Marshall

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. 20546

REPLY TO ATTN OF: GP

JUN 21 1974

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 [X] 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

United States Patent [19]

Fletcher et al.

[11] **3,814,350**

[45] **June 4, 1974**

[54] **THRUST-ISOLATING MOUNTING**

[76] Inventors: **James C. Fletcher,** Adminstrator of the National Aeronautics and Space Administration with respect to an invention by; **Dallas G. Wetzler,** 1575 Bluff Dr., Florissant, Mo. 63031

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[21] Appl. No.: **343,607**

[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

[56] **References Cited**

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[57] **ABSTRACT**

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.

13 Claims, 6 Drawing Figures

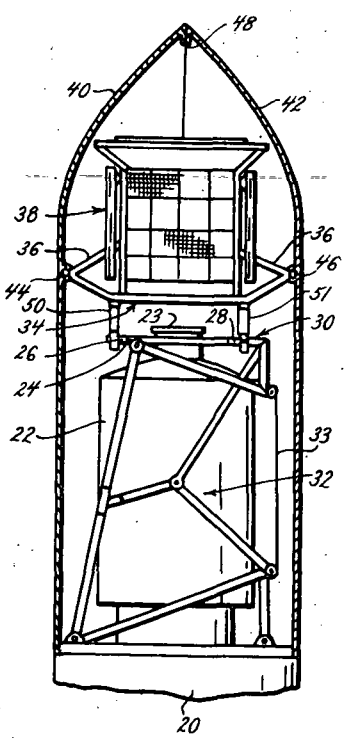


FIG. 1.

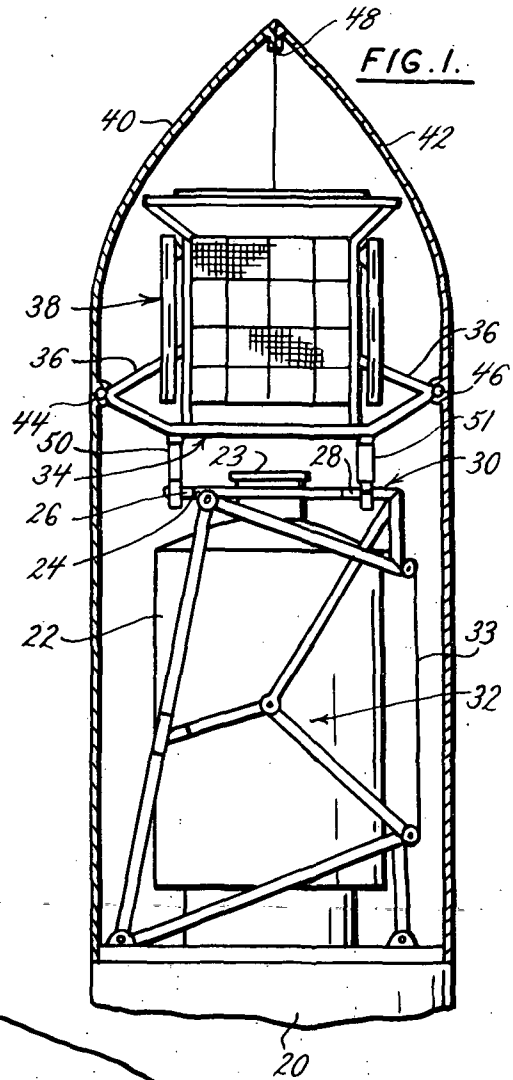
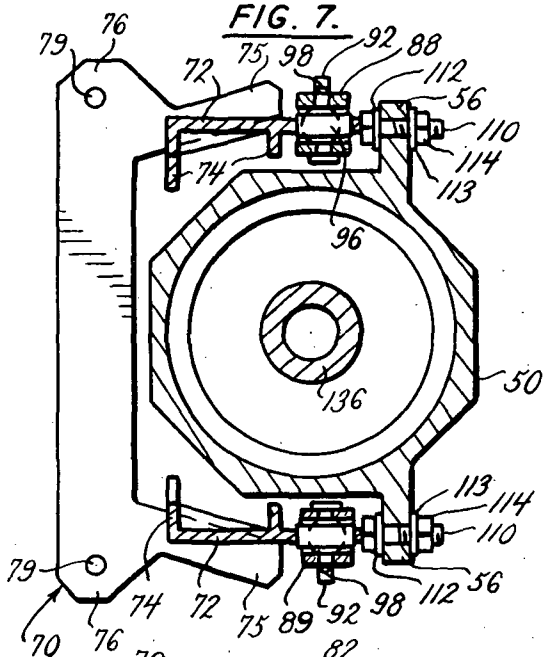


FIG. 7.



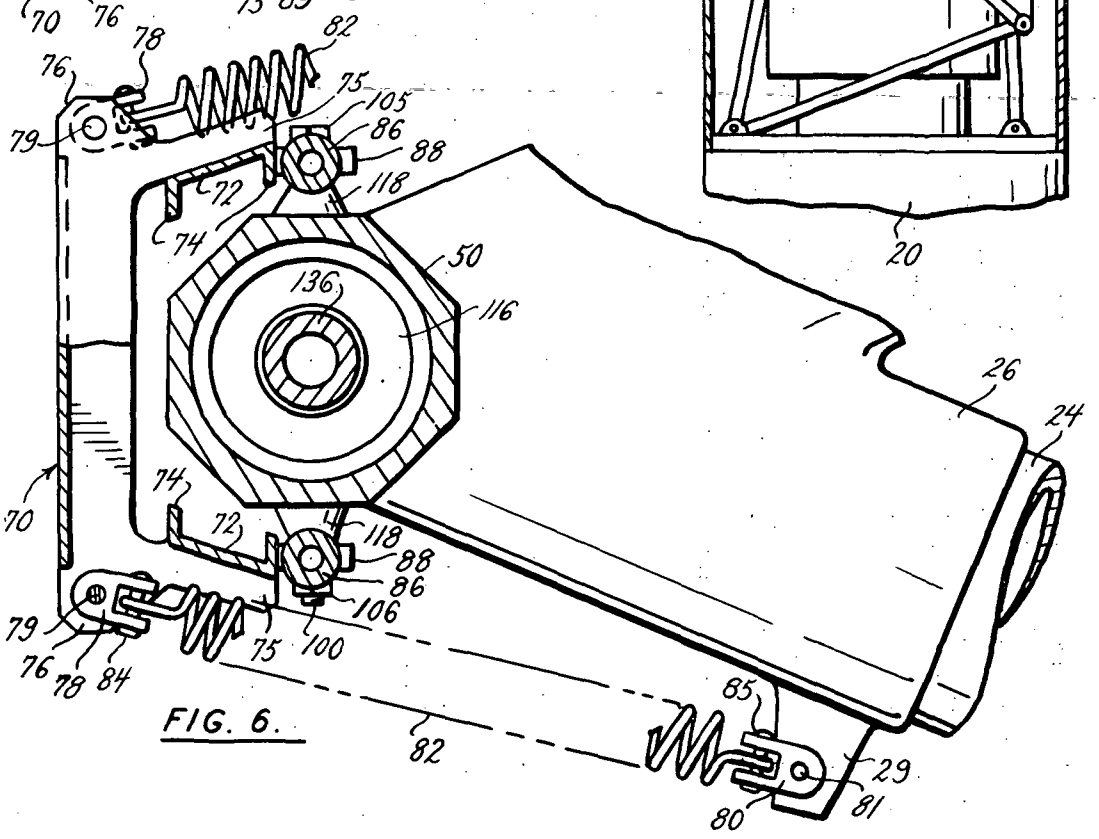


FIG. 6.

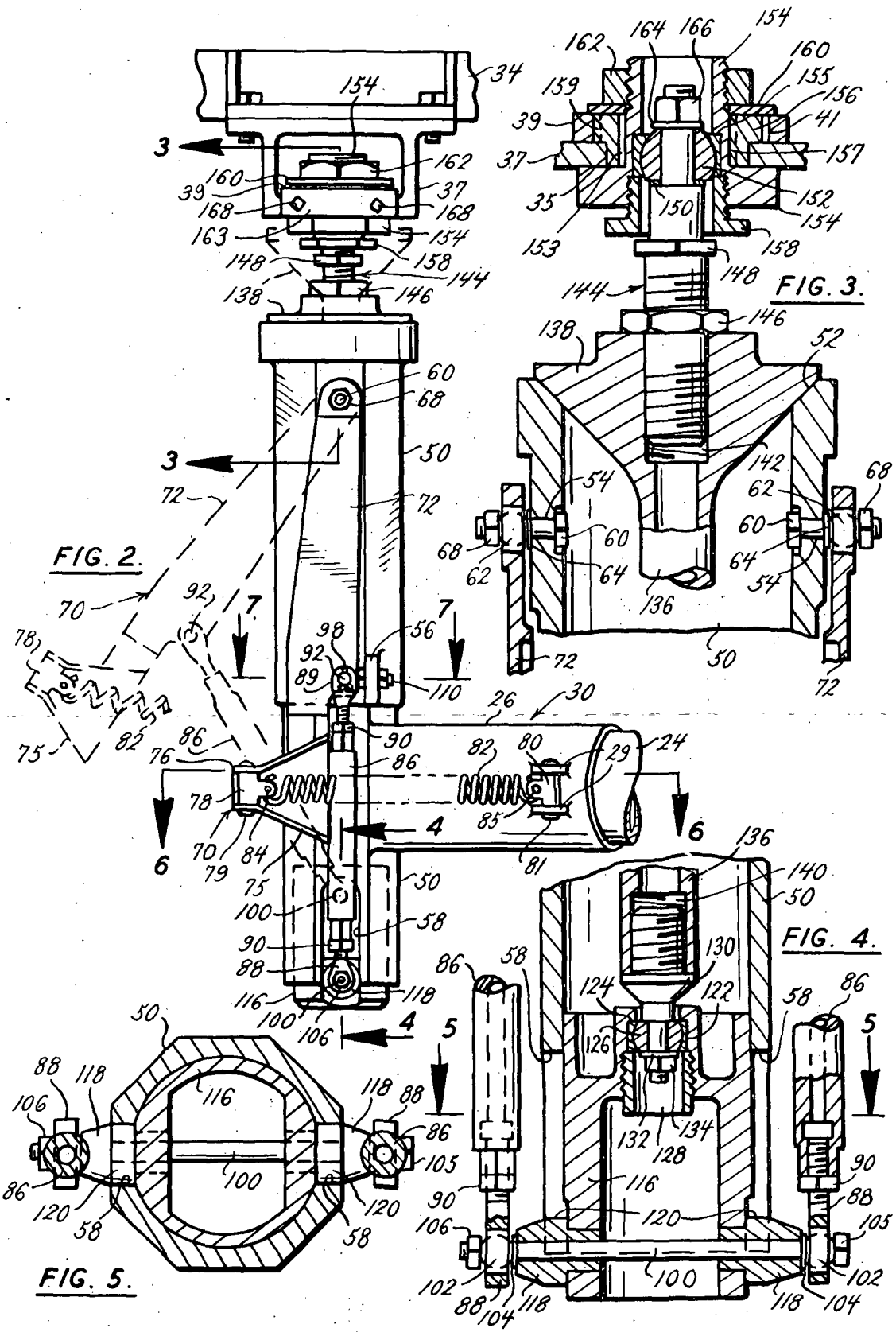


FIG. 2.
FIG. 3.
FIG. 4.
FIG. 5.

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 quided 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, be 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 imtimate 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 from the thrust-induced forces which could be developed within the load **38** and the framework **34** as the 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;

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 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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