*Gimbal mounted virtual reality display system.** Mead, R., Bolas, M., McDowall, I. 2004: U.S. Patent 6,774,870, 2002: U.S. Patent 6,396,462, 2000: U.S. Patent 6,094,180

US006094180A

United States Patent [19]

Mead, Jr. et al.

[11] **Patent Number: 6,094,180**

[45] **Date of Patent: *Jul. 25, 2000**

[54] **GIMBAL-MOUNTED VIRTUAL REALITY DISPLAY SYSTEM**

[75] Inventors: **Russell C. Mead, Jr.**, San Francisco; **Mark Bolas**, Mountain View; **Ian McDowall**, Palo Alto, all of Calif.

[73] Assignee: **Fakespace, Inc.**, Mountain View, Calif.

[*] Notice: This patent issued on a continued prosecution application filed under 37 CFR 1.53(d), and is subject to the twenty year patent term provisions of 35 U.S.C. 154(a)(2).

[21] Appl. No.: **08/630,948**

[22] Filed: **Apr. 5, 1996**

[51] **Int. Cl.**[7] **G09G 5/00**

[52] **U.S. Cl.** **345/8**; 345/156; 248/603; 361/681; 434/43

[58] **Field of Search** 248/188.1, 603, 248/160, 622, 163.1, 274.1, 188.3, 188.7; 345/8, 156, 157, 161, 7, 9; 434/35, 36, 37, 38, 39, 40, 41, 42, 43, 44; 361/681, 682; 359/427

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Primary Examiner—Dennis-Doon Chow
Assistant Examiner—Amr Awad
Attorney, Agent, or Firm—K. David Crockett, Esq.; Crockett & Crockett

[57] **ABSTRACT**

A compliant structure which includes a sensor for sensing translation and rotation of a top plate is disclosed. The structure is composed of a base plate and three supporting legs. The legs are compliant. The deflections of the structure are substantially in a plane and the translation and twist of the top platform may be measured by the gimbaled sensor assembly attached to one of the legs.

5 Claims, 7 Drawing Sheets

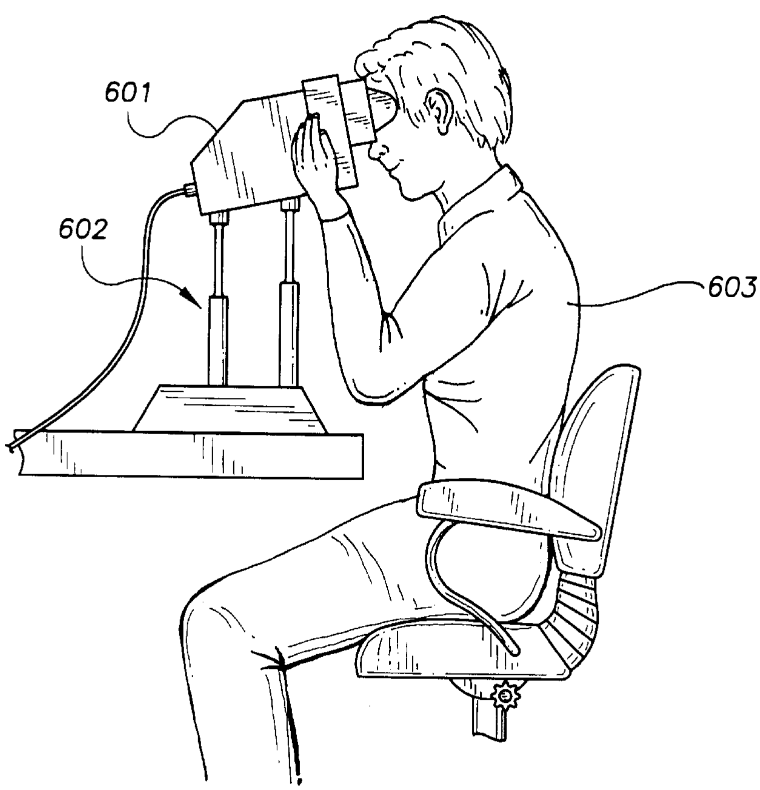


FIG. 1

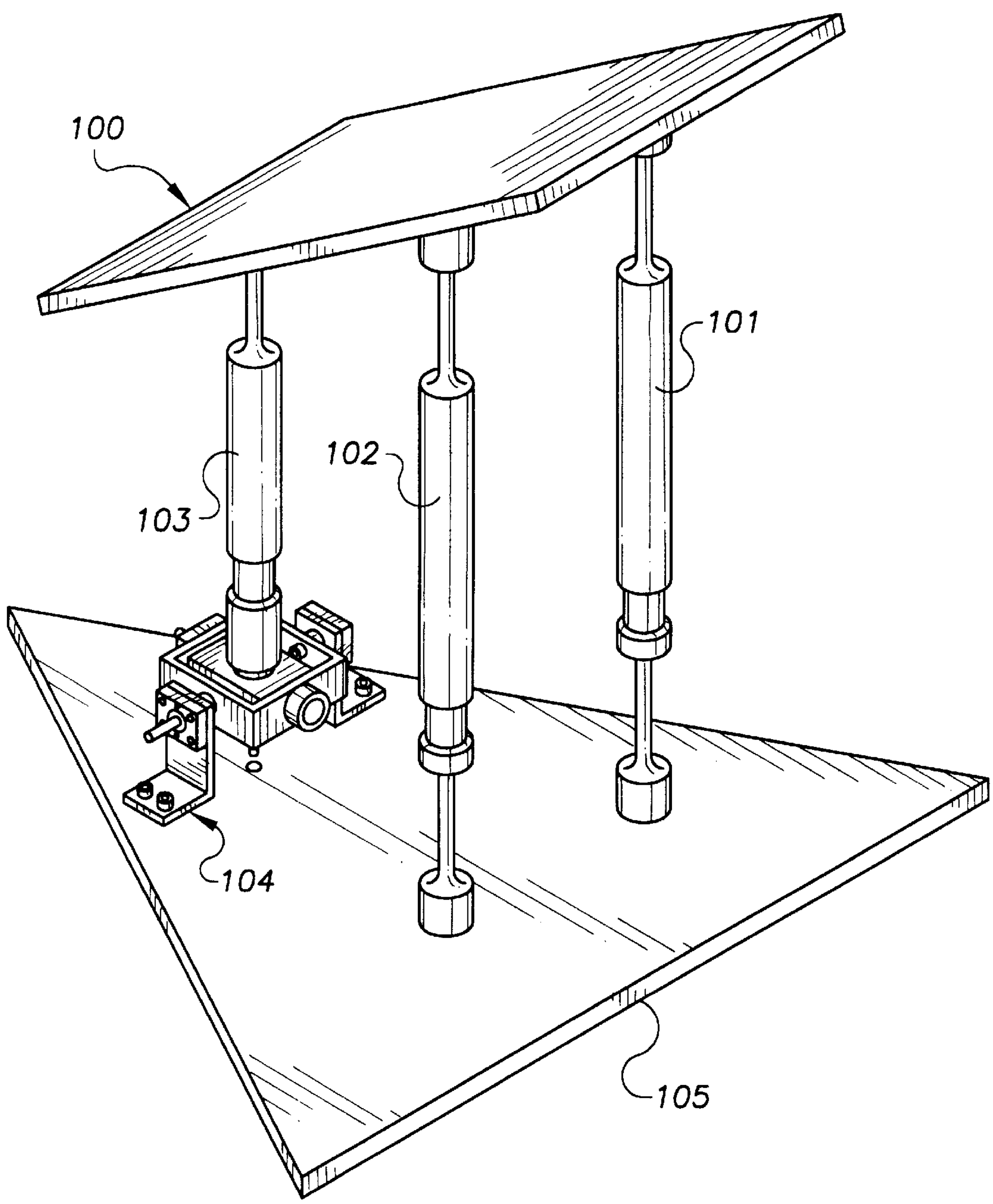
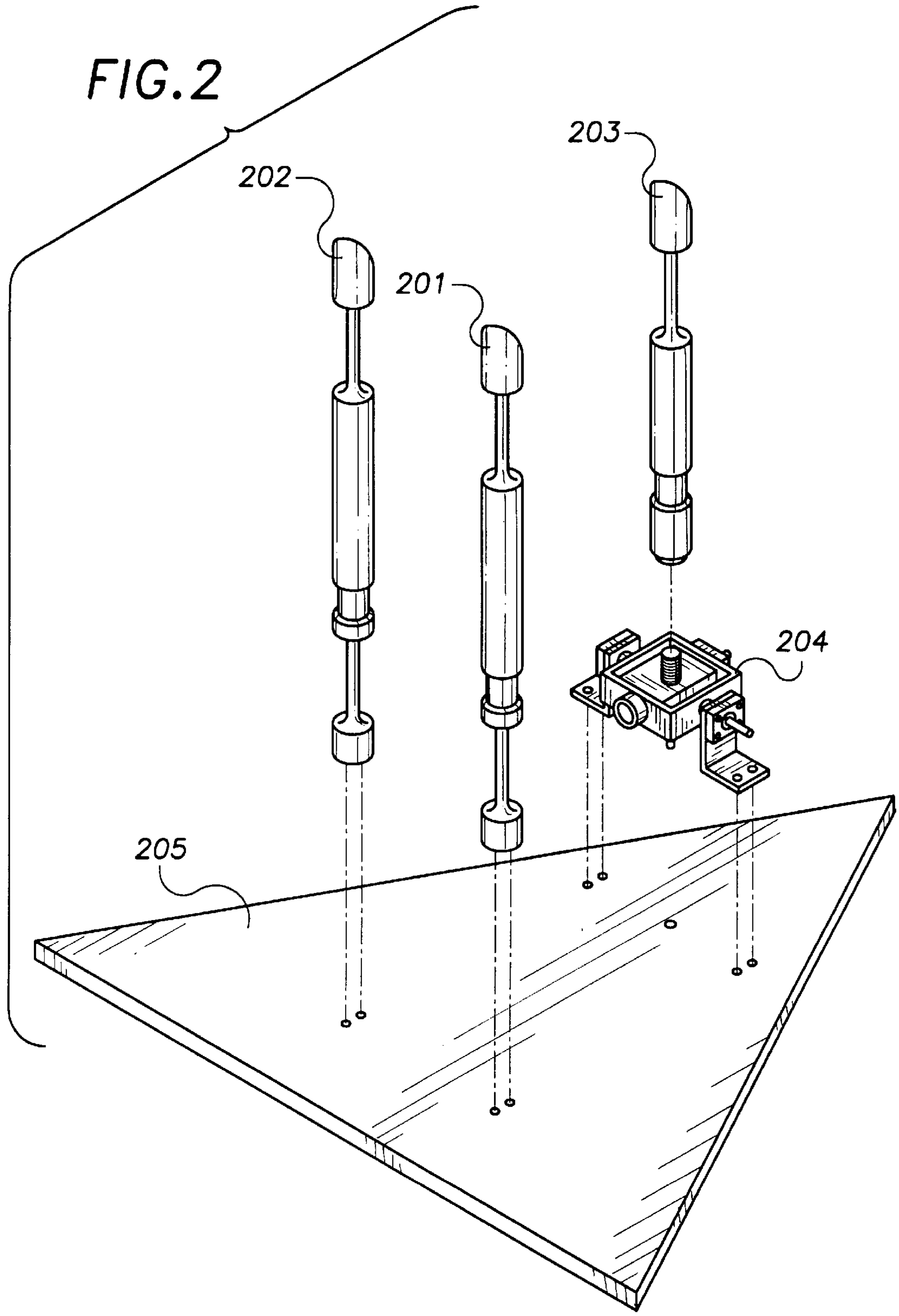


FIG. 2



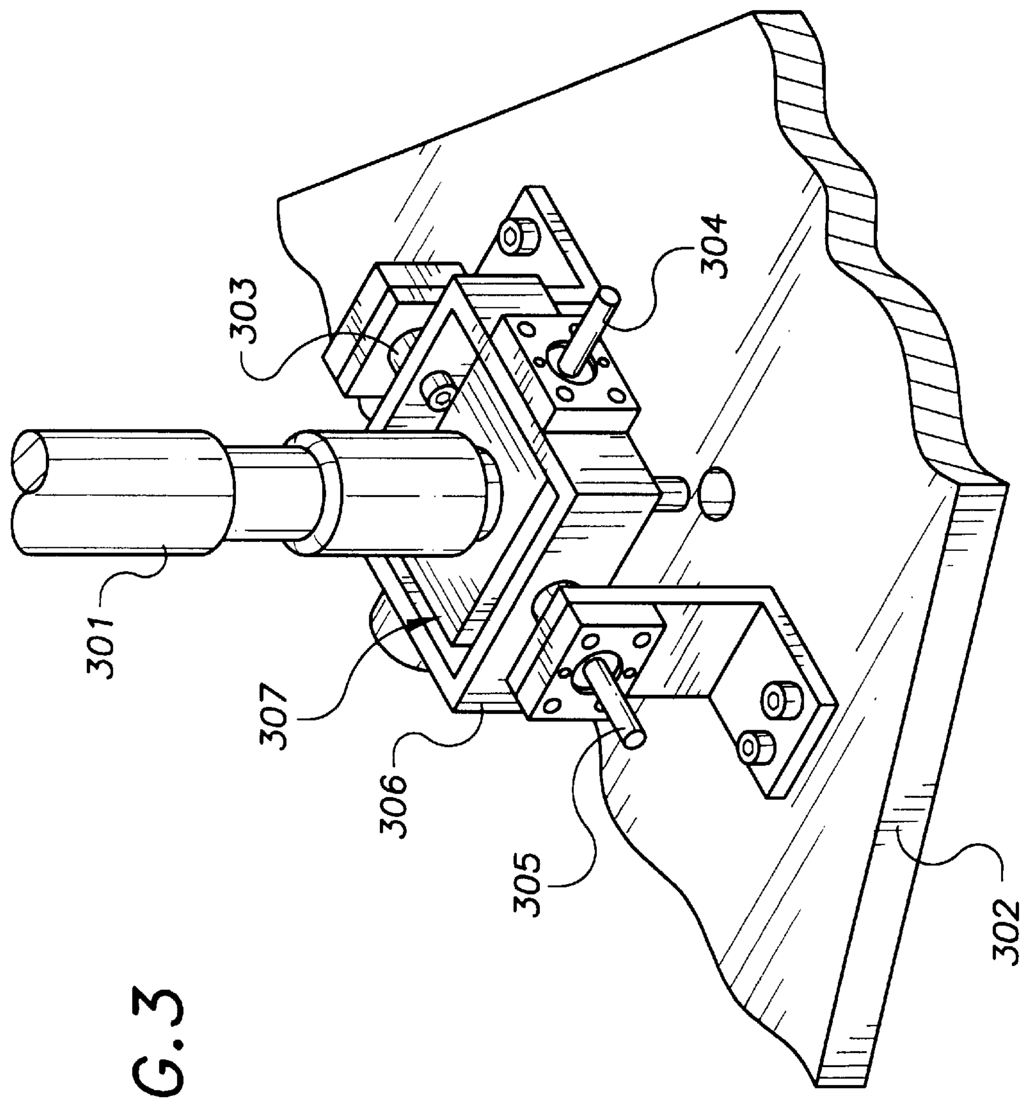


FIG. 3

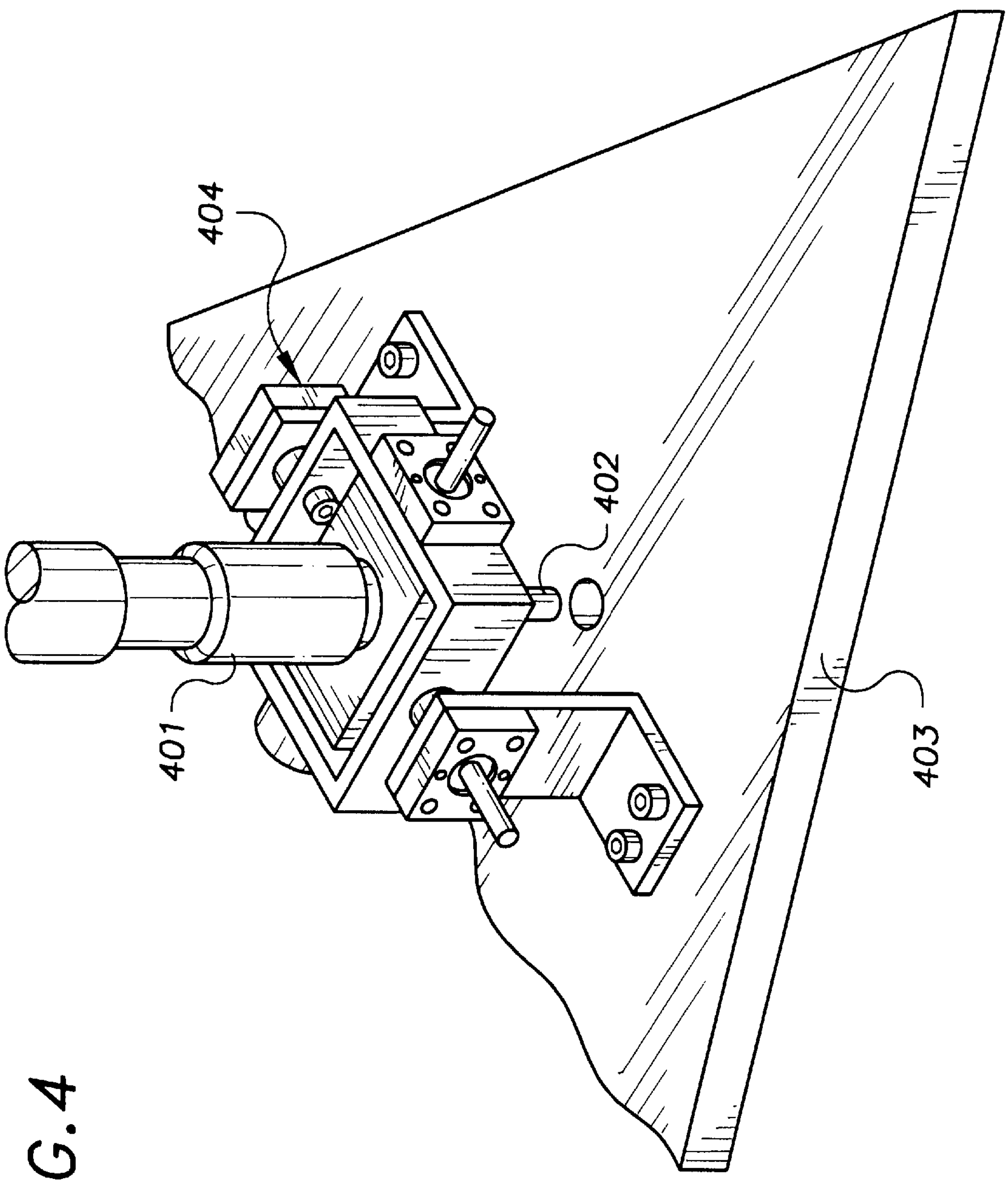


FIG. 4

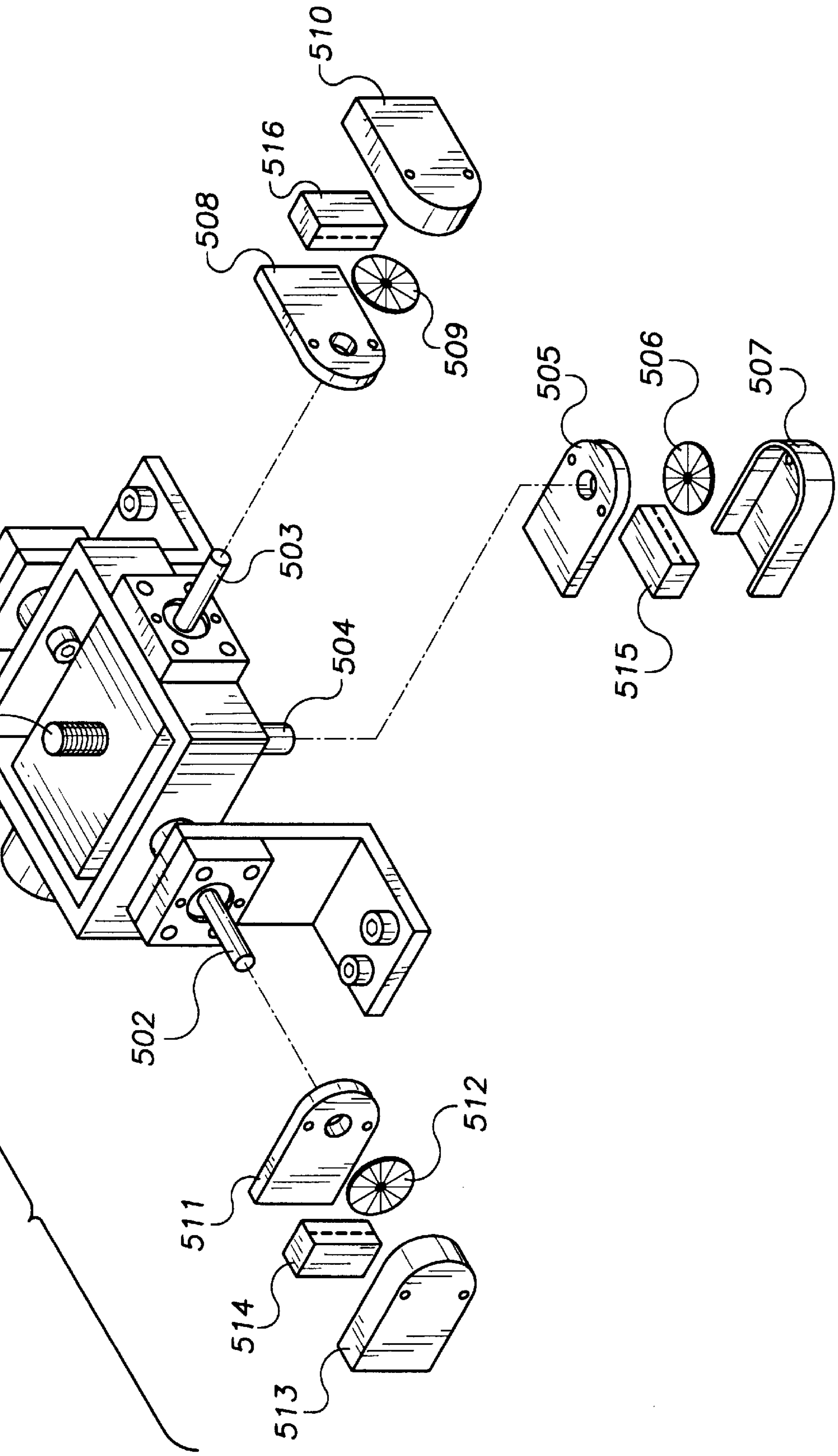

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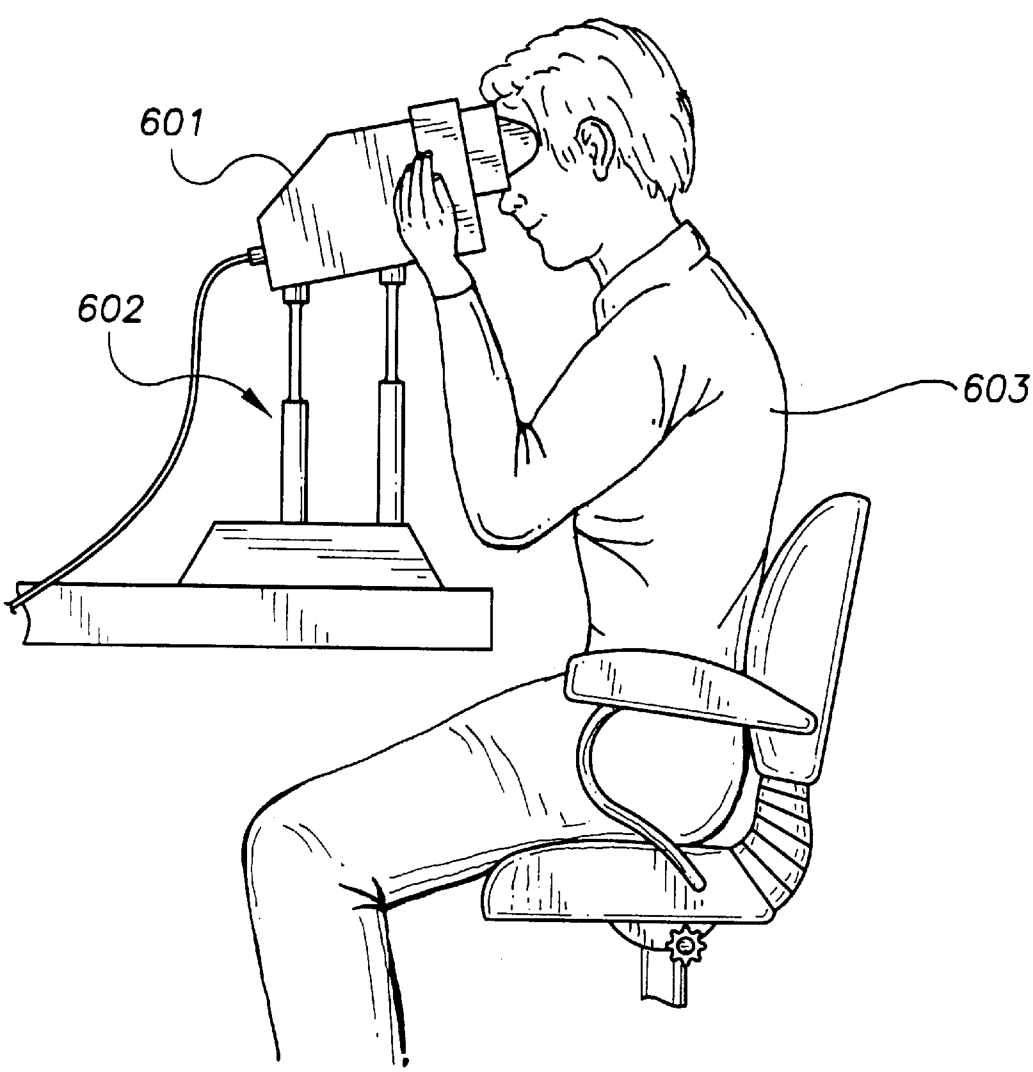
FIG. 5

FIG. 6



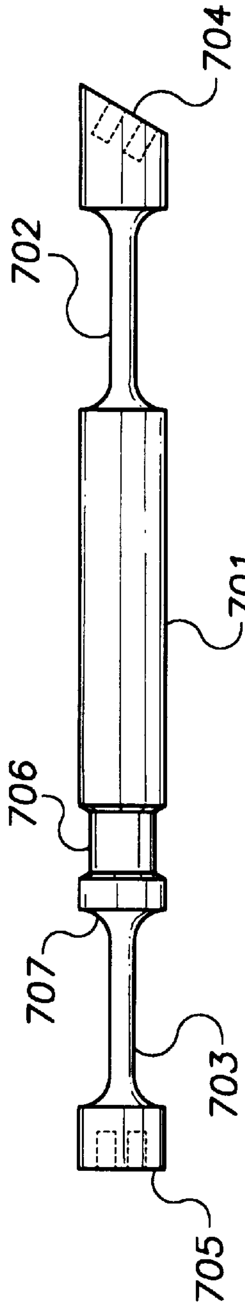


FIG. 7

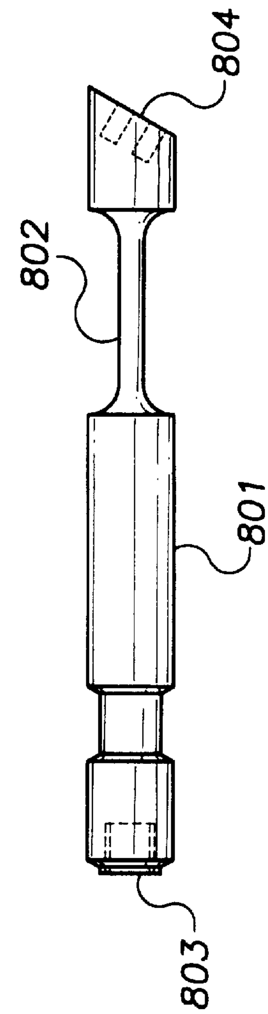


FIG. 8

GIMBAL-MOUNTED VIRTUAL REALITY DISPLAY SYSTEM

This application is a continuation of co-pending application Ser. No. 08/630,948, filed Apr. 5, 1996.

BACKGROUND OF THE INVENTION

1. Field of Invention

This invention relates to the art of mechanical structures whose deformation can be easily measured.

2. Description of the Prior Art

In the field of virtual reality, displays are mounted on structures which can be manipulated by a user. The motion of the display is measured and is used to control the user's view point in a computer generated world. Such devices are exemplified by the art described in U.S. Pat. No. 5,436,638. Making a suitable structure for mounting a display on is a challenge, one desires that the display be movable with little force. It is also desirable that the platform encourages controllable motion which means that the perceived stiffness in the left—right directions be matched with forward—back and that twist also feels similarly stiff. As detailed in U.S. Pat. No. 5,436,638 it is desired that it be possible for the structure to facilitate rotations about a user. This invention provides that flexibility is a way which is easy to sense and measure.

SUMMARY OF THE INVENTION

A structure suitable for holding a display is the object of this invention. The platform is supported by three compliant members. One of these members is attached to a gimbaled mechanism which facilitates the easy measurement of the deflection of the platform as it is moved by the user.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** shows the three legged structure, the plate where a display may be mounted, and king assembly.

FIG. **2** is an exploded view of the base, legs, and sensor assembly.

FIG. **3** shows the sensor assembly.

FIG. **4** shows the sensor assembly.

FIG. **5** shows where the encoders are mounted on the sensor assembly.

FIG. **6** shows how the display is mounted on the base and used.

FIG. **7** shows the dimensions of the two front legs.

FIG. **8** shows the detail of the rear leg which attaches to the gimbaled sensor means.

Description of the Reference Numerals in the FIGURES

100	Flat plate for display
101	front right leg
102	front left leg
103	rear leg
104	gimbaled sensor assembly
105	base plate
201	front right leg
202	front left leg
203	rear leg
204	gimbaled sensor assembly
205	base plate
301	rear leg

-continued

Description of the Reference Numerals in the FIGURES

302	base plate
303	forward/back rotational joint of gimbals
304	left/right rotational joint of gimbals, and shaft for encoder
305	encoder shaft for forward/back rotational joint
306	part of gimbaled frame
307	part of gimbals frame for the rotational joint encoding twist
401	rear leg
402	shaft for encoder to measure twist of leg 401
403	base plate
404	rest of gimbaled assembly
501	gimbaled assembly
502	shaft for forward/back measurement
503	shaft for left/right measurement
504	shaft for twist measurement
505	mounting plate for encoder
506	encoder disk
507	encoder cover
508	mounting plate for encoder
509	encoder disk
510	encoder cover
511	mounting plate for encoder
512	encoder disk
513	encoder cover
514	encoder reader
515	encoder reader
516	encoder reader
517	threaded shaft for attachment to rear leg
601	display
602	compliant measured structure
701	main body of front leg
702	hinge at top of leg
703	hinge at bottotn of leg
704	angle at top of leg where it attaches to the plate the display rests on
705	mounting for attaching leg to base plate
706	slight necking to allow for cover clearance
707	radiused join between hinge 703 and main body 701
801	rear leg body
802	top hinge for rear leg
803	threaded mounting for gimbaled assembly

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. **1** shows the front view of the invention. The compliant measured structure is composed of a base plate **105** which supports the plate for the display **100** on three compliant delrin legs. The front legs **101** and **102** provide support for plate **100**. The rear leg **103** provides support to **100** and mates with the gimbaled sensor assembly **104**. The plate **100** is thus supported in a way such that it can be moved forward/back, side to side, and rotated about an arbitrary vertical axis. When the plate **100** is moved from its rest position, the three legged structure holds it level and the legs flex to accommodate the new position. As the legs flex, the display will move in the desired direction and will also get closer to the base **105** by a tiny amount. Deflections of the legs are generally small—in the range of about ±10 degrees or so.

FIG. **2** illustrates how the device is put together. The legs **201** and **202** are mounted directly onto base plate **205** with each leg being attached with two screws to the base plate so the legs **201** and **202** can not rotate in place. The gimbaled assembly **204** is also rigidly mounted onto base plate **205**. The top of the gimbaled assembly is threaded and attaches to leg **203**.

FIG. **3** shows the gimbaled assembly in more detail. The gimbaled assembly is mounted on base plate **302**. The rear leg **301** is attached to the gimbaled assembly and the shaft which is attached to the leg **301** passes through block and rotary bearing **307**. Rotary joint **303** provides rotation of frame **306** so that shaft and rotary joint **305** can measure the angle of leg **301** in the forward/back plane. The deflection of the leg **301** is transferred through block **307** to frame **306** which is measured by an encoder mounted on **305**. The left/right motion of the top plate is transferred to a rotation of leg **301** which is transferred to block **307** and is measured by an encoder mounted on shaft **304**. Thus we can see two of the three degrees of freedom of the gimbaled assembly—forward/back motion will appear at shaft **305** and left/right motion will appear at shaft **304**.

FIG. **4** shows another view of the gimbaled assembly. Rear leg **401** is attached to gimbaled assembly **404** which is mounted on base plate **403**. The shaft **402** rotates with the rotation of leg **401** since they are attached. An encoder mounted on **402** will report the degree of twist of leg **401**. Thus, as a torque is applied to the display plate **100**, the rotation may be measured at shaft **402**.

FIG. **5** illustrates how the encoders are mounted onto the gimbaled assembly **501**. The rear leg is attached to threaded shaft **517**. Shaft **503** encodes left/right motion of the platform and is measured by attachment of the encoder disk **509**. The mounting plate **508**, and reader **516** are mounted onto the gimbaled assembly. The cover **510** helps prevent dirt from fouling the encoder disk **509**. Shaft **502** encodes forward/back motion of the platform. This motion is detected by attaching encoder disk **512** onto the shaft. The mounting plate **511** and reader **514** are attached to the gimbaled assembly and cover **513** prevents dirt from fouling the encoder disk. Twisting the platform results in a twist of the rear leg which is attached at **517** and appears at shaft **504** which is the other end of the threaded attachment point **517**. Motion at shaft **504** is measured by attaching encoder disk **506** to the shaft **504**. The base plate **505** and the reader **515** are attached to the gimbaled assembly and cover **507** prevents dirt from fouling the encoder disk **506**.

FIG. **6** shows how the compliant platform is used. A user **603** looks into a display **601** mounted on the invention **602**. The user may push the display forward and the encoders will register this motion and send it to the computer which is generating the images seen in the display **601**. This will allow the user to move forward in the computer generated world. Pushing the display to the left will be measured in a similar fashion and the images updated accordingly. Twisting the display will be measured by the third encoder of the gimbals and will result in turning in the virtual world. Combining these motions lets a user maneuver easily in the virtual world. In particular, sliding to the right and twisting to the left at the same time results in an orbiting motion which is good for looking at the other side of an object. Slightly pushing forward at the same time results in a spiral path.

FIG. **7** shows the details on the construction of the front two legs. The main body of the delrin leg **701** joins the two flexible hinge areas **703** and **702**. The leg is mounted with two screws to the base plate at the end **705**. The end **704** is angled to mate with the mounting play for the display and is also attached with two fasteners so the leg can't rotate. The necking down **706** is so that a cover does not bind on the man body of the leg at maximum deflection. The joint between the hinges **703** and **702** with the main body of the leg **701** are radiused as shown at **707**.

FIG. **8** shows the structure of the rear leg. This delrin part is similar to the front legs. Main body **801** is attached to the gimbaled assembly by threaded hole **803**. The plate for mounting the display is attached to the leg at the angled end **804**. The hinge for the leg is **802** the transition from the main body of the leg to the hinge is radiused in a similar manner to the front legs.

The structure is compliant in that the three legs are springy. The top plate on which a display may be mounted moves substantially in a plane relative to the base plate. This motion is measured by the gimbaled sensor assembly at the base of the rear leg. The encoders used to measure the motion could be replaced by another sensing means. For example, the encoders could be replaced by rotary potentiometers to measure the angles. Another alternative would be to use rotary switches.

In addition to having the leg members including an explicit hinge point, it would be possible to design legs where the flexing occurred over the entire length of the leg. In this invention, the legs are made on a lathe from round stock but making legs whose hinge elements were not symmetric about the vertical axis would allow one to adjust the springiness in particular directions. By adjusting the cross section of the legs, a system could be made in which left—right motion was easy and forward—back motion more difficult for example.

It would be possible to have more than two compliant supporting legs if desired. Thus if the display were particularly heavy or for aesthetic reasons, a number of additional legs could be introduced without impacting the performance of the structure.

At present, the range of motion of the structure is limited by having a cover with three holes mounted part way up the structure. Then when the structure is pushed to the limit, the legs bang into the edges of the holes in the cover.

What is claimed is:

1. A display system mounted on a compliant structure comprising:

a first leg and a second leg, said first and second legs being attached at their lower ends to a base plate, and supporting at their upper ends a platform;

wherein the first leg is secured to the base plate with a gimbaled assembly allowing the first leg to tilt and rotate in relation to the base plate;

wherein the second leg is secured to the base plate in such a manner that it may tilt in relation to the base plate, but is restricted from rotating about an axis perpendicular to the plane of the base plate;

and wherein said platform is operably connected to a sensor assembly which senses the position of the platform in relation to the base plate; and

an electronic display and a computer which generates and transmits an image to the electronic display, wherein the electronic display is mounted on the platform, and the sensor assembly provides information regarding the position of the platform to a computer, and wherein the computer generates and transmits images to the electronic display which vary according the sensed position of the platform.

2. A display system mounted on a compliant structure comprising:

a first leg and a second leg, said first and second legs being attached at their lower ends to a base plate, and supporting at their upper legs a platform;

wherein the first leg is secured to the base plate with a gimbaled assembly allowing the first leg to tilt and rotate in relation to the base plate;

wherein the second leg is secured to the base plate in such a manner that it may tilt in relation to the base plate, but is restricted from rotating about an axis perpendicular to the plane of the base plate;

and wherein said platform is operably connected to a sensor assembly which senses the position of the platform in relation to the base plate; and

wherein the sensor assembly is operably connected to the first leg, and senses the tilt and rotation of the first leg; and

an electronic display and a computer which generates and transmits an image to the electronic display, wherein the electronic display is mounted on the platform, and the sensor assembly provides information regarding the tilt and rotation of the first leg to a computer, and wherein the computer generates and transmits images to the electronic display which vary according the sensed position of the first leg.

3. A system for controlling the image displayed on a display screen, said system comprising:

a computer programmed to generate images for display on the display screen in response to physical movement of the display screen;

a platform supporting the display screen;

a base plate;

a first leg rotatably and tiltably secured to the base plate;

a second leg tiltably secured to the base plate;

wherein the display screen is supported by the first and second legs, and the display screen may be moved in relation to the base;

a sensor assembly operably connected to the first leg for sensing the tilt and rotation of the first leg, said sensor assembly also being operably connected to the computer and transmitting tilt and rotation information regarding the first leg to the computer;

said computer receives tilt and rotation information from the sensor assembly of the first leg, calculates the position of the display screen base upon said tilt and rotation information, generates an image for display on the display screen based upon the position of the display screen, and transmits said image to the display screen.

4. A system for controlling the image displayed on a display screen, said system comprising:

a computer programmed to generate images for display on the display screen in response to physical movement of the display screen;

a platform supporting the display screen;

a base plate;

a first leg rotatably and tiltably secured to the base plate;

a second leg tiltably secured to the base plate but not rotatable about an axis perpendicular to the plane of the base plate;

wherein the display screen is supported by the first and second legs, and the display screen may be moved in relation to the base;

a sensor assembly operably connected to the display screen to sense the position of the display screen, said sensor assembly also being operably connected to the computer and transmitting information regarding position of the display screen to the computer;

said computer being programmed to receive information regarding position of the display screen sensor assembly, generates an image for display on the display screen based upon the position of the display screen, and transmits said image to the display screen.

5. A system for controlling the image displayed on a display screen, said system comprising:

a computer programmed to generate images for display on the display screen in response to physical movement of the display screen;

a platform supporting the display screen;

a base plate;

at least one leg rotatably and tiltably secured to the base plate;

wherein the display screen is supported by the leg, and the display screen may be moved in relation to the base;

a sensor assembly operably connected to the display screen to sense the position of the display screen, said sensor assembly also being operably connected to the computer and transmitting information regarding position of the display screen to the computer;

said computer being programmed to receive information regarding position of the display screen sensor assembly, and for generating an image for display on the display screen based upon the position of the display screen, and transmitting said image to the display screen.

* * * * *

US006396462B1

(12) **United States Patent**
Mead, Jr. et al.

(10) **Patent No.: US 6,396,462 B1**
(45) **Date of Patent: *May 28, 2002**

(54) **GIMBAL-MOUNTED VIRTUAL REALITY DISPLAY SYSTEM**

(75) Inventors: **Russell C. Mead, Jr.**, San Francisco; **Mark Bolas**, Mountain View; **Ian McDowall**, Palo Alto, all of CA (US)

(73) Assignee: **Fakespace Labs, Inc.**, Mountain View, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **09/624,939**

(22) Filed: **Jul. 25, 2000**

Related U.S. Application Data

(63) Continuation of application No. 08/630,948, filed on Apr. 5, 1996, now Pat. No. 6,094,180.

(51) **Int. Cl.**[7] **G09G 5/00**

(52) **U.S. Cl.** **345/7**; 345/8; 345/156; 361/681; 434/43

(58) **Field of Search** 345/7, 8, 9, 156, 345/157, 161; 248/188.1, 603, 160, 622, 163.1, 274.1; 361/681, 680, 679; 463/1, 2; 434/43

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6,094,180 A	*	7/2000	Mead, Jr. et al.	345/8

* cited by examiner

Primary Examiner—Steven Saras
Assistant Examiner—Amr Awad
(74) *Attorney, Agent, or Firm*—K. David Crockett, Esq.; Crockett & Crockett

(57) **ABSTRACT**

A compliant structure which includes a means for sensing translation and rotation of a top plate is disclosed. The structure is composed of a base plate and three supporting legs. The legs are compliant. The deflections of the structure are substantially in a plane and the translation and twist of the top platform may be measured by the gimbaled sensor assembly attached to one of the legs.

11 Claims, 7 Drawing Sheets

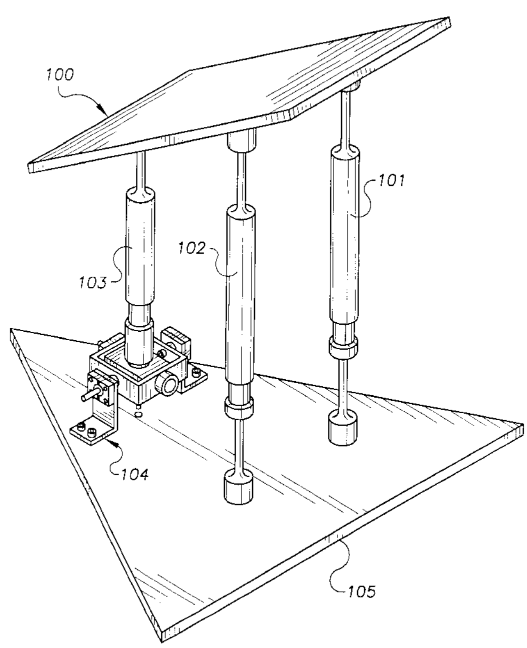
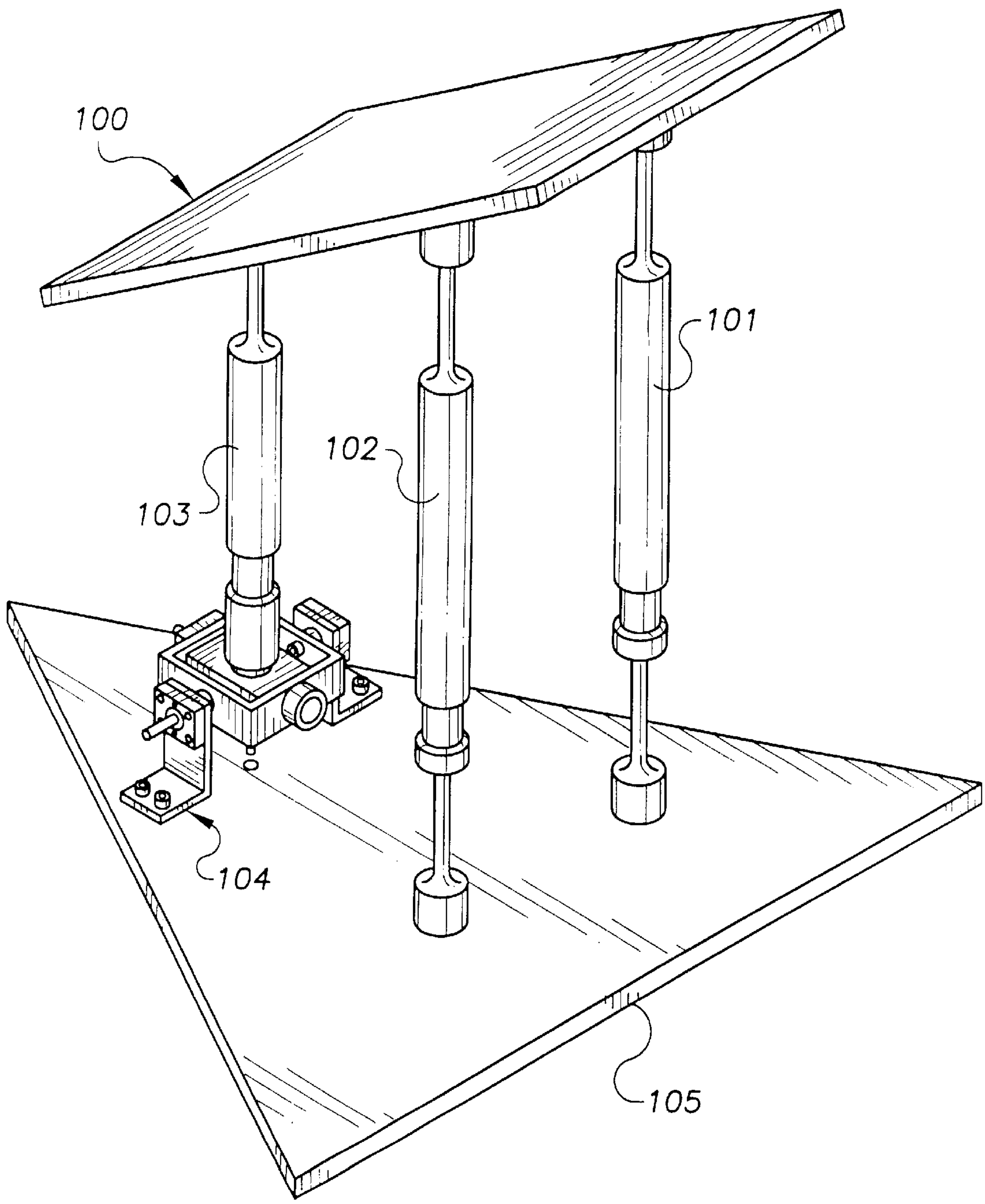


FIG. 1



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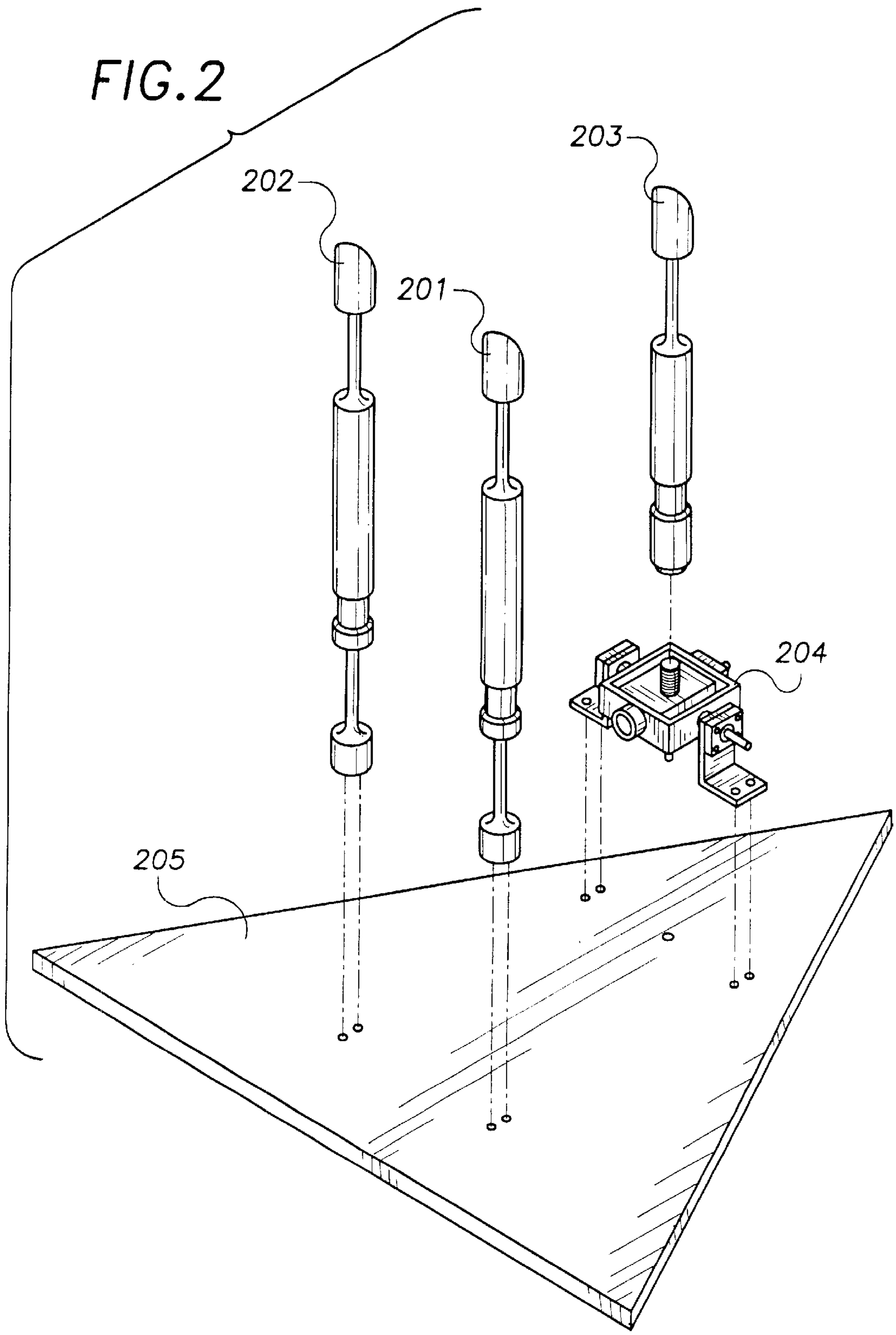

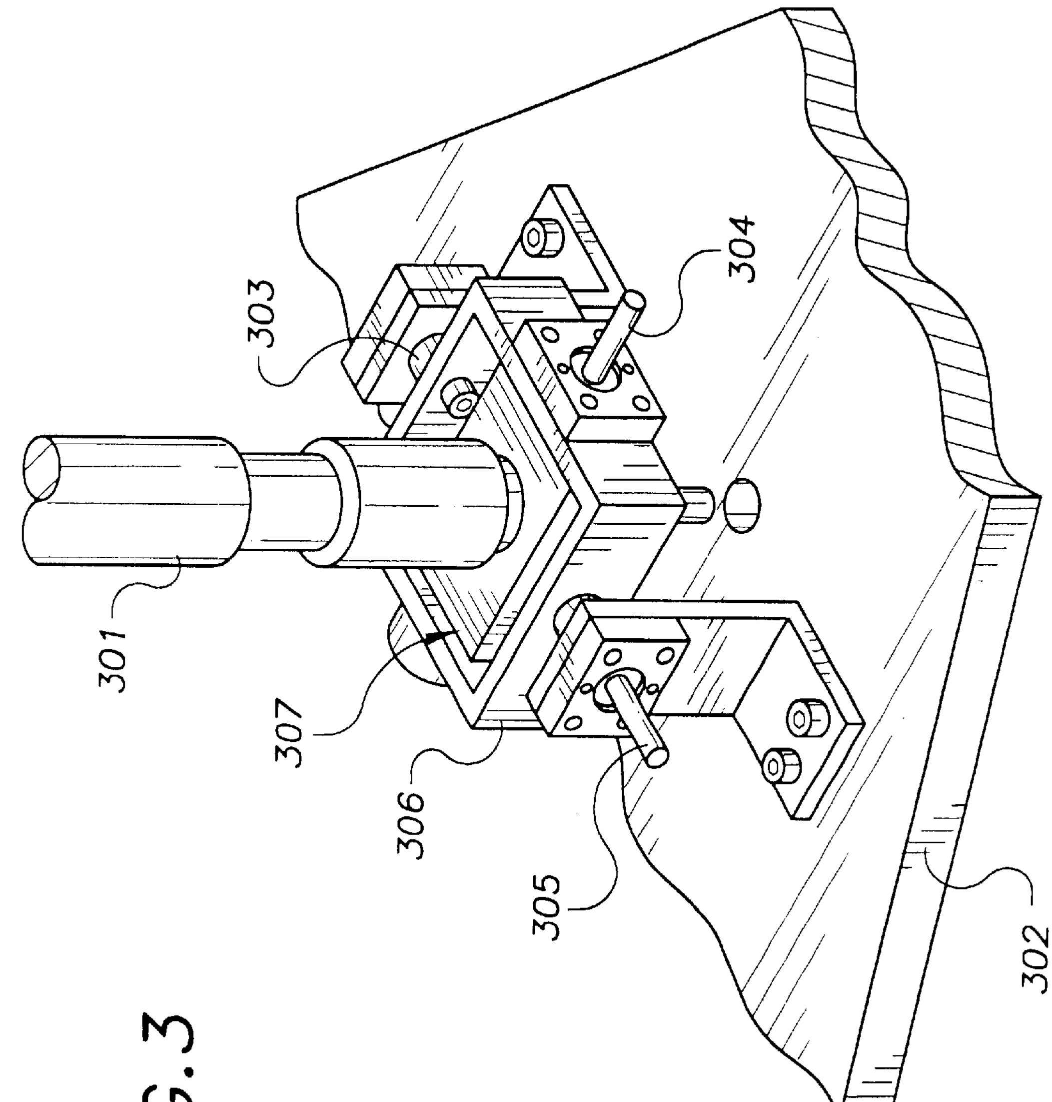

FIG. 3

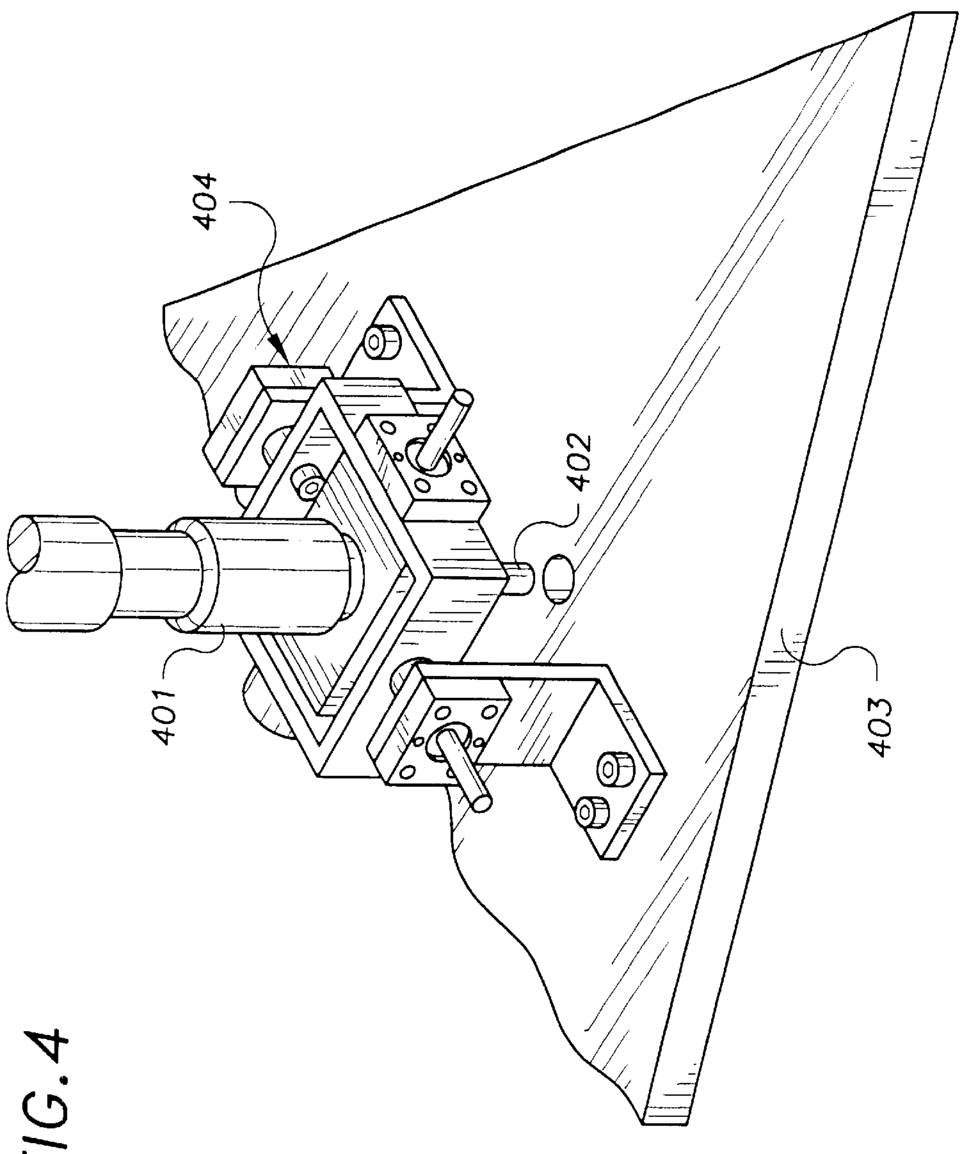

FIG. 4

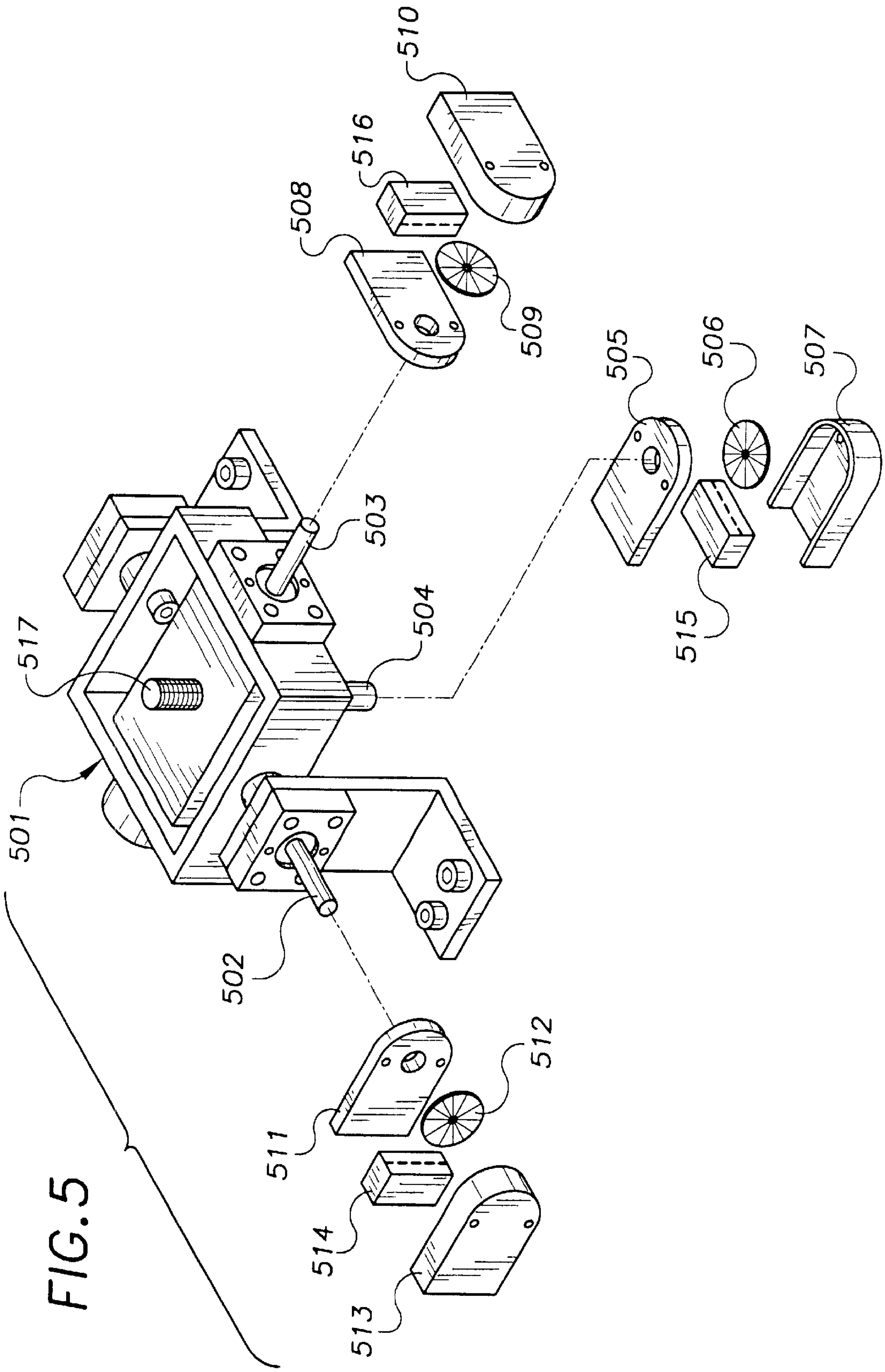
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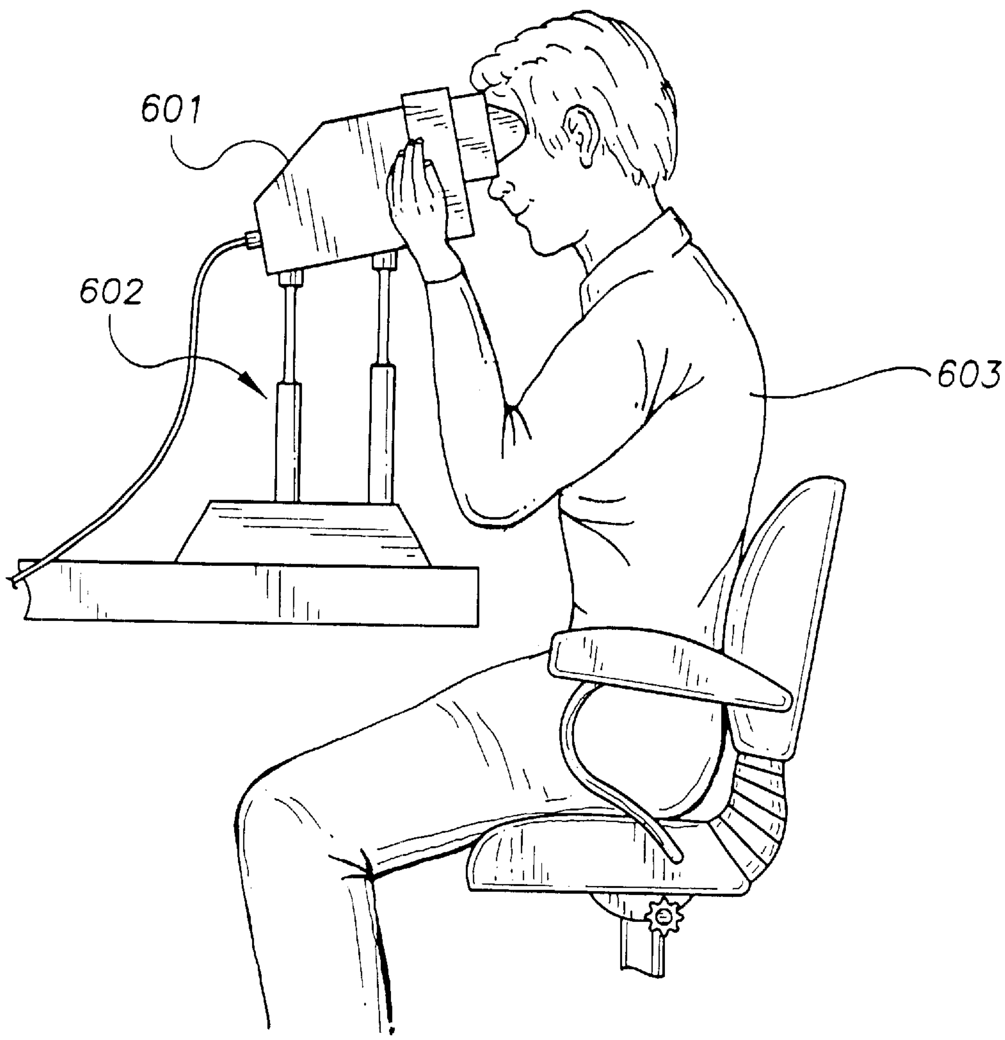
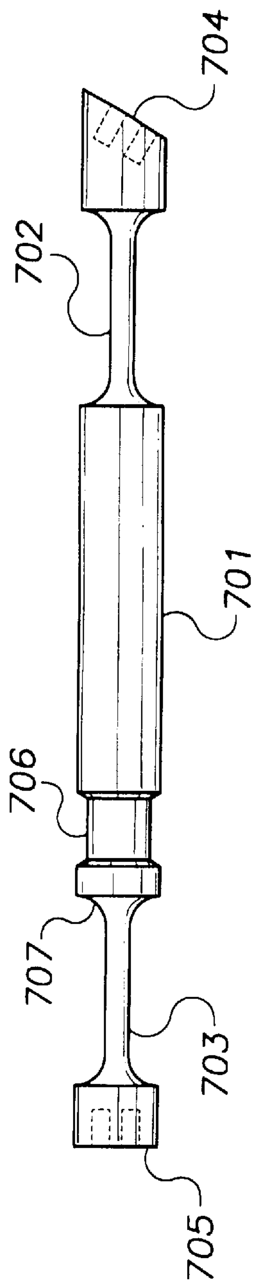
FIG. 5

FIG. 6





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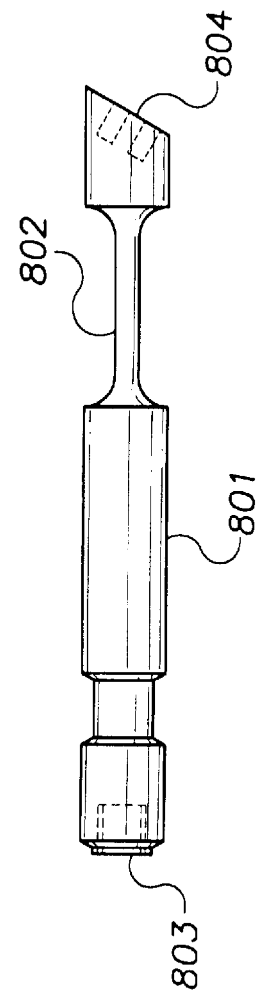

FIG. 8

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RELATED PATENT APPLICATION

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FIG. **7** shows the dimensions of the two front legs

FIG. **8** shows the detail of the rear leg which attaches to the gimbaled sensor means.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. **1** shows the front view of the invention. The compliant measured structure is composed of a base plate **105** which supports the plate for the display **100** on three compliant delrin legs. The front legs **101** and **102** provide support for plate **100**. The rear leg **103** provides support to plate **100** and mates with the gimbaled sensor assembly **104**. The plate **100** is thus supported in a way such that it can be moved forward/back, side to side, and rotated about an arbitrary vertical axis. When the plate **100** is moved from its rest position, the three legged structure holds it level and the legs flex to accommodate the new position. As the legs flex, the display will move in the desired direction and will also get closer to the base **105** by a tiny amount. Deflections of the legs are generally small—in the range of about +/−10 degrees or so.

FIG. **2** illustrates how the device is put together. The legs **201** and **202** are mounted directly onto base plate **205** with each leg being attached with two screws to the base plate so the legs **201** and **202** can not rotate in place. The gimbaled assembly **204** is also rigidly mounted onto base plate **205**. The top of the gimbaled assembly is threaded and attaches to leg **203**.

FIG. **3** shows the gimbaled assembly in more detail. The gimbaled assembly is mounted on base plate **302**. The rear leg **301** is attached to the gimbaled assembly and the shaft which is attached to the leg **301** passes through block and rotary bearing **307**. Rotary joint **303** provides rotation of frame **306** so that shaft and rotary joint **305** can measure the angle of leg **301** in the forward/back plane. The deflection of the leg **301** is transferred through block **307** to frame **306** which is measured by an encoder mounted on **305**. The left/right motion of the top plate is transferred to a rotation of leg **301** which is transferred to block **307** and is measured by an encoder mounted on shad **304**. Thus we can see two of the three degrees of freedom of the gimbaled assembly-forward/back motion will appear at shaft **305** and left/right motion will appear at shaft **304**.

FIG. **4** shows another view of the gimbaled assembly. Rear leg **401** is attached to gimbaled assembly **404** which is mounted on base plate **403**. The shaft **402** rotates with the rotation of leg **401** since they are attached. An encoder mounted on **402** will report the degree of twist of leg **401**. Thus, as a torque is applied to the display plate **100**, the rotation may be measured at shaft **402**.

FIG. **5** illustrates how the encoders are mounted onto the gimbaled assembly **501**. The rear leg is attached to threaded shaft **517**. Shaft **503** encodes left/right motion of the platform and is measured by attachment of the encoder disk **509**. The mounting plate **508**, and reader **516** are mounted onto the gimbaled assembly. The cover **510** helps prevent dirt from fouling the encoder disk **509**. Shaft **502** encodes forward/back motion of the platform. This motion is detected by attaching encoder disk **512** onto the shaft. The mounting plate **511** and reader **514** are attached to the gimbaled assembly and cover **513** prevents dirt from fouling the encoder disk. Twisting the platform results in a twist of the rear leg which is attached at **517** and appears at shaft **504** which is the other end of the threaded attachment point **517**. Motion at shaft **504** is measured by attaching encoder disk **506** to the shaft **504**. The base plate **505** and the reader **515** are attached to the gimbaled assembly and cover **507** prevents dirt from fouling the encoder disk **506**.

FIG. **6** shows how the compliant platform is used. A user **603** looks into a display **601** mounted on the invention **602**. The user may push the display forward and the encoders will register this motion and send it to the computer which is generating the images seen in the display **601**. This will allow the user to move forward in the computer generated world. Pushing the display to the left will be measured in a similar fashion and the images updated accordingly. Twisting the display will be measured by third encoder of the gimbals and will result in turning in the virtual world. Combining these motions lets a user maneuver easily in the virtual world. In particular, sliding to the right and twisting to the left at the same time results in an orbiting motion which is good for looking at the other side of an object. Slightly pushing forward at the same time results in a spiral path.

FIG. 7 shows the details on the construction of the front two legs. The main body of the delrin leg **701** joins the two flexible hinge areas **703** and **702**. The leg is mounted with two screws to the base plate at the end **705**. The end **704** is angled to mate with the mounting plate for the display and is also attached with two fasteners so the leg can't rotate. The necking down **706** is so that a cover does not bind on the main body of the leg at maximum deflection. The joint between the hinges **703** and **702** with the main body of the leg **701** are radiused as shown at **707**.

FIG. 8 shows the structure of the rear leg. This delrin part is similar to the front legs. Main body **801** is attached to the gimbaled assembly by threaded hole **803**. The plate for mounting the display is attached to the leg at the angled end **804**. The hinge for the leg is **802** and the transition from the main body of the leg to the hinge is radiused in a similar manner to the front legs.

The structure is compliant in that the three legs are springy. The top plate on which a display may be mounted moves substantially in a plane relative to the base plate. This motion is measured by the gimbaled sensor assembly at the base of the rear leg. The encoders used to measure the motion could be replaced by another sensing means. For example, the encoders could be replaced by rotary potentiometers to measure the angles. Another alternative would be to use rotary switches.

In addition to having the leg members including an explicit hinge, it would be possible to design legs where the flexing occurred over the entire length of the leg. In this invention, the legs are made on a lathe from round stock but making legs whose hinge elements were not symmetric about the vertical axis would allow one to adjust the springiness in particular directions. By adjusting the cross section of the legs, a system could be made in which left-right motion was easy and forward-back motion more difficult, for example.

It would be possible to have more than two compliant supporting legs if desired. Thus if the display were particularly heavy or for aesthetic reasons, a number of additional legs could be introduced without impacting the performance of the structure.

At present, the range of motion of the structure is limited by having a cover with three holes mounted part way up the structure. Then when the structure is pushed to the limit, the legs bang into the edges of the holes in the cover.

We claim:

1. A system for controlling an image displayed on a display screen, said system comprising:

a computer programmed to generate images for display on the display screen in response to physical movement of the display screen;

a platform for supporting the display screen;

a base plate;

at least one leg rotatably and tiltably secured to the base plate, the display screen is supported by the at least one leg and the display screen may be moved in relation to the base plate; and

a sensor assembly operably connected to the at least one leg for sensing the tilt and rotation of the at least one leg, the sensor assembly also being operably connected to the computer and transmitting tilt and rotation information regarding the at least one leg to the computer;

wherein said computer receives tilt and rotation information from the sensor assembly of the at least one leg, calculates the position of the display screen based upon said tilt and rotation information, generates an image for display on the display screen based upon the position of the display screen, and transmits the image to the display screen;

wherein the at least one leg is made of material having sufficient flexibility to permit movement of the platform relative to the base.

2. The system of claim **1** wherein the at least one leg is made of synthetic resinous plastic material.

3. The system of claim **1** wherein the at least one leg comprises a main body and at least one hinge element.

4. A display system mounted on a compliant structure comprising:

a first leg and a second leg, the first leg and the second leg being attached, at their lower ends, to a base plate, the first and second legs supporting, at their upper ends, a platform;

wherein the first leg is secured to the base plate with a gimbaled assembly allowing the first leg to tilt and rotate in relation to the base plate;

wherein the second leg is secured to the base plate in such a manner that it may tilt in relation to the base plate, but is restricted from rotating about an axis perpendicular to the plane of the base plate;

wherein the second leg is made of material having sufficient flexibility to permit movement of the platform relative to the base;

wherein the platform is operably connected to a sensor assembly which senses the position of the platform in relation to the base plate; and

an electronic display and a computer which generates and transmits an image to the electronic display, wherein the electronic display is mounted on the platform and the sensor assembly provides information regarding the position of the platform to a computer, wherein the computer generates and transmits images to the electronic display which vary according to the sensed position of the platform.

5. The system of claim **4** wherein the second leg is made of synthetic resinous plastic material.

6. The system of claim **4** wherein the second leg comprises a main body and at least one hinge element.

7. A system for controlling an image displayed on a display screen, the display screen being mounted on a platform which may be moved by an operator, said system comprising:

a computer programmed to generate images for display on the display screen in response to physical movement of the display screen;

a platform for supporting the display screen;

a base plate;

a first leg rotatably secured to the base plate;

a second leg tiltably secured to the base plate;

wherein the display screen is supported by the first and second legs, and the display screen may be moved in relation to the base plate;

a sensor assembly operably connected to the first leg for sensing the tilt and rotation of the first leg, the sensor assembly also being operably connected to the computer and transmitting tilt and rotation information regarding the first leg to the computer;

said computer receives tilt and rotation information from the sensor assembly of the first leg, calculates the position of the display screen based upon said tilt and rotation information, generates an image for display on the display screen based upon the position of the display screen, and transmits the image to the display screen;

wherein the second leg is sufficiently flexible to twist and bend in response to movement of the display screen relative to the base plate.

8. The system of claim **7** wherein the second leg comprises a main body and at least one hinge element providing a flexible segment in the second leg.

9. The system of claim **7** wherein the second leg is made of synthetic resinous plastic material.

10. A system for controlling an image displayed on a display screen, said system comprising:

a computer programmed to generate images for display on the display screen in response to physical movement of the display screen;

a platform for supporting the display screen;

a base plate;

a first leg rotatably and tiltably secured to the base plate;

a second leg tiltably secured to the base plate but not rotatable about an axis perpendicular to the plane of the base plate;

wherein the display screen is supported by the first and second legs, and the display screen may be moved in relation to the base plate;

a sensor assembly operably connected to the first leg for sensing the tilt and rotation of the first leg, the sensor assembly also being operably connected to the computer and transmitting tilt and rotation information regarding the first leg to the computer;

wherein said computer receives tilt and rotation information from the sensor assembly of the first leg, calculates the position of the display screen based upon said tilt and rotation information, generates an image for display on the display screen based upon the position of the display screen, and transmits the image to the display screen;

wherein the second leg comprises a main body and at least one hinge element.

11. The system of claim **10** wherein the second leg is made of synthetic resinous plastic material.

* * * * *

US006774870B2

(12) **United States Patent**
Mead, Jr. et al.

(10) **Patent No.: US 6,774,870 B2**
(45) **Date of Patent: *Aug. 10, 2004**

(54) **GIMBAL-MOUNTED VIRTUAL REALITY DISPLAY SYSTEM**

(75) Inventors: **Russell C. Mead, Jr.**, San Francisco, CA (US); **Ian McDowall**, Palo Alto, CA (US); **Mark Bolas**, Mountain View, CA (US)

(73) Assignee: **Fakespace Labs, Inc.**, Mountain View, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **10/154,171**

(22) Filed: **May 21, 2002**

(65) **Prior Publication Data**

US 2002/0140634 A1 Oct. 3, 2002

Related U.S. Application Data

(63) Continuation of application No. 09/624,939, filed on Jul. 25, 2000, now Pat. No. 6,396,462, which is a continuation of application No. 08/630,948, filed on Apr. 5, 1996, now Pat. No. 6,094,180.

(51) **Int. Cl.**[7] **G09G 5/00**
(52) **U.S. Cl.** **345/8**; 345/156; 248/603; 361/681; 434/43
(58) **Field of Search** 345/7–8, 156, 345/157, 161; 248/188.1, 603, 160, 622, 163.1, 274.1; 361/680, 681, 679; 463/1–2; 434/43

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(74) *Attorney, Agent, or Firm*—K. David Crockett, Esq.; Crockett & Crockett

(57) **ABSTRACT**

A compliant structure which includes a means for sensing translation and rotation of a top plate is disclosed. The structure is composed of a base plate and three supporting legs. The legs are compliant. The deflections of the structure are substantially in a plane and the translation and twist of the top platform may be measured by the gimbaled sensor assembly attached to one of the legs.

6 Claims, 7 Drawing Sheets

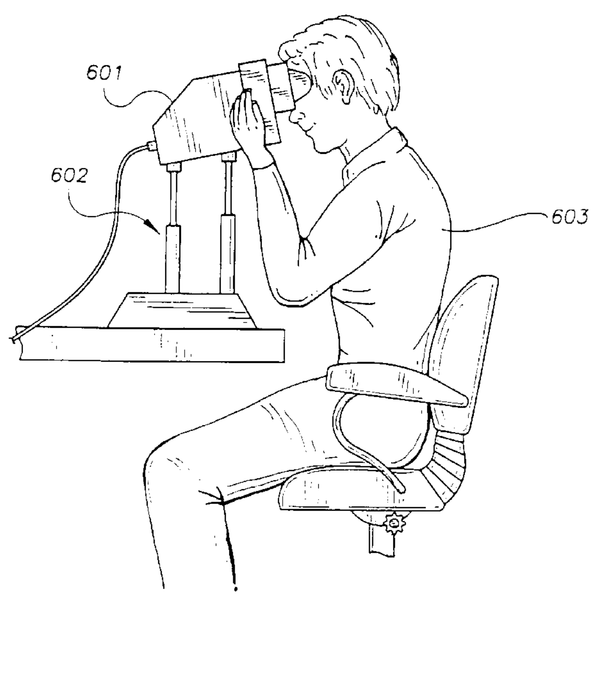


FIG. 1

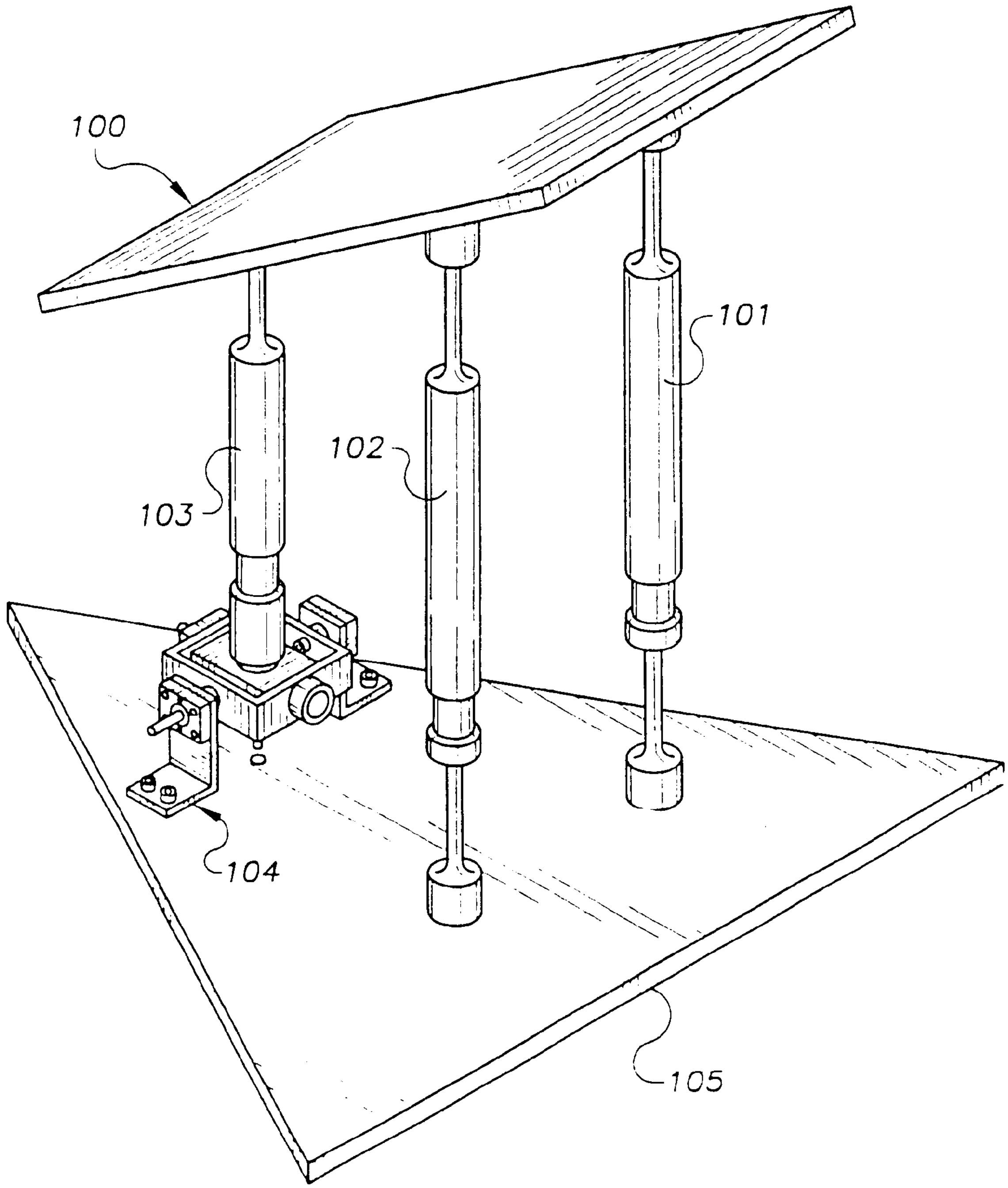
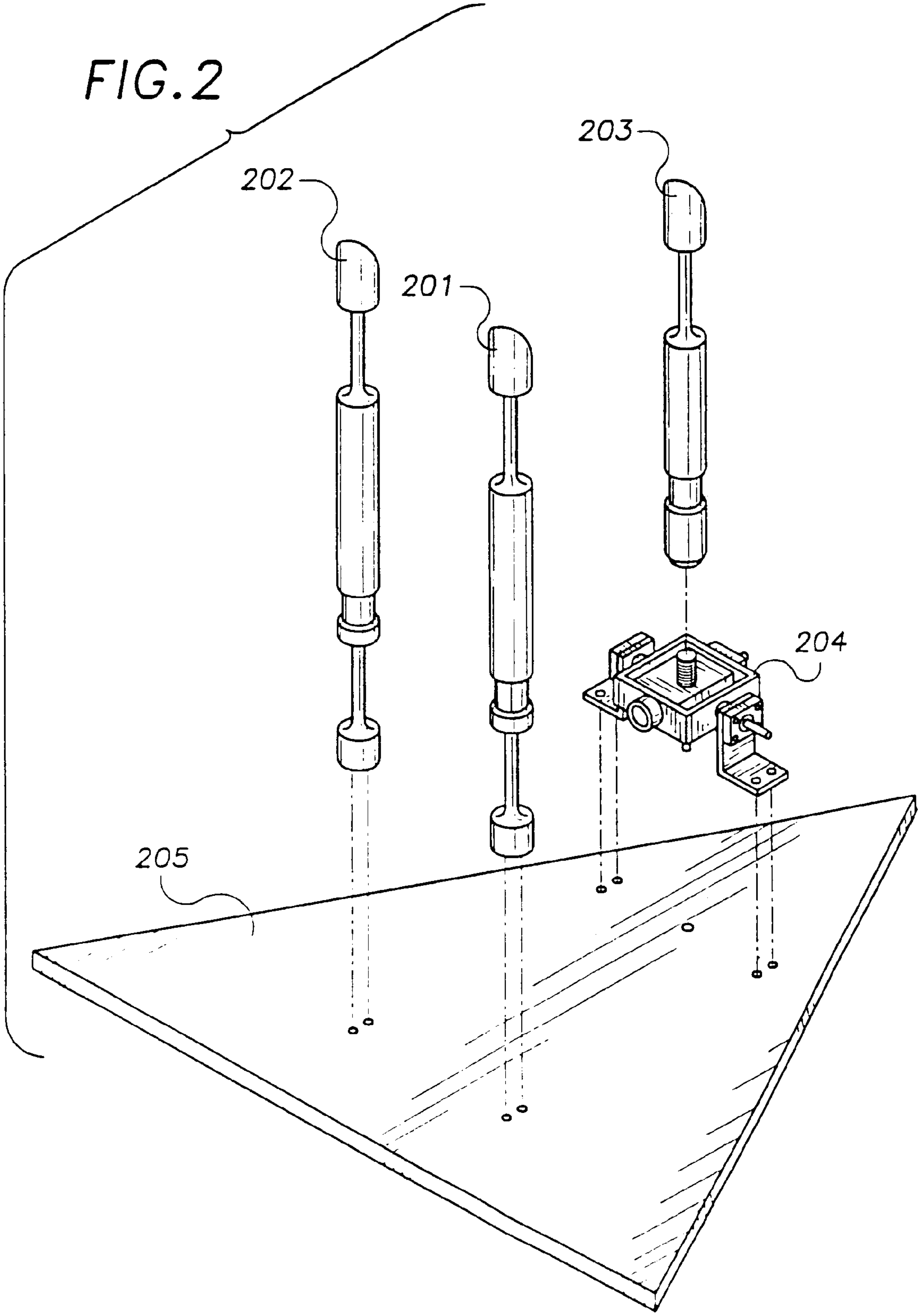


FIG. 2



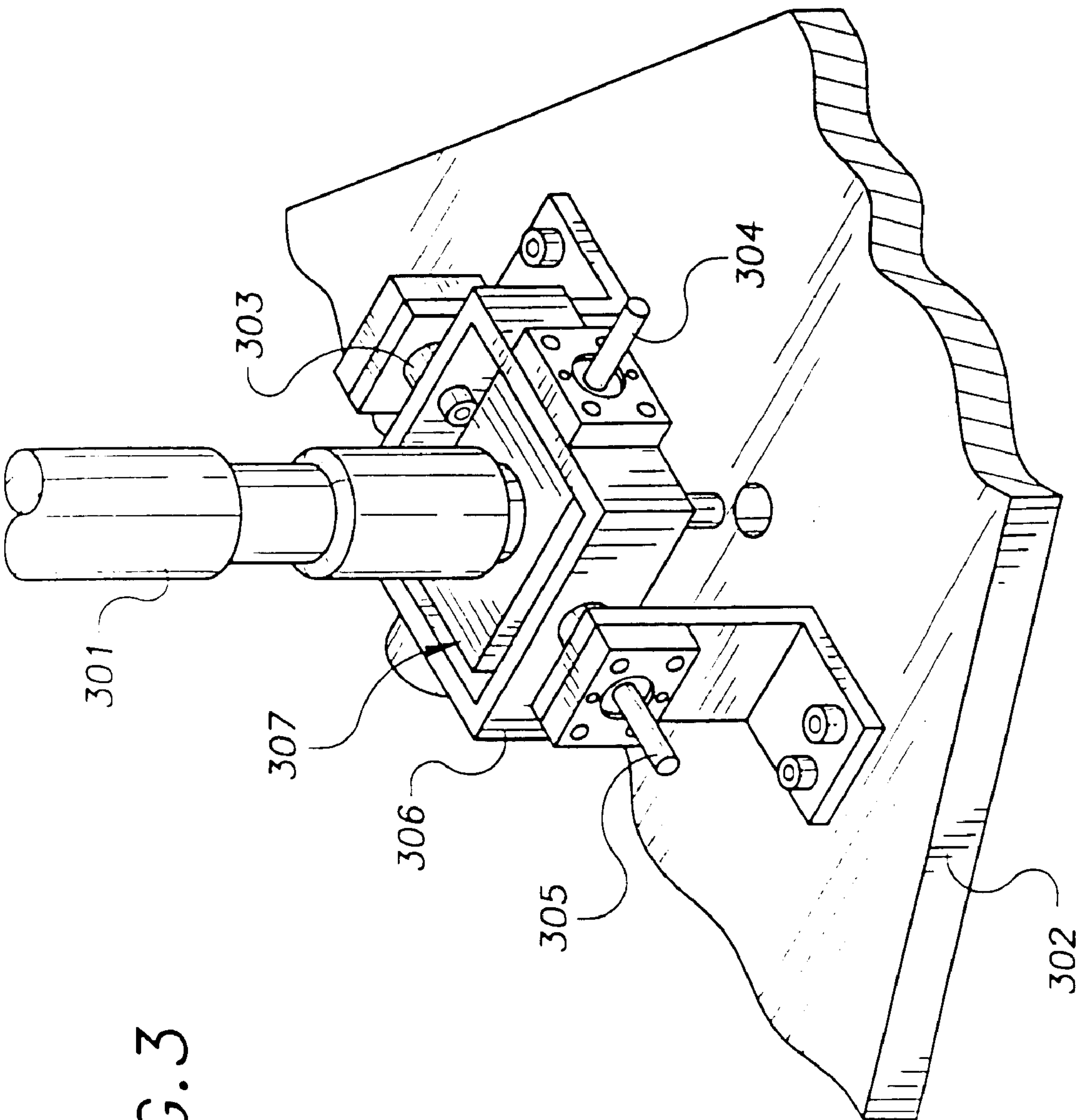


FIG. 3

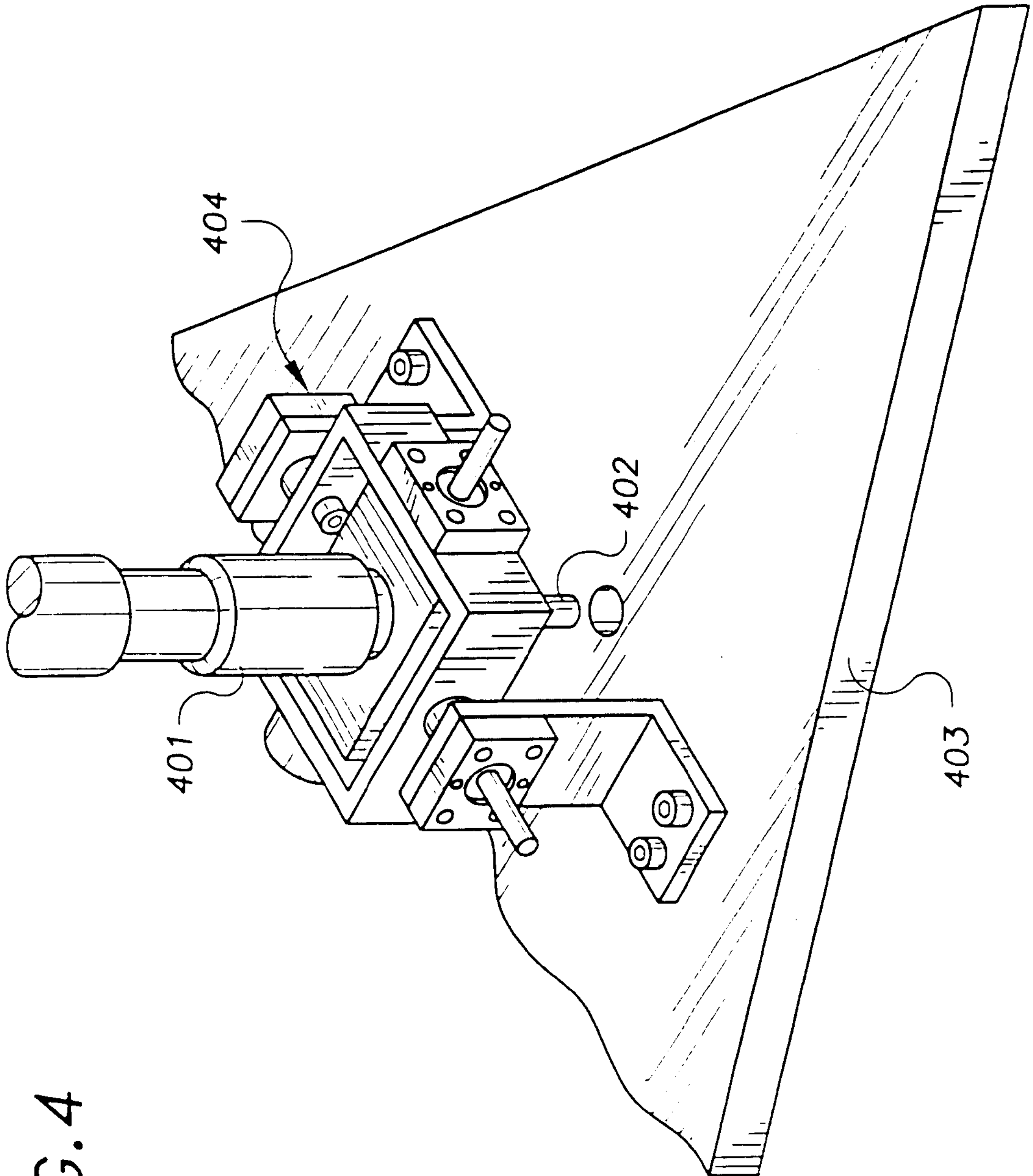


FIG. 4

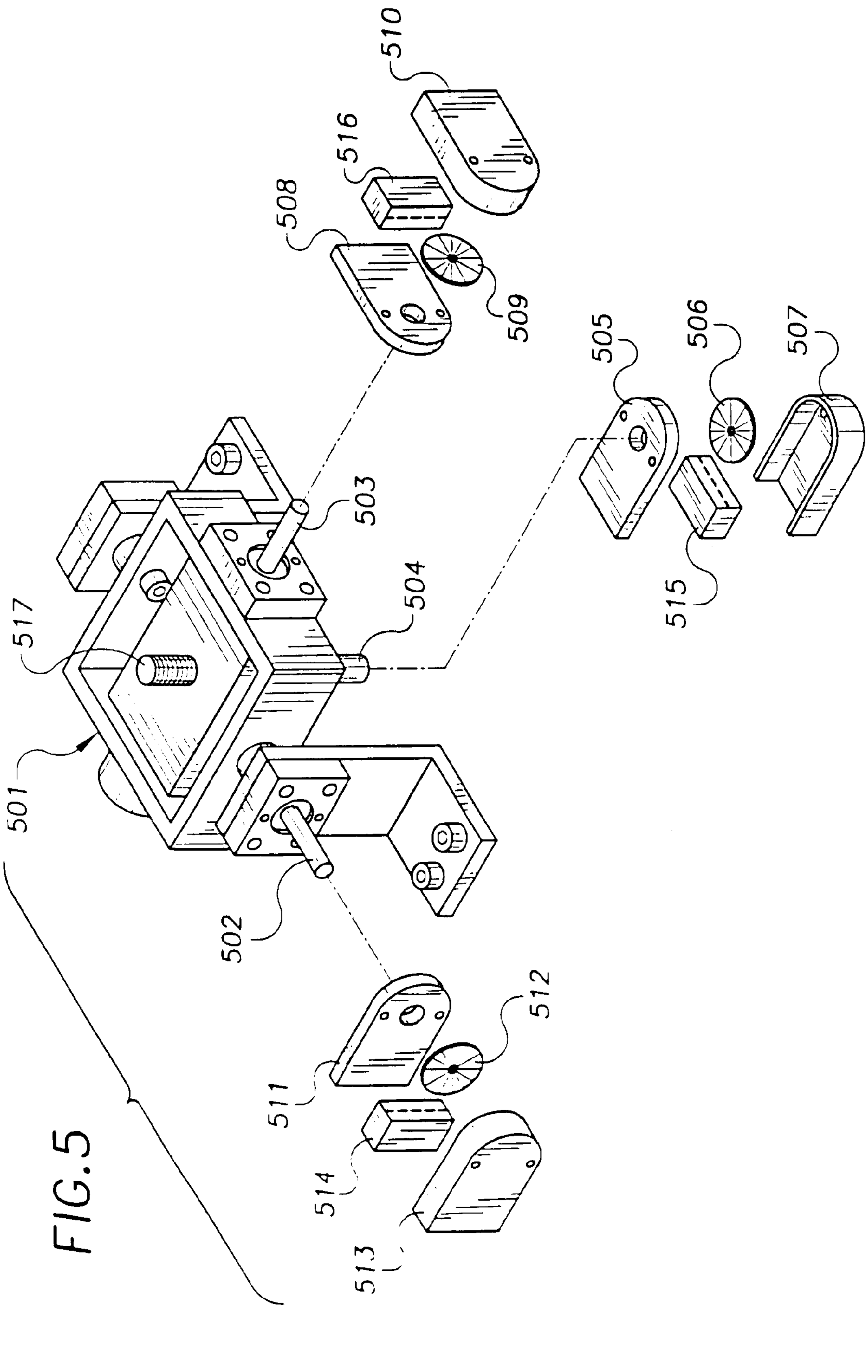

510
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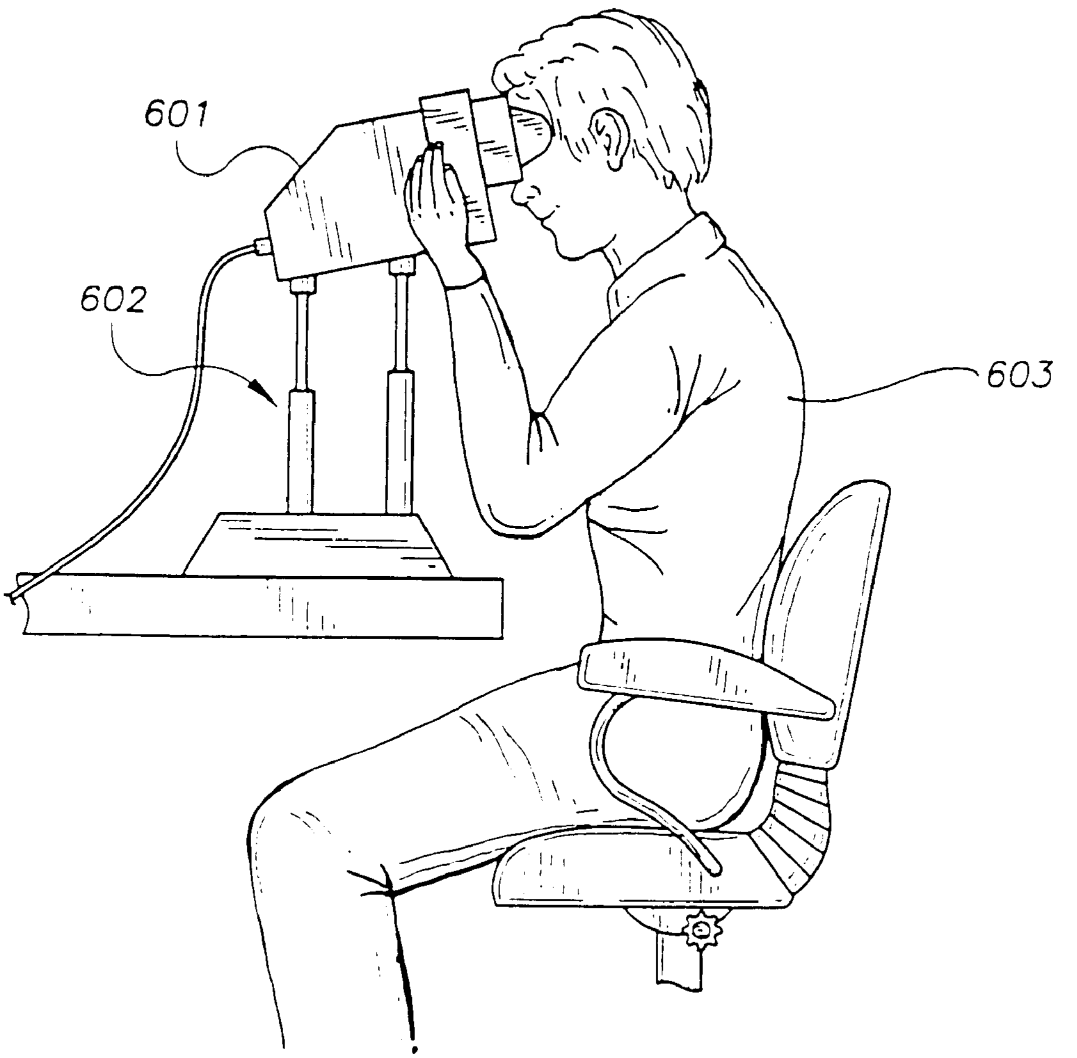
FIG. 5

FIG. 6



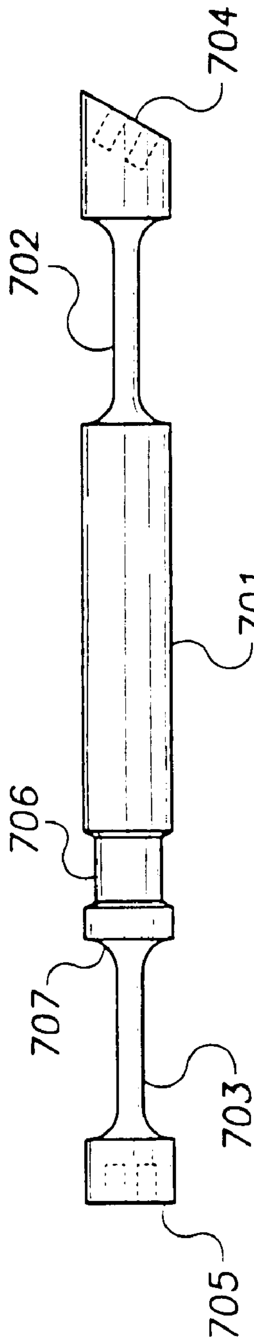


FIG.7

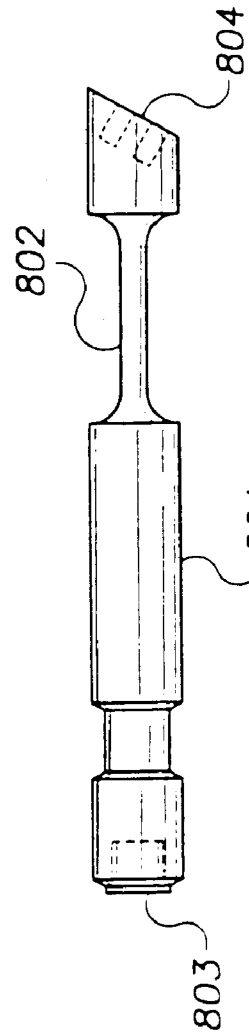


FIG.8

GIMBAL-MOUNTED VIRTUAL REALITY DISPLAY SYSTEM

RELATED PATENT APPLICATIONS

This application is a continuation of application Ser. No. 09/624,939 filed Jul. 25, 2000, now U.S. Pat. No. 6,396,462, which is a continuation of application Ser. No. 08/630,948 filed Apr. 5, 1996, now U.S. Pat. No. 6,094,180.

FIELD OF THE INVENTIONS

This invention relates to the art of mechanical structures whose deformation can be easily measured.

BACKGROUND OF THE INVENTIONS

In the field of virtual reality, displays are mounted on structures which can be manipulated by a user. The motion of the display is measured and is used to control the user's view point in a computer generated world. Such devices are exemplified by the art described in U.S. Pat. No. 5,436,638. Making a suitable structure for mounting a display on is a challenge, one desires that the display be movable with little force. It is also desirable that the platform encourages controllable motion which means that the perceived stiffness in the left-right directions be matched with forward-back and that twist also feels similarly stiff. As detailed in U.S. Pat. No. 5,436,638 it is desired that it be possible for the structure to facilitate rotations about a user. This invention provides that flexibility in a way which is easy to sense and measure.

SUMMARY

A structure suitable for holding a display is the object of this invention. The platform is supported by three compliant members. One of these members is attached to a gimbaled mechanism which facilitates the easy measurement of the deflection of the platform as it is moved by the user.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** shows the three legged structure, the plate where a display may be mounted, and the tracking assembly.

FIG. **2** is an exploded view of the base, legs, and sensor assembly.

FIG. **3** shows the sensor assembly.

FIG. **4** shows the sensor assembly.

FIG. **5** shows where the encoders are mounted on the sensor assembly.

FIG. **6** shows how the display is mounted on the base and used.

FIG. **7** shows the dimensions of the two front legs

FIG. **8** shows the detail of the rear leg which attaches to the gimbaled sensor means.

DETAILED DESCRIPTION OF THE INVENTIONS

FIG. **1** shows the front view of the invention. The compliant measured structure is composed of a base plate **105** which supports the plate for the display **100** on three compliant delrin legs. The front legs **101** and **102** provide support for plate **100**. The rear leg **103** provides support to plate **100** and mates with the gimbaled sensor assembly **104**. The plate **100** is thus supported in a way such that it can be moved forward/back, side to side, and rotated about an arbitrary vertical axis. When the plate **100** is moved from its rest position, the three legged structure holds it level and the legs flex to accommodate the new position. As the legs flex, the display will move in the desired direction and will also get closer to the base **105** by a tiny amount. Deflections of the legs are generally small—in the range of about ±10 degrees or so.

FIG. **2** illustrates how the device is put together. The legs **201** and **202** are mounted directly onto base plate **205** with each leg being attached with two screws to the base plate so the legs **201** and **202** can not rotate in place. The gimbaled assembly **204** is also rigidly mounted onto base plate **205**. The top of the gimbaled assembly is threaded and attaches to leg **203**.

FIG. **3** shows the gimbaled assembly in more detail. The gimbaled assembly is mounted on base plate **302**. The rear leg **301** is attached to the gimbaled assembly and the shaft which is attached to the leg **301** passes through block and rotary bearing **307**. Rotary joint **303** provides rotation of frame **306** so that shaft and rotary joint **305** can measure the angle of leg **301** in the forward/back plane. The deflection of the leg **301** is transferred through block **307** to frame **306** which is measured by an encoder mounted on **305**. The left/right motion of the top plate is transferred to a rotation of leg **301** which is transferred to block **307** and is measured by an encoder mounted on shad **304**. Thus we can see two of the three degrees of freedom of the gimbaled assembly—forward/back motion will appear at shaft **305** and left/right motion will appear at shaft **304**.

FIG. **4** shows another view of the gimbaled assembly. Rear leg **401** is attached to gimbaled assembly **404** which is mounted on base plate **403**. The shaft **402** rotates with the rotation of leg **401** since they are attached. An encoder mounted on **402** will report the degree of twist of leg **401**. Thus, as a torque is applied to the display plate **100**, the rotation may be measured at shaft **402**.

FIG. **5** illustrates how the encoders are mounted onto the gimbaled assembly **501**. The rear leg is attached to threaded shaft **517**. Shaft **503** encodes left/right motion of the platform and is measured by attachment of the encoder disk **509**. The mounting plate **508**, and reader **516** are mounted onto the gimbaled assembly. The cover **510** helps prevent dirt from fouling the encoder disk **509**. Shaft **502** encodes forward/back motion of the platform. This motion is detected by attaching encoder disk **512** onto the shaft. The mounting plate **511** and reader **514** are attached to the gimbaled assembly and cover **513** prevents dirt from fouling the encoder disk. Twisting the platform results in a twist of the rear leg which is attached at **517** and appears at shaft **504** which is the other end of the threaded attachment point **517**. Motion at shaft **504** is measured by attaching encoder disk **506** to the shaft **504**. The base plate **505** and the reader **515** are attached to the gimbaled assembly and cover **507** prevents dirt from fouling the encoder disk **506**.

FIG. **6** shows how the compliant platform is used. A user **603** looks into a display **601** mounted on the invention **602**. The user may push the display forward and the encoders will register this motion and send it to the computer which is generating the images seen in the display **601**. This will allow the user to move forward in the computer generated world. Pushing the display to the left will be measured in a similar fashion and the images updated accordingly. Twisting the display will be measured by third encoder of the gimbals and will result in turning in the virtual world. Combining these motions lets a user maneuver easily in the virtual world. In particular, sliding to the right and twisting to the left at the same time results in an orbiting motion which is good for looking at the other side of an object. Slightly pushing forward at the same time results in a spiral path.

FIG. **7** shows the details on the construction of the front two legs. The main body of the delrin leg **701** joins the two flexible hinge areas **703** and **702**. The leg is mounted with two screws to the base plate at the end **705**. The end **704** is angled to mate with the mounting plate for the display and is also attached with two fasteners so the leg can't rotate. The necking down **706** is so that a cover does not bind on the main body of the leg at maximum deflection. The joint between the hinges **703** and **702** with the main body of the leg **701** are radiused as shown at **707**.

FIG. **8** shows the structure of the rear leg. This delrin part is similar to the front legs. Main body **801** is attached to the gimbaled assembly by threaded hole **803**. The plate for mounting the display is attached to the leg at the angled end **804**. The hinge for the leg is **802** and the transition from the main body of the leg to the hinge is radiused in a similar manner to the front legs.

The structure is compliant in that the three legs are springy. The top plate on which a display may be mounted moves substantially in a plane relative to the base plate. This motion is measured by the gimbaled sensor assembly at the base of the rear leg. The encoders used to measure the motion could be replaced by another sensing means. For example, the encoders could be replaced by rotary potentiometers to measure the angles. Another alternative would be to use rotary switches.

In addition to having the leg members including an explicit hinge, it would be possible to design legs where the flexing occurred over the entire length of the leg. In this invention, the legs are made on a lathe from round stock but making legs whose hinge elements were not symmetric about the vertical axis would allow one to adjust the springiness in particular directions. By adjusting the cross section of the legs, a system could be made in which left-right motion was easy and forward-back motion more difficult, for example.

It would be possible to have more than two compliant supporting legs if desired. Thus if the display were particularly heavy or for aesthetic reasons, a number of additional legs could be introduced without impacting the performance of the structure.

At present, the range of motion of the structure is limited by having a cover with three holes mounted part way up the structure. Then when the structure is pushed to the limit, the legs bang into the edges of the holes in the cover.

We claim:

1. A device for mounting a display, said device comprising:

a first leg and a second leg, said first and second legs being attached at their lower ends to a base plate, and supporting at their upper ends a platform;

wherein the first leg is secured to the base plate with a gimbaled assembly allowing the first leg to tilt and rotate in relation to the base plate;

wherein the second leg is secured to the base plate in such a manner that it may tilt in relation to the base plate, but is restricted from rotating about an axis perpendicular to the plane of the base plate; and

wherein said platform is operably connected to a sensor assembly which senses the position of the platform in relation to the base plate.

2. The display system of claim **1** wherein the second leg comprises a main body and a hinge element, wherein the hinge element is sized and dimensioned such that the platform is biased move preferentially along a predetermined direction relative to the base plate.

3. A display system mounted on a compliant structure comprising:

a first leg and a plurality of additional legs, said first leg and plurality of additional legs being attached at their lower ends to a base plate, and supporting at their upper ends a platform;

wherein the first leg is secured to the base plate with a gimbaled assembly allowing the first leg to tilt and rotate in relation to the base plate;

wherein the plurality of additional legs are secured to the base plate in such a manner that the plurality of additional legs may tilt in relation to the base plate, but are restricted from rotating about an axis perpendicular to the plane of the base plate;

and wherein said platform is operably connected to a sensor assembly which senses the position of the platform in relation to the base plate; and

an electronic display and a computer which generates and transmits an image to the electronic display, wherein the electronic display is mounted on the platform, and the sensor assembly provides information regarding the position of the platform to a computer, and wherein the computer generates and transmits images to the electronic display which vary according the sensed position of the platform.

4. The display system of claim **3** wherein the plurality of additional legs comprises two additional legs.

5. The display system of claim **3** wherein at least one leg of the plurality of additional legs comprises a main body and a hinge element, wherein the hinge element is sized and dimensioned such that the platform is biased to move preferentially along a predetermined direction relative to the base plate.

6. A system for controlling an image displayed on a display screen, said system comprising:

a computer programmed to generate images for display on the display screen in response to physical movement of the display screen;

a platform for supporting the display screen;

a base plate;

a first leg and a plurality of additional legs, said first leg rotatably and tiltably secured to the base plate, wherein the display screen is supported by the first leg and the plurality of legs and the display screen may be moved in relation to the base plate; and

a sensor assembly operably connected to the first leg for sensing the tilt and rotation of the first leg, the sensor assembly also being operably connected to the computer and transmitting tilt and rotation information regarding the first leg to the computer;

wherein said computer receives tilt and rotation information from the sensor assembly of the first leg, calculates the position of the display screen based upon said tilt and rotation information, generates an image for display on the display screen based upon the position of the display screen, and transmits the image to the display screen;

wherein the plurality of additional legs are made of material having sufficient flexibility to permit movement of the platform relative to the base;

wherein at least one of the plurality of additional legs comprises a main body and a hinge element, wherein the hinge element is sized and dimensioned such that the platform is biased to move preferentially along a predetermined direction relative to the base plate.

* * * * *