US005675359A

United States Patent [19]

Anderson

[11] Patent Number: 5,675,359

[45] Date of Patent: Oct. 7, 1997

[54] **JOYSTICK CONTROLLER**

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[73] Assignee: **Advanced Technology Systems, Inc.**, Waterbury, Conn.

[21] Appl. No.: **372,572**

[22] Filed: **Jan. 13, 1995**

[51] **Int. Cl.**^{6} **G09G 5/08**

[52] **U.S. Cl.** .... **345/161**; 74/471; 200/6 R

[58] **Field of Search** .... 345/161; 273/438, 273/148 B; 338/68; 74/471; 200/6 R

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Assistant Examiner—Amare Mengistu
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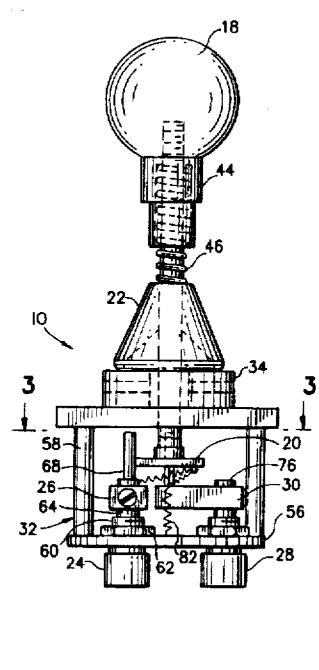
[57] **ABSTRACT**

A joystick controller for utilizing omnidirectional pivoting manual displacement by an operator to operate transducers for producing control signals comprises a mounting plate defining an opening therethrough and gimbal mounting means secured to the mounting plate for pivotally mounting a joystick shaft extending through the opening. The joystick shaft has an operator knob on one end, and a gauge plate on the other end, the gauge plate having a first straight edge and a second straight edge perpendicular thereto. First and second lever arms are pivotally mounted and biased against the first and second straight edges of the gauge plate, whereby displacement of the joystick knob causes displacement of the gauge plate and pivots the lever arms biased thereagainst. Follower rods extend from the lever arms to engage the gauge plate. First and second transducers are respectively operated by the pivoting lever arms. The transducers are either potentiometers, Hall effect sensing devices, LDVT transducers or LED-based transducers. A spring biased sliding centering collar returns the joystick shaft to its neutral position, absent operator input. The opening in the mounting plate limits inclination of the joystick shaft to maintain biased engagement of the gauge plate and lever arms.

29 Claims, 6 Drawing Sheets



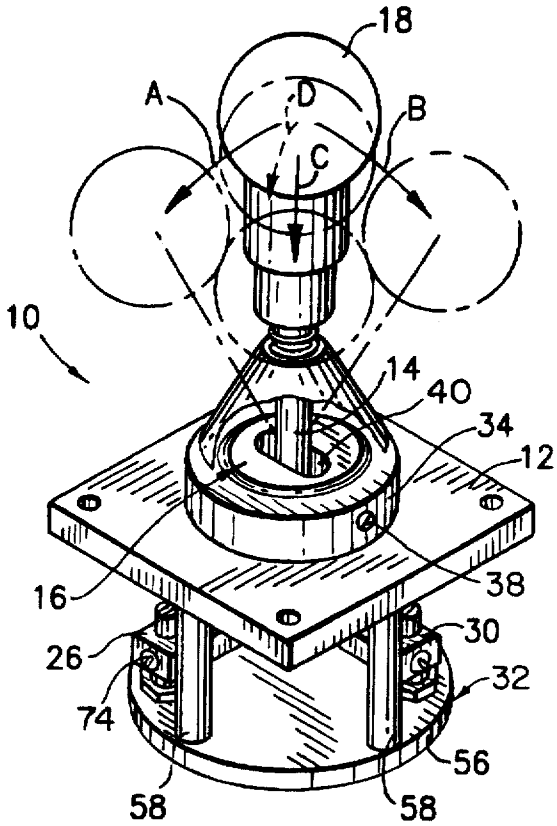

18
A
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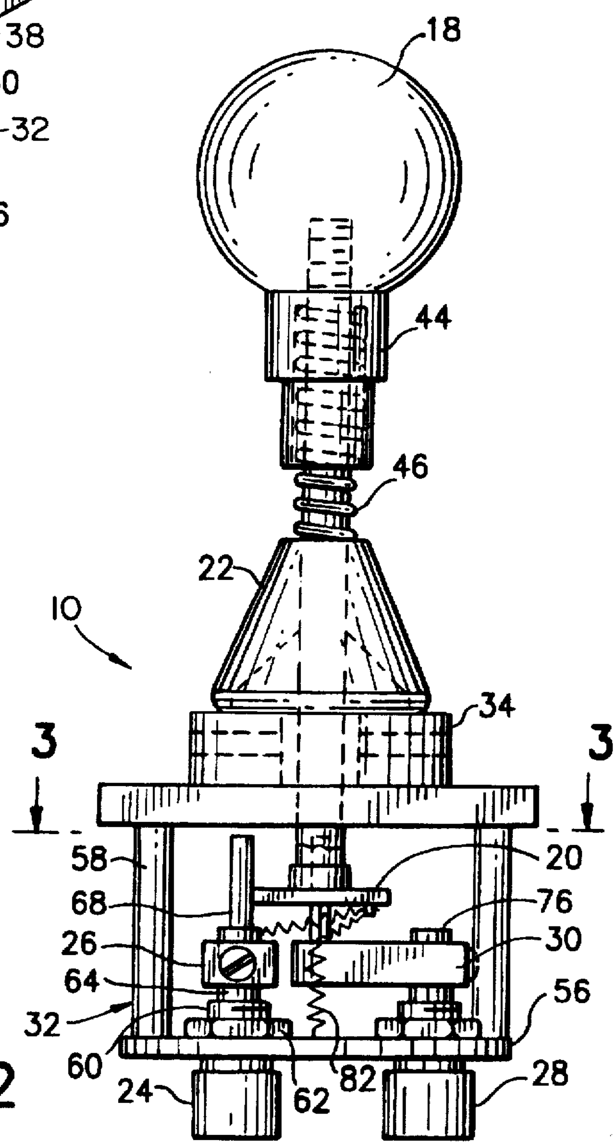
FIG. 1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44
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22
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FIG. 2

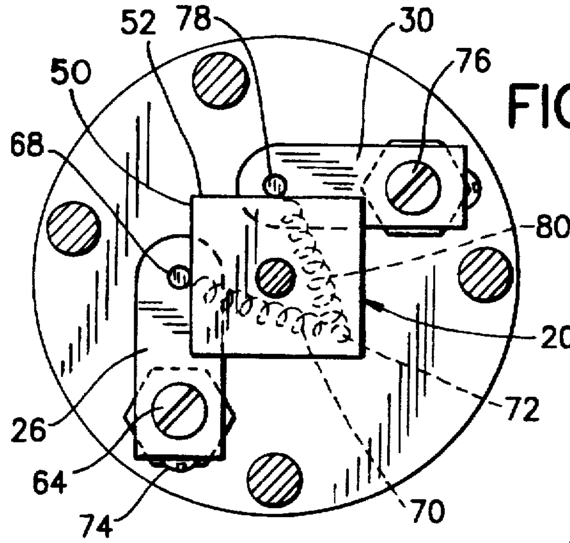


FIG. 3

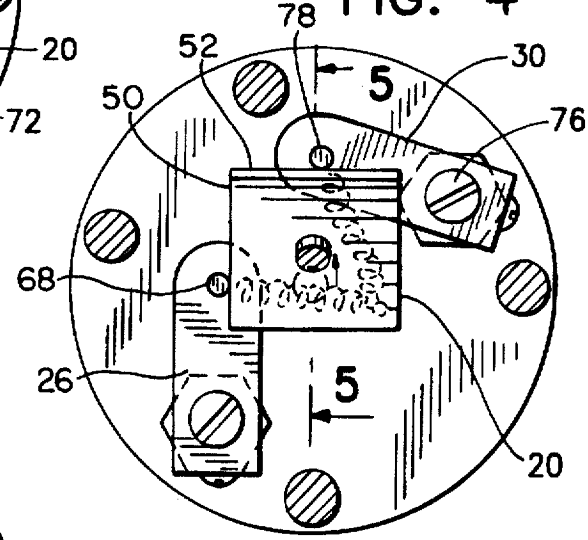


FIG. 4

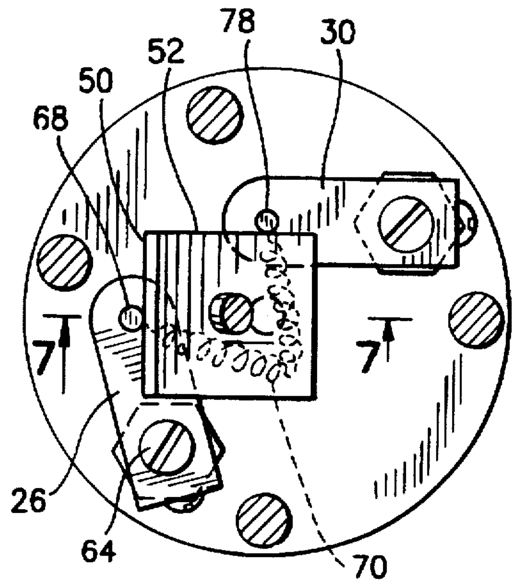


FIG. 6

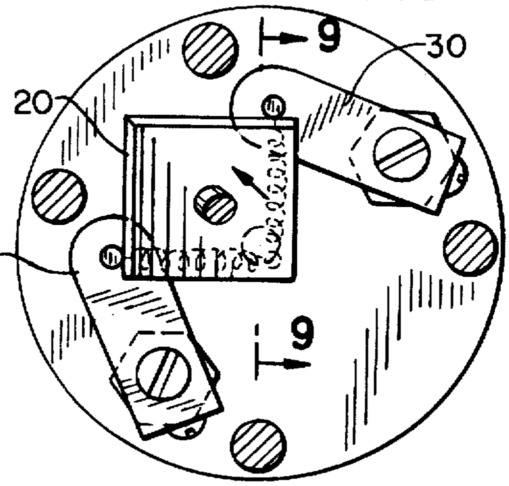


FIG. 8

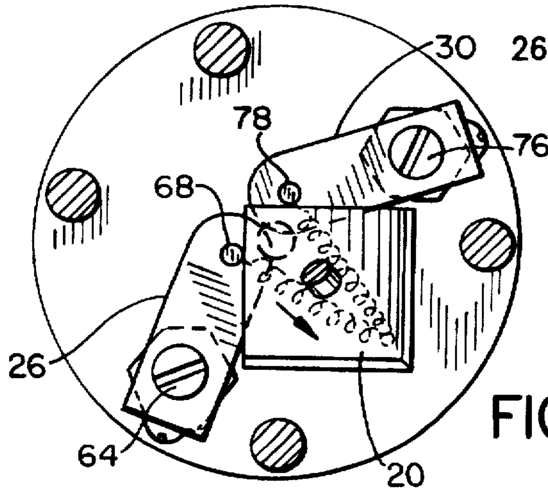


FIG. 10

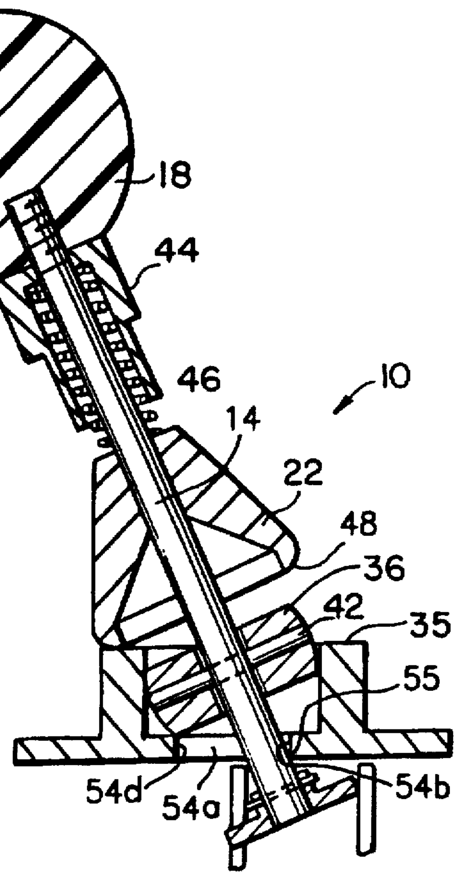


FIG. 5

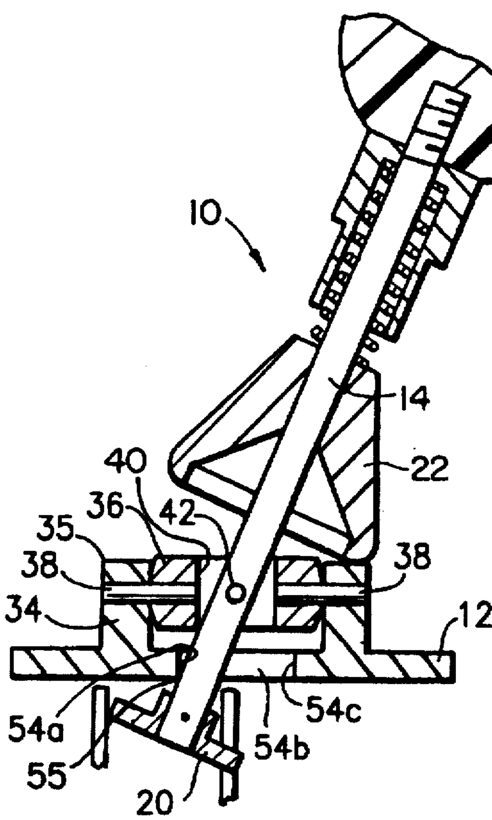


FIG. 7

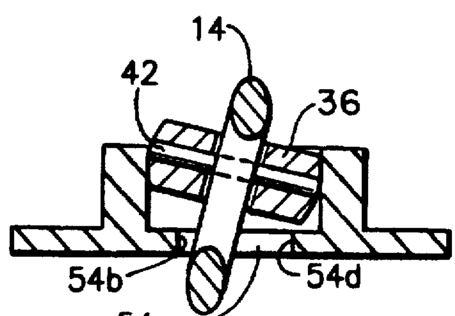
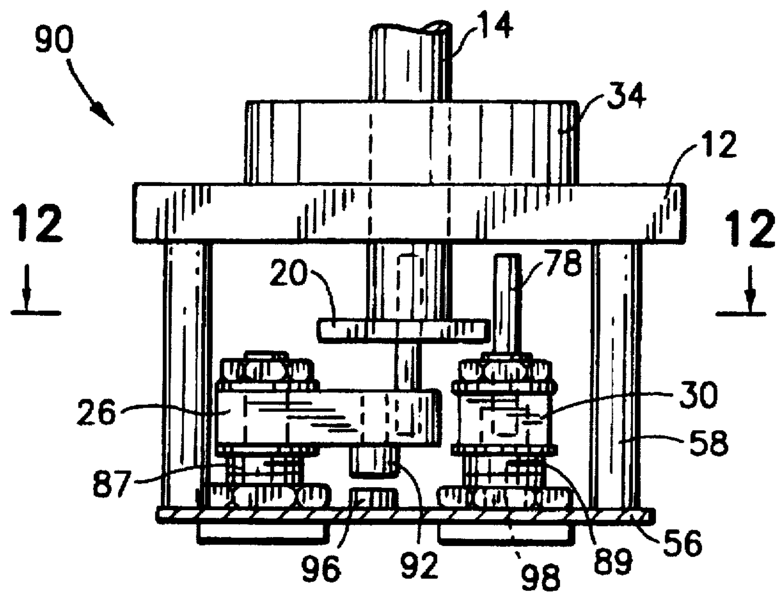


FIG. 9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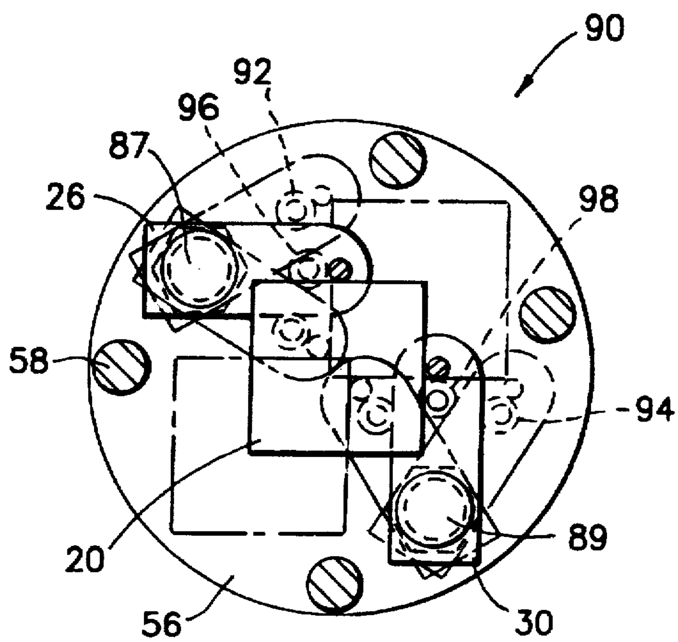
14
34
12
12
12
20
78
26
30
58
87
56
96
92
98
89

FIG. 11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92
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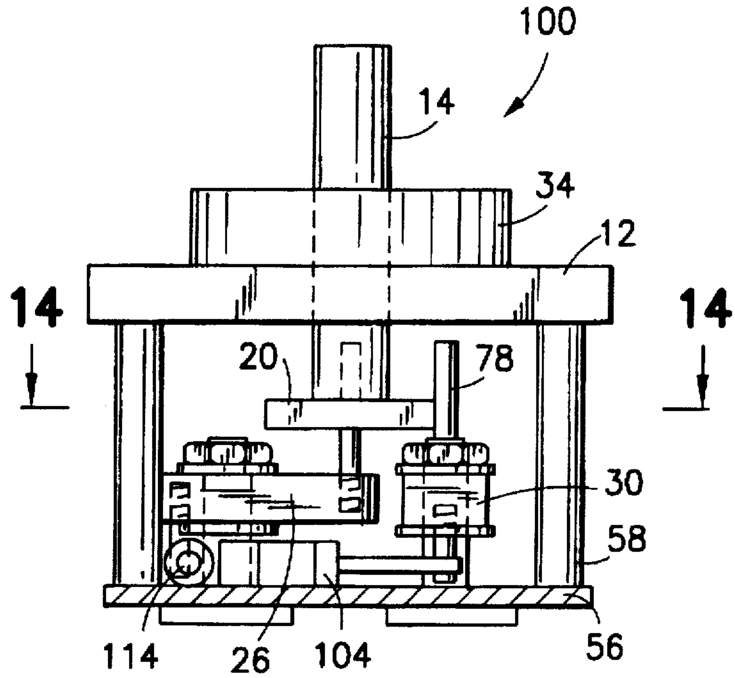
26
98
58
94
89
20
56
30

FIG. 12


100
14
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12
14
14
20
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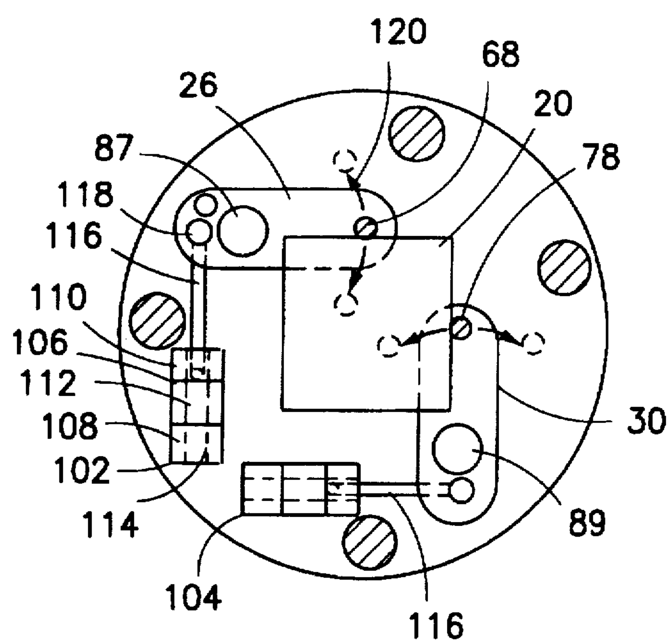
30
58
56
114
26
104

FIG. 13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20
87
78
118
116
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106
112
108
102
114
30
89
104
116

FIG. 14

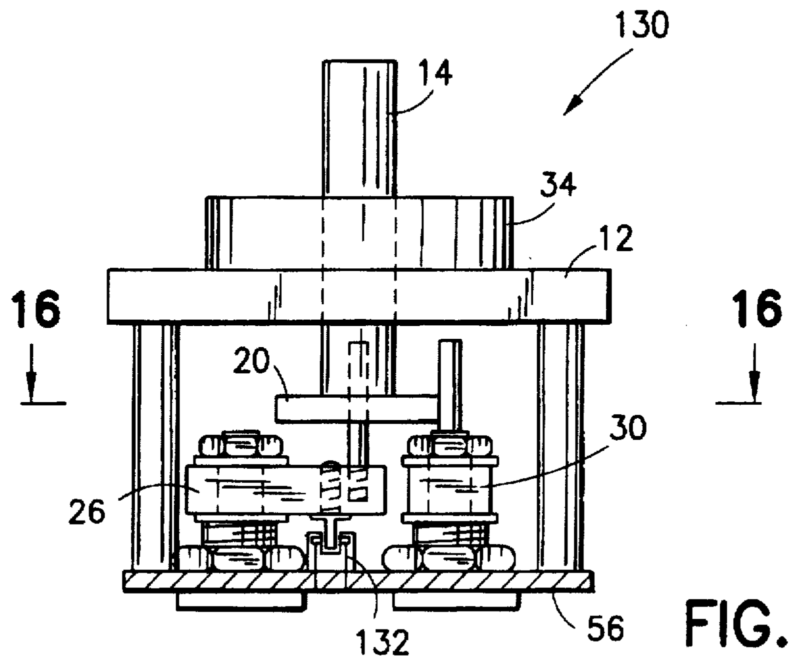

FIG. 15

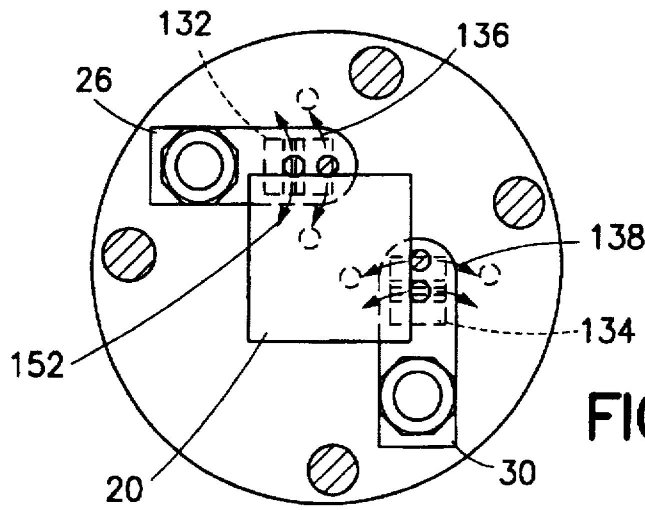

FIG. 16

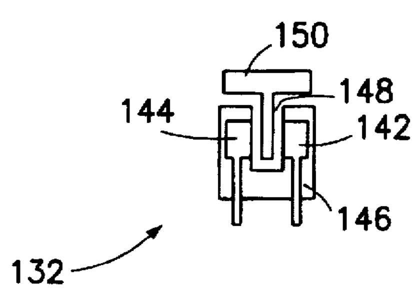

FIG. 17

JOYSTICK CONTROLLER

FIELD OF THE INVENTION

The invention herein relates to a joystick controller using omnidirectional pivoting manual displacement by an operator for producing control signals.

BACKGROUND OF THE INVENTION

Joystick controllers are used to translate operator manipulations to electrical control signals. At least a direction and often velocity of motion are controlled. Typical applications are found in industrial equipment and construction equipment, such as forklift trucks and excavating equipment, where a joystick can provide one-hand operation of direction and speed in order to free the operator's other hand for controlling other aspects of the machine. Other typical applications for joysticks are in booms, trenching equipment, jetways, and the like.

It is important that joysticks used in such industrial, construction and transportation devices be dependable and accurate in their response to operator inputs. In this regard, it is desirable that a joystick include rugged mechanical structure for receiving the operator manipulation, and means for translating the operator input into control signals which are accurate and cannot be abused or damaged by such operator inputs.

SUMMARY OF INVENTION

It is a principal object of the invention herein to provide a joystick controller for converting omnidirectional pivoting manual displacement by an operator to electrical control signals indicative of that manual displacement.

It is another object of the invention herein to provide a joystick controller of the above character which is rugged, dependable and accurate, with a minimum of moving parts.

It is a further object of the invention herein to provide a joystick controller which is characterized by a biased, resilient interface between a manually displaceable joystick and transducer means for translating the displacement of the joystick to control signals.

In accordance with the object of the invention herein, there is provided a joystick controller for omnidirectional pivoting manual displacement by an operator to produce electrical control signals, comprising a mounting plate and a joystick shaft extending through the mounting plate and gimbal mounted to the mounting plate intermediate its length. The joystick shaft has an operator's knob on one end thereof, and a gauge plate is mounted to the other end of the joystick shaft. The gauge plate has a first straight edge, and a second straight end perpendicular to the first straight edge. A first transducer and pivoting lever arm actuator is mounted to the mounting plate, with the lever arm biased against the first straight edge of the gauge plate. A second transducer and pivoting lever arm actuator are also supported on the mounting plate, with the second lever arm biased against the second straight edge of the gauge plate. Pivotal manual displacement of the joystick on its gimbal mounting causes corresponding displacement of the gauge plate and the lever arms biased to follow the gauge plate, positioning the transducers to provide a signal indicative of the direction of joystick displacement. The invention further contemplates utilizing the same transducers to provide an indication of the extent of manual displacement.

According to further aspects of the invention, each of the lever arms has an upstanding follower biased against a respective straight edge of the gauge plate, and the lever arms are pivotally mounted to a subplate supported below the mounting plate with the gauge plate being positioned therebetween. Coil springs bias the followers against the gauge plate.

According to additional aspects of the invention, the transducers are potentiometers, and the lever arms are mounted to input shafts of the potentiometers for rotating them in response to displacement of the gauge plate. Alternately, the transducers are Hall effect sensors or switches, with a magnetic input being positioned on each of the lever arms. Also alternately, the transducers are LED devices with the lever arms mounting light baffles, or LVDT (Linear Velocity Differential Transducer) devices with the lever arms driving moveable coil slugs.

According to other aspects of the invention, the joystick controller includes means for centering the joystick shaft in the absence of operator input. One centering means comprises a collar slidingly received on the joystick shaft and having an annular contact surface biased against a flat surface associated with the mounting plate. An additional, backup centering means comprises a spring secured to the gauge plate end of the joystick in alignment with the joystick's neutral position.

The invention further includes positioning the edge of the opening in the mounting plate, through which the joystick shaft extends, to limit angular displacement of the joystick shaft and maintain biased engagement of the gauge plate and lever arms.

Other and more specific objects and features of the invention herein will in part be recognized by those skilled in the art and will in part appear in the following description of the preferred embodiments and claims, taken together with the accompanying drawings.

DRAWINGS

FIG. **1** is a perspective view of a joystick controller according to the invention herein;

FIG. **2** is a side elevation view of the joystick controller of FIG. **1**;

FIG. **3** is a sectional view, taken along the lines **3—3** of FIG. **2** of the joystick controller of FIG. **1** in its neutral position;

FIG. **4** is a sectional view of the joystick controller of FIG. **1**, similar to FIG. **3** but with the joystick shaft displaced from its neutral position;

FIG. **5** is a longitudinal sectional view of the joystick controller of FIG. **1**, taken along the lines **5—5** of FIG. **4** and showing joystick shaft displacement corresponding to FIG. **4**;

FIG. **6** is a sectional view of the joystick controller of FIG. **1**, similar to FIG. **3** but with the joystick shaft displaced from its neutral position;

FIG. **7** is a longitudinal sectional view of the joystick controller of FIG. **1**, taken along the lines **7—7** of FIG. **6** and showing joystick shaft displacement corresponding to FIG. **6**;

FIG. **8** is a sectional view of the joystick controller of FIG. **1**, similar to FIG. **3** but with the joystick shaft displaced from its neutral position;

FIG. **9** is a fragmentary longitudinal sectional view of the joystick controller of FIG. **1**, taken along the lines **9—9** of FIG. **8** and showing the gimbal mount of joystick shaft displacement corresponding to FIG. **8**;

FIG. **10** is a sectional view of the joystick controller of FIG. **1**, similar to FIG. **3**, but with the joystick shaft displaced from its neutral position;

FIG. 11 is a side elevation view, partially broken away, of another joystick controller according to the invention herein;

FIG. 12 is a sectional view of the joystick controller of FIG. 11, taken along the lines 12—12 of FIG. 11;

FIG. 13 is a side elevation view, partially broken away, of another joystick controller according to the invention herein;

FIG. 14 is a sectional view of the joystick controller of FIG. 13, taken along the lines 14—14 of FIG. 13;

FIG. 15 is a side elevation view, partially broken away, of another joystick controller according to the invention herein;

FIG. 16 is a sectional view of the joystick controller of FIG. 15, taken along the lines 16—16 of FIG. 15; and

FIG. 17 is a fragmentary side elevation view of a transducer of the joystick controller of FIG. 15.

The same reference numerals refer to the same elements throughout the various figures.

DESCRIPTION OF PREFERRED EMBODIMENTS

FIGS. 1–10 depict a first joystick controller **10** according to the invention herein. The joystick controller **10** generally comprises a mounting plate **12** having a joystick shaft mounted therethrough on a gimbal mount **16**. The joystick shaft has a knob **18** at one end thereof, and a gauge plate **20** at the other end thereof. A spring biased center collar **22** maintains the joystick in neutral position. A first transducer is a potentiometer **24** operated by a lever arm actuator **26** and a second transducer is a potentiometer **28** operated by a lever arm actuator **30**, in response to manual displacement of the joystick. The potentiometers are mounted on a subframe **32**.

The joystick shaft may be manipulated in omnidirectional pivoting displacement, as illustrated by the arrows A–D and dotted positions in FIG. 1. The term "omnidirectional" as used herein means that the joystick can be displaced in 360° of freedom with respect to the top surface of the mounting plate 12, although the extent of the tilting of the joystick **14** is limited, as described more fully below.

The gimbal mount **16** comprises an outer ring **34** integral with the mounting plate **12**. As best seen in FI 5, 7 and 9, a truncated sphere **36** is mounted within the annular collar **34** on pins **38** defining a first pivot axis. The truncated sphere defines a slot opening **40** through which the joystick shaft **14** extends. The joystick shaft is pivotally mounted to the truncated sphere by a pin **42**, which lies in the same plane as pins **38**, thereby providing the two-axis gimbal mounting of the joystick shaft **14**.

The knob **18** is threaded onto the upper end of the joystick shaft **14**. The knob **18** bears against a spring retainer **44** which captures a coil spring **46** biasing the centering collar **22** against the flat, annular top centering surface **35** of the outer ring **34** of the gimbal mount. The centering collar **22** is provided in the shape of a truncated cone and has an annular lower surface **48**, best seen in FIGS. **5** and **7**, which bears evenly against the centering surface **35** of the annular ring **34** when the joystick is in its neutral position. Upon displacement of the joystick shaft **14**, the centering collar **22** slides upwardly toward knob **18**, compressing the spring **46**, and causing point contact between the lower annular surface **48** of the centering collar and the centering surface **35** of the outer ring **34**. If the joystick shaft is released, the spring **46** drives the centering collar into flush engagement with the centering surface **35**, thereby centering the joystick shaft as shown in FIGS. **1** and **2**.

The gauge plate **20** is mounted to the other end of the joystick shaft **14**, below the mounting plate **12**. As best seen in FIGS. **3**, **4**, **6**, **8** and **10**, the gauge plate **20** is generally rectangular, and comprises at least a first straight edge **50** and a second straight edge **52** which is perpendicular to the first straight edge **50**. As best seen in FIGS. **5**, **7** and **9**, the portion of the joystick shaft **14** between the gauge plate **20** and the pivot pin **42** extends through an opening **54** in the mounting plate **12**.

The opening **54** is square and has its parallel sides **54*a***, **54*c*** and **54*b***, **54*d*** respectively aligned with the gimbal pivot axes established by pins **38**, **42**, and with the first and second straight edges of the gauge plate. For instance, in FIG. **9** sides **54*c*** are parallel with pin **42**, and sides **54*b***, **54*d*** are parallel with pins **38**. The opening **54** is sized to limit the degree of angular displacement the joystick **14** may exhibit relative to the mounting plate **12** by contact, e.g., at **55**. When the joystick controller **10** is oriented with respect to the operator to present the pivot axes as an X–Y coordinate system, the square opening provides for a maximum displacement in one of the X or Y axis, limited by one edge of the square opening, with movement of the joystick shaft in the other of the X or Y axis obtainable by sliding the joystick shaft along the edge of the square opening. This also provides that, as the gauge plate **20** moves in an arc below the mounting plate **12**, the gauge plate is spaced from the mounting plate, even in the greatest degree of inclination of the joystick shaft **14**, and that the gauge plate does not disengage from the lever arm actuators **26** and **30**.

The subframe **32**, as best seen in FIGS. **1** and **2**, comprises a subplate **56** suspended below and parallel to the mounting plate **12** on struts **58**. The first potentiometer **24** is mounted through the subplate **56** by means of its threaded mounting shaft **60** and nut **62**, with its rotatable operating shaft **64** protruding upwardly. The first lever arm **26** has one of, its ends mounted on the shaft **64**. A follower **68** extends upwardly from the other end of the lever arm **26**, and is engaged against the straight edge **50** of the gauge plate **20**. Coil spring **70** has one end secured to the follower **68** and its other end secured to an anchor pin **72** on gauge plate **20**, and serves to bias the follower **68** against the straight edge **50**. The lever arm extends generally parallel to the first edge **50** of the gauge plate **20** when the joystick is in its neutral position, as best seen in FIGS. **1**, **2** and **3**. The lever arm **26** is secured to the shaft **64** potentiometer **24** by means of a set screw **74**, which permits the shaft of the potentiometer to be adjusted to a neutral output with the joystick in its neutral position.

The second potentiometer **28** is also mounted through the subplate **56**, and lever arm **30** is mounted to the operating shaft **76** of the potentiometer **28**. A follower **78** extends upwardly from the lever arm **30** and bears against the straight edge **52** of the gauge plate **20**. Coil spring **80** biases the follower **78** against straight edge **52**. The lever arm **30** lies generally along the straight edge **52** of gauge plate **20** when the joystick is in the neutral position shown in FIG. **3**.

The joystick controller **10** also includes a centering spring **82** extending from the end of the joystick shaft **14** and gauge plate **20** to the subplate **56**, providing an additional backup centering force for returning the joystick shaft to its neutral position absent operator input. In most applications, it is desirable that the joystick return to its neutral position absent operator input, which generally idles any equipment being controlled by the joystick.

FIGS. **3–10** illustrate operation of the joystick controller **10**. As noted above, FIG. **3** (as well as FIGS. **1** and **2**) illustrate the joystick shaft **14** in its neutral position. In the neutral position, the lever arms **26**, **30** lie generally parallel to edges **50**, **51** respectively, of the gauge plate **20**, and the potentiometers are positioned for neutral output. With respect to FIGS. **4** and **5**, an operator input has displaced the joystick shaft in the direction of arrow A in FIG. **1**, with a corresponding directional displacement of the gauge plate **20**. This is a single axis displacement of the gauge plate **20**, which results in pivoting the lever arm **30** and rotating the shaft **76** of the potentiometer **28**. As is well-known, rotating a potentiometer connected in an electrical circuit will provide a change in a signal provided by the circuit, and can be utilized as a control signal. During the displacement of FIGS. **4** and **5**, the follower **68** slides along the edge **50** of gauge plate **20**, without pivoting lever arm **26**.

With reference to FIGS. **6** and **7**, the displacement of the joystick shaft **14** indicated by the arrow B in FIG. **1** is illustrated. This displacement is perpendicular to the displacement illustrated in FIGS. **4** and **6** described above, and results in the lever arm **28** rotating shaft **64** of the potentiometer **24**. The displacement of the gauge plate **20** is transmitted to the lever arm by follower **68**, and follower **76** slides along edge **52** without pivoting lever arm **30**.

FIGS. **8** and **9** illustrate displacement of the joystick shaft **14** in the direction of arrow C of FIG. **1**, i.e., in a direction which causes rotation of both lever arms **26** and **30**, thereby rotating the shafts of both potentiometers to provide a control signal corresponding to the operator manipulation of the joystick. Both followers **68**, **76** slide along the edges **50**, **52**, in addition to being displaced and thereby causing pivoting movement of the lever arms.

With reference to FIG. **10**, it illustrates displacement of the joystick indicated by the dotted arrow D in FIG. **1**, with corresponding displacement of the gauge plate **20**. Both of the lever arms **26** and **30** are rotated in the opposite directions from FIGS. **8** and **9** described above, thereby rotating the shafts of the potentiometers to adjust an electrical control signal according to a different operator input. It will be appreciated that in all instances, the amount of inclination of the joystick shaft produces a proportional rotation of the potentiometer shafts, and thereby signals which are indicative of both direction and extent of operator input. Thus the signals can be used, for instance, to control both the direction and speed of a vehicle.

In all of the manipulations of the joystick, the followers **68** and **78** of lever arms **26** and **30**, respectively, are biased against the straight edges **50** and **52** of the gauge plate, again respectively, by the coil springs **70** and **80**. However, it should additionally be noted that the gauge plate **20** swings through an arc when manipulated, as best seen in FIGS. **5** and **7**, wherein the edges **50**, **52** of the gauge plate ride up and down the followers **68** and **78**, while the followers are maintained against the edge plate. This accommodation of the arcuate motion of the gauge plate through a biased sliding interface contributes to the simplicity of structure and reliability of the joystick controller **10**, and permits use of a variety of transducers operated independently of the arcuate motion of the gauge plate.

With reference to FIGS. **11** and **12**, another joystick controller **90** according to the invention herein is illustrated. It is the same as the joystick controller **10** in its provision of a gimbal mounted joystick shaft **14** extending through a mounting plate **12** and including a gauge plate **20** on the distal end thereof. Similarly, lever arms **26** and **30** are pivotally mounted to a subplate **56** depending on struts **58** below the mounting plate **12**, except that lever arms **26** and **30** are mounted on shafts **87**, **89** respectively instead of on the input shafts to potentiometers. The centering collar **22** is not shown, for simplicity in the drawing.

The joystick controller **90** differs from the joystick controller **10** described above in the type of transducer utilized to convert motion of the gauge plate and lever arms into electrical control signals. The joystick controller **90** utilizes magnets **92** and **94** respectively mounted near the free ends of the lever arms **26** and **30**, and Hall effect devices **96** and **98** mounted to the subplate **56** for cooperation with the Hall effect magnets. It will be appreciated that electrical control signal may be produced from the motion of the magnets over the Hall effect devices as the joystick shaft is manipulated to move the lever arms **26**, **30**, and that the lever arms **26**, **30** provide a constant vertical spacing of the magnets **92**, **94** with respect to the Hall effect sensing devices **96**, **98**, despite the arcuate motion of the gauge plate **20**, permitting the Hall effect sensing devices to operate accurately in the intended manner. The Hall effect devices **96**, **98** may be proportional sensors or switches, as desired. Microswitch Division of Honeywell Corporation provides a line of Hall effect transducers suitable for this joystick. It should also be noted that the subplate **56** in the joystick controller **90** is a printed circuit board, which may mount other elements of an electrical control circuit together with the Hall effect devices.

FIGS. **13** and **14** illustrate another joystick controller **100** according to the invention herein, characterized by the use of LVDT (Linear Velocity Differential Transducer) transducers **102** and **104**. The joystick controller comprises the mounting plate **12**, gimbal mounted joystick shaft **14**, gauge plate **20**, and lever arms **26** and **30** having followers **68** and **78**, respectively, as described above, and centering collar, not shown. The lever arms **26**, **30** are pivotally mounted on subplate **56** on pivot shafts **87**, **89**, and are pivotally displaced by operator input to the joystick shaft **14**.

The LVDT transducer **102** comprises a central primary coil **106** and two flanking secondary coils **108** and **110**. An iron core slug **112** is slidably disposed in passage **114** formed by the aligned open centers of the coils. Connecting rod **116** has one end attached to the core slug **112** and its other end attached to the pivot arm **26** at **118** spaced from the pivot shaft **87**. Thus, as the pivot arm **26** is pivoted through the range of motion indicated by arrow **118** in FIG. **14**, the coil slug **112** is correspondingly displaced in the passage **114**.

The central coil **106** is connected in an AC circuit and the secondary coils **108**, **112** are tapped. The signal derived from the secondary coils is dependent upon the position of the coil slug **112**, providing a position dependent output. LVDT transducer **104** is connected to lever arm **30** by connecting rod **122**, and provides a signal for displacement in the other axis from LVDT **102**, and the transducers thereby together indicate the direction and extent of motion of operator input to joystick **14**.

With reference to FIGS. **15–17**, another joystick controller **130** is shown, using light emitting diode (LED)—based transducers **132** and **134**. The joystick controller **130** is like the joystick controllers **10**, **90** and **100** described above, except for the use of the LED-based transducers in place of the transducers used in the other units. Thus, a plate **12** carries gimbal-mounted joystick shaft **14**, which displaces gauge plate **20** in response to operator input. Lever arms **26**, **30** are biased against the gauge plate **20**, and are pivoted through the range of motion indicated by arrows **136**, **138**, respectively, by displacement of gauge plate **20**.

The LED-based transducer **132** is shown in FIG. **17**. It comprises an LED emitter **142** and a facing LED detector **144** in a frame **146** which provides a separation in gap **148**. The foregoing parts of the LED-based transducer **134** are mounted to the subplate **56** below lever arm **26**, and the transducer further comprises a vane **150** mounted to lever arm **26** for movement in gap **148**. As lever arm **26** is pivoted in response to operator input, vane **150** is moved in gap **148**, as indicated by arrow **152** in FIG. **16**, to unblock the LED emitter **142** and permit light to reach collector **144**, in proportion to the extent of movement. The LED collector is of the "split" type, so that the output is indicative of both the direction and extent of movement. The LED-based transducer **134** is similarly cooperative with lever arm **30**, and the LED-based transducers **132** and **134** together provide a signal indicative of the direction and extent of operator input to the joystick shaft **14**.

The LED-based transducers **132**, **134** can also be operated as switches, i.e., to provide an output at a distinct level of light reception. This provides an indication of direction of displacement of the joystick shaft, but not a linear indication of extent of displacement.

Accordingly, described above are preferred embodiments of joystick controllers which admirably achieve the objects of the invention herein. It will be appreciated that changes may be made from the preferred embodiments without departing from the spirit and scope of the invention, which is limited only by the following claims.

I claim:

1. A joystick controller for converting omnidirectional pivoting manual displacement by an operator to control signals, the joystick comprising:

A) a mounting plate defining an opening therethrough;

B) a joystick shaft having an operator's knob on one end thereof;

C) gimbal mounting means pivotally connecting the joystick shaft intermediate its length to the mounting plate and extending through the opening defined by the mounting plate, for omnidirectional manual displacement with respect to the mounting plate;

D) a gauge plate mounted to the other end of the joystick shaft, the gauge plate having a first straight edge and a second straight edge perpendicular to the first straight edge; and

E) a first transducer and a first pivoting lever arm actuator supported on the mounting plate and operating the first transducer by pivoting motion of the first lever arm actuator, the first lever arm actuator biased against the first straight edge of the gauge plate, and a second transducer and a second pivoting lever arm actuator supported on the mounting plate and operating the second transducer by pivoting motion of the second lever arm actuator, the second lever arm actuator biased against the second straight edge of the gauge plate;

wherein pivoting manual displacement of the joystick on its gimbal mounting causes corresponding displacement of the gauge plate and pivots the lever arm actuators biased thereagainst, and the first and second lever arm actuators respectively position the first and second transducers for providing control signals indicative of the manual displacement.

2. A joystick controller as defined in claim **1** wherein the pivoting lever arm actuators each include a follower upstanding therefrom, and the followers are respectively biased against the first and second straight edges of the gauge plate to follow displacement thereof.

3. A joystick controller as defined in claim **2** wherein the first and second lever arm actuators are biased against the gauge plate by coil springs, one end of a first coil spring extending between the gauge plate and the first lever arm actuator, and a second coil spring extending between the gauge plate and the second lever arm actuator.

4. A joystick controller as defined in claim **3** wherein the coil springs extend from the followers of the lever arms.

5. A joystick controller as defined in claim **3** wherein the lever arm actuators are pivotally mounted to a subplate secured to and positioned spaced apart from the mounting plate, with the gauge plate and its displacement motion accommodated therebetween.

6. A joystick controller as defined in claim **5** wherein the first and second transducers are potentiometers mounted to the subplate, and the first and second lever arm actuators are respectively mounted to the shafts of the potentiometers for rotating the shafts in response to manual displacement of the joystick shaft.

7. A joystick controller as defined in claim **5** wherein the first and second transducers are Hall effect devices mounted on the subplate, and the lever arm actuators are pivotally mounted to the subplate and have magnets mounted thereto for relative movement with respect to the Hall effect devices in response to manipulation of the joystick shaft.

8. A joystick controller as defined in claim **7** wherein the Hall effect devices are Hall sensors.

9. A joystick controller as defined in claim **7** wherein the Hall effect devices are Hall switches.

10. A joystick controller as defined in claim **5** wherein the first and second transducers are LVDT transducers each including a core slug slidably disposed in a multiple coil array and displaced therein by its respective lever arm actuator.

11. A joystick controller as defined in claim **5** wherein the first and second transducers are LED-based transducers including a light source and a light detector mounted to the subplate, and a vane mounted to the associated lever arm actuator controlling the transmission of light therebetween.

12. A joystick controller as defined in claim **1** wherein the first and second transducers are potentiometers, and the first and second lever arm actuators are respectively mounted to the shafts of the potentiometers for rotating the shafts in response to manual displacement of the joystick shaft.

13. A joystick controller as defined in claim **1** wherein the first and second transducers are Hall effect devices, and the lever arm actuators have magnets mounted thereto for relative movement with respect to the Hall effect devices in response to manipulation of the joystick shaft.

14. A joystick controller as defined in claim **1** wherein the first and second transducers are LVDT transducers each including a core slug slidably disposed in a multiple coil array and displaced therein by its respective lever arm actuator.

15. A joystick controller as defined in claim **1** wherein the first and second transducers are LED-based transducers including a light source and a light detector fixedly mounted with respect to the mounting plate, and a vane mounted to the associated lever arm actuator controlling the transmission of light therebetween.

16. A joystick controller as defined in claim **1** wherein the mounting plate has a flat centering surface associated therewith surrounding the opening through which the joystick shaft extends, and further comprising

F) centering means including a centering collar slidably received on the joystick shaft between the operator's knob and the centering surface, the centering collar having an annular surface which seats on the centering surface to center the joystick in a neutral position, and spring means biasing the centering collar against the centering surface.

17. A joystick controller as defined in claim **16** wherein the centering surface is defined by an outer ring of gimbal mounting means, the outer ring being mounted to the mounting plate surrounding the opening defined therethrough.

18. A joystick controller as defined in claim 12 and further comprising:

G) secondary centering means including a coil spring connected to the gauge plate and tensioned to hold the gauge plate and joystick shaft in a neutral position, absent operator input.

19. A joystick controller as defined in claim 1 wherein the opening defined by the mounting plate and having the joystick shaft extending therethrough is sized and shaped to limit inclination of the joystick shaft and corresponding displacement of the gauge plate to maintain the lever arms in biased engagement with the gauge plate.

20. A joystick controller as defined in claim 19 wherein the opening defined by the mounting plate is generally rectangular, and the gauge plate is gimbal mounted with its first and second straight edges respectively generally aligned with adjacent edges of the rectangular opening defined by the mounting plate.

21. A joystick controller for converting omnidirectional pivoting manual displacement by an operator to electrical control signals, the joystick controller comprising:

A) a mounting plate defining an opening therethrough;

B) a gimbal mounting means having
   1) an outer ring secured to the mounting plate surrounding the opening defined therethrough; and
   2) an inner member pivotally mounted to the outer ring, the inner member defining an opening therethrough;

C) a joystick shaft pivotally mounted intermediate its length to the inner member and extending through the opening in the inner member and the opening in the mounting plate, wherein the joystick shaft is gimbal mounted with respect to the mounting plate;

D) a knob on one end of the joystick shaft and a centering collar slidably received on the joystick shaft between the knob and the outer ring of the gimbal mount, and a spring biasing the centering collar against the outer ring, the centering collar having an annular surface which seats on the outer ring to center the joystick in a neutral position;

E) a gauge plate on the other end of the joystick shaft, the gauge plate having a first straight edge and a second straight edge perpendicular thereto;

F) a subplate mounted spaced from the mounting plate with the gauge plate and displacement thereof accommodated therebetween; and

G) first and second transducers and first and second respectively associated lever arms pivotally mounted on the subplate for operating the transducers, the first lever arm biased against the first edge of the gauge plate for operating the first transducer in response to movement of the gauge plate in a first axis, and the second lever arm biased against the second edge of the gauge plate for operating the second transducer in response to movement of the gauge plate in a second axis;

wherein displacement of the knob end of the joystick shaft causes corresponding displacement of the gauge plate, thereby operating the lever arms and associated transducers for producing control signals indicative of the displacement.

22. A joystick controller as defined in claim 21 wherein the first and second transducers are potentiometers mounted on the subplate, and the first and second lever arms are respectively mounted to rotate input shafts of the first and second transducers.

23. A joystick controller as defined in claim 22 wherein the lever arms include follower rods engaged against the first and second straight edges of the gauge plate.

24. A joystick controller as defined in claim 21 wherein the first and second transducers are Hall effect devices mounted to the subplate and actuated by magnets mounted to the first and second lever arms, wherein pivoting of the lever arms moves the magnets relative to the Hall effect sensing devices.

25. A joystick controller as defined in claim 24 wherein the lever arms include follower rods engaged against the first and second straight edges of the gauge plate.

26. A joystick controller as defined in claim 21 wherein the first and second transducers are LVDT transducers each including a core slug slidably disposed in a multiple coil array and displaced therein by its respective lever arm actuator.

27. A joystick controller as defined in claim 21 wherein the first and second transducers are LED-based transducers including a light source and a light detector mounted to the subplate, and a vane mounted to the associated lever arm actuator controlling the transmission of light therebetween.

28. A joystick controller as defined in claim 21 wherein the first and second lever arms each have a follower rod extending therefrom, and the follower rods are respectively biased against the first and second straight edges of the gauge plate.

29. A joystick controller as defined in claim 28 wherein the lever arms are biased against the gauge plate by coil springs, each follower rod having one end of a coil spring secured thereto with the other end of the coil spring secured to the gauge plate.

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