by the connecting of said load to said means, said load being fully and solidly held by said frame and said support when said interacting surfaces are in engagement with each other after said load has been disconnected from said means; wherein an adjustable connection between said load and said support can be adjusted to compensate for lateral misalignments between said support and said frame, and wherein said adjustable connection includes a tiltable bearing.

2. A mounting for a load which comprises a frame; a support which is secured to said load and which is movable with said load relative to said frame; interacting surfaces on said support and on said frame which can engage each other to enable said frame to fully and solidly hold said support and thereby enable said frame and said support to fully and solidly hold said load, said interacting surfaces on said support and on said frame being separable from each other to relieve said frame of forces due to said load; and means to which said load can be selectively connected, to selectively hold said load and said support in positions wherein said interacting surfaces are separated from each other, and from which said load can be selectively disconnected, to selectively permit said load and said support to move to other positions wherein said interacting surfaces engage each other to enable said frame to fully and solidly hold said support, said load being fully and solidly held by said means as long as said interacting surfaces are kept separated from each other by the connecting of said load to said means, said load being fully and solidly held by said frame and said support when said interacting surfaces are in engagement with each other after said load has been disconnected from said means; wherein an adjustable connection between said load and said support can be adjusted to compensate for axial misalignments between said support and said frame, and wherein said adjustable connection includes a tiltable bearing.

3. A mounting for a load which comprises a frame; a support which is secured to said load and which is movable with said load relative to said frame; interacting surfaces on said support and on said frame which can engage each other to enable said frame to fully and solidly hold said support and thereby enable said frame and said support to fully and solidly hold said load, said interacting surfaces on said support and on said frame being separable from each other to relieve said frame

of forces due to said load; and means to which said load can be selectively connected, to selectively hold said load and said support in positions wherein said interacting surfaces are separated from each other, and from which said load can be selectively disconnected, to selectively permit said load and said support to move to other positions wherein said interacting surfaces engage each other to enable said frame to fully and solidly hold said support, said load being fully and solidly held by said means as long as said interacting surfaces are kept separated from each other by the connecting of said load to said means, said load being fully and solidly held by said frame and said support when said interacting surfaces are in engagement with each other after said load has been disconnected from said means; wherein an adjustable connection between said load and said support permits the position of said support relative to said load to be adjusted and then fixed, and wherein said adjustable connection includes an axially-adjustable threaded element.

4. A mounting for a load which comprises a frame; a support which is secured to said load and which is movable with said load relative to said frame; for interacting surfaces on said support and on said frame which can engage each other to enable said frame to fully and solidly hold said support and thereby enable said frame and said support to fully and solidly hold said load, said interacting surfaces on said support and on said frame being separable from each other to relieve said frame of forces due to said load; and means to which said load can be selectively connected, to selectively hold said load and said support in positions wherein said interacting surfaces are separated from each other, and from which said load can be selectively disconnected, to selectively permit said load and said support to move to other positions wherein said interacting surfaces engage each other to enable said frame to fully and solidly hold said support, said load being fully and solidly held by said means as long as said interacting surfaces are kept separated from each other by the connecting of said load to said means, said load being fully and solidly held by said frame and said support when said interacting surfaces are in engagement with each other after said load has been disconnected from said means; wherein further means automatically move said load and said support to said other positions when said load is disconnected from the first said means, and wherein said further means includes a spring.

5. A mounting for a load which comprises a frame; a support which is secured to said load and which is movable with said load relative to said frame; interacting surfaces on said support and on said frame which can engage each other to enable said frame to fully and solidly hold said support and thereby enable said frame and said support to fully and solidly hold said load, said interacting surfaces on said support and on said frame being separable from each other to relieve said frame of forces due to said load; and means to which said load can be selectively connected, to selectively hold said load and said support in positions wherein said interacting surfaces are separated from each other, and from which said load can be selectively disconnected, to selectively permit said load and said support to move to other positions wherein said interacting surfaces engage each other to enable said frame to fully and solidly hold said support, said load being fully and solidly held by means as long as said interacting surfaces are kept

separated from each other by the connecting of said load to said means, said load being fully and solidly held by said frame and said support when said interacting surfaces are in engagement with each other after said load has been disconnected from said means; wherein said frame includes a tubular post-like member, wherein said support includes a connector member that extends into said tubular postlike member, and wherein a piston-like slide is slidably mounted within said tubular post-like member and is connected to said connected member.

6. A mounting for a load which comprises a frame; a support which is secured to said load and which is movable with said load relative to said frame; interacting surfaces on said support and on said frame which can engage each other to enable said frame to fully and solidly hold said support and thereby enable said frame to said support to fully and solidly hold said load, said interacting surfaces on said support and on said frame being separable from each other to relieve said frame of forces due to said load; and means to which said load can be selectively connected, to selectively hold said load and said support in positions wherein said interacting surfaces are separated from each other, and from which said load can be selectively disconnected, to selectively permit said load and said support to move to other positions wherein said interacting surfaces engage each other to enable said frame to fully and solidly hold said support, said load being fully and solidly held by said means as long as said interacting surfaces are kept separated from each other by the connecting of said load to said means, said load being fully and solidly held by said frame and said support when said interacting surfaces are in engagement with each other after said load has been disconnected from said means; wherein an adjustable connection between said load and said support permits the position of said support relative to said load to be adjusted and then fixed, and wherein said adjustable connection includes a circumferentially-adjustable eccentric element.

7. The mounting as recited in claim 6 wherein said adjustable connection includes an axially-adjustable threaded element.

8. A mounting for a load which comprises a frame; a support which is secured to said load and which is movable with said load relative to said frame; interacting surfaces on said support and on said frame which can engage each other to enable said frame to fully and solidly hold said support and thereby enable said frame and said support to fully and solidly hold said load, said interacting surfaces on said support and on said frame being separable from each other to relieve said frame of forces due to said load; and means to which said load can be selectively connected, to selectively hold said load and said support in positions wherein said interacting surfaces are separated from each other, and from which said load can be selectively disconnected, to selectively permit said load and said support to move to other positions wherein said interacting surfaces engage each other to enable said frame to fully and solidly hold said support, said load being fully and solidly held by said means as long as said interacting surfaces are kept separated from each other by the connecting of said load to said means, said load being fully and solidly held by said frame and said support when said interacting surfaces are in engagement with each other after said load has been disconnected from said means;

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wherein said means includes a shroud which can be selectively jettisoned to permit said load and said support to move to said other positions.

9. The mounting as recited in claim 8 wherein separate joints initially hold said shroud in position but are selectively actuated to jettison said shroud.

10. A mounting for a load which comprises a frame; a support which is secured to said load and which is movable with said load relative to said frame; interacting surfaces on said support and on said frame which can engage each other to enable said frame to fully and solidly hold said support and thereby enable said frame and said support to fully and solidly hold said load, said interacting surfaces on said support and on said frame being separable from each other to relieve said frame of forces due to said load; and means to which said load can be selectively connected, to selectively hold said load and said support in positions wherein said interacting surfaces are separated from each other, and from which said load can be selectively disconnected, to selectively permit said load and said support to move to other positions wherein said interacting surfaces engage each other to enable said frame to fully and solidly hold said support, said load being fully and solidly held

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by means as long as said interacting surfaces are kept separated from each other by the connecting of said load to said means, said load being fully and solidly held by said frame and said support when said interacting surfaces are in engagement with each other after said load has been disconnected from said means; wherein further means automatically move said load and said support to said other positions when said load is disconnected from the first said means, and wherein said further means includes an over-center linkage.

11. The mounting as recited in claim 10 wherein said further means includes a stop which permits said over-center linkage to move toward and to pass through the center position thereof but thereafter holds said over-center linkage close to said center position thereof.

12. The mounting as recited in claim 10 wherein said load and said support reach said other positions as said over-center linkage moves into the center position thereof.

13. The mounting as recited in claim 12 wherein a stop and spring can thereafter hold said over-center linkage immediately adjacent said center position thereof.

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