June 2, 1970 G. L. SNIDER 3,516,055

INTERNALLY GIMBALED ATTITUDE INDICATOR

Filed May 20, 1968 3 Sheets-Sheet 1

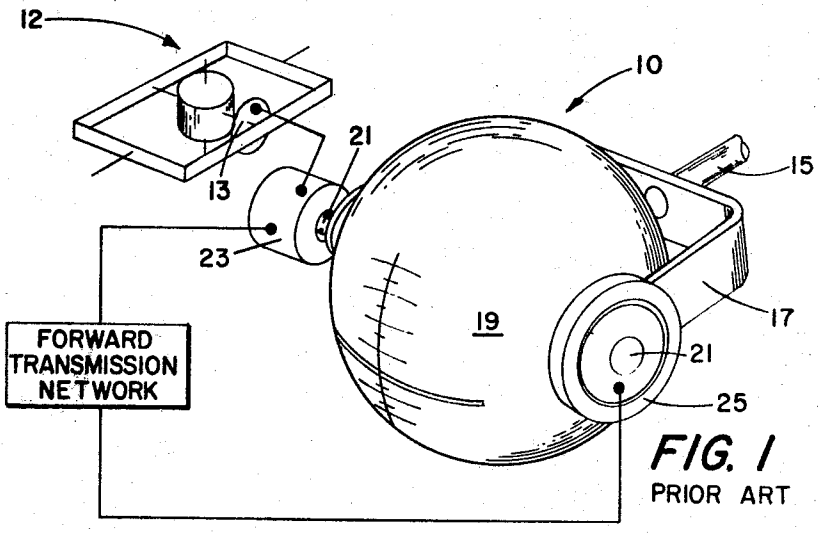

FIG. 1
PRIOR ART

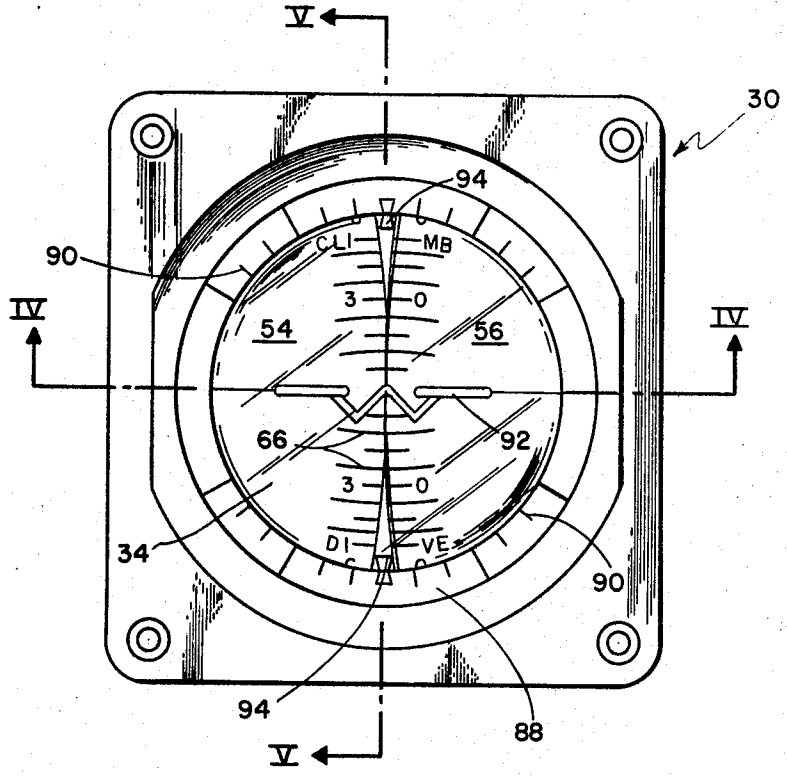

FIG. 3

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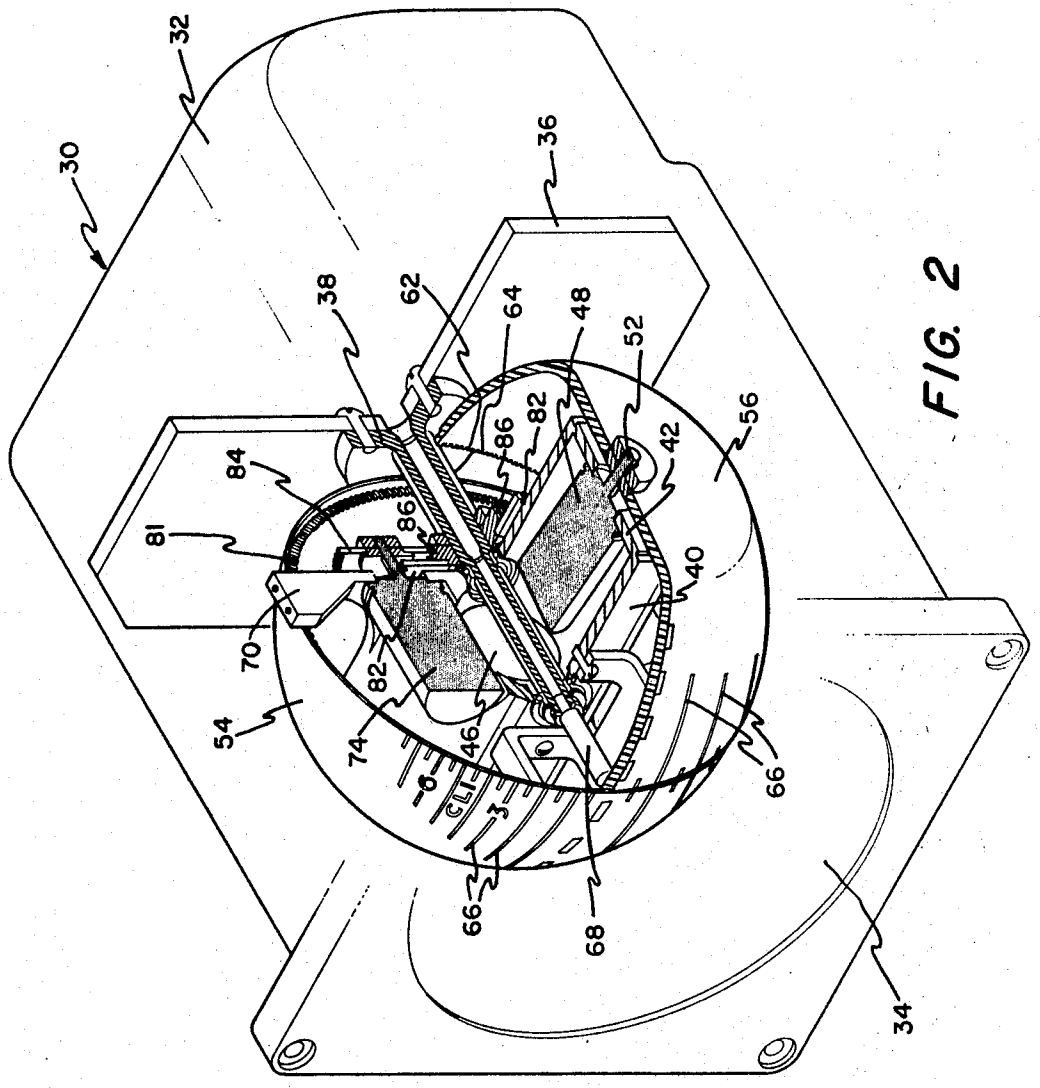

FIG. 2

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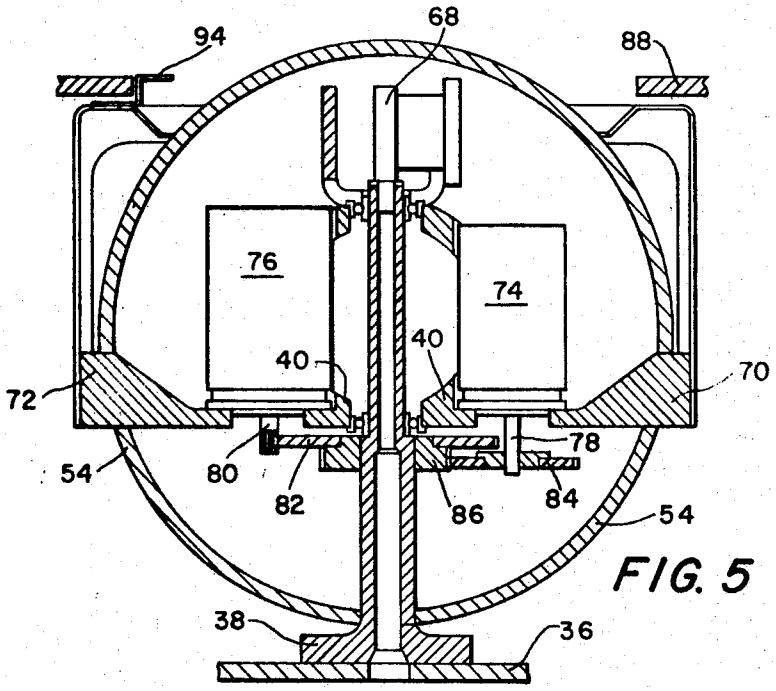

FIG. 5

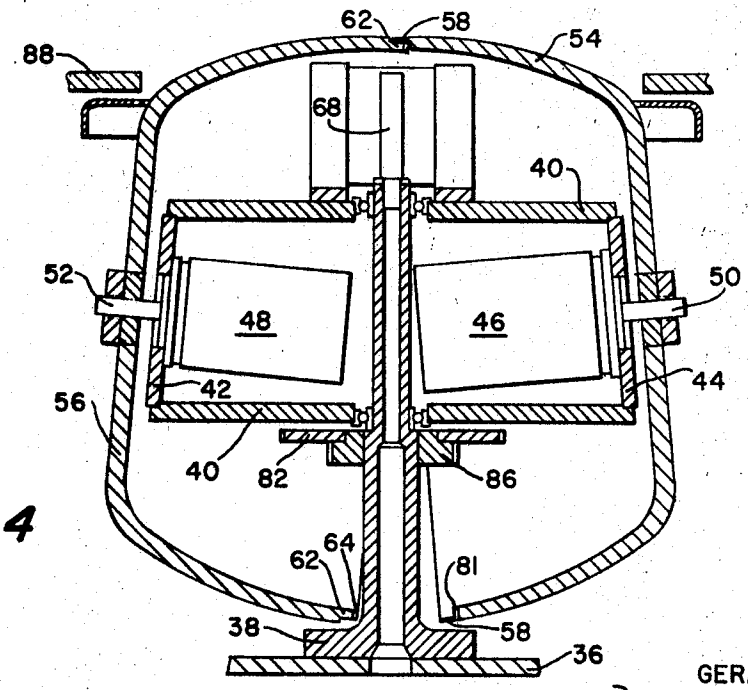

FIG. 4

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3,516,055

INTERNALLY GIMBALED ATTITUDE INDICATOR

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Int. Cl. G01c 19/44; G08c 21/00
U.S. Cl. 340—27 18 Claims

ABSTRACT OF THE DISCLOSURE

An aircraft attitude indicator including a pair of generally hemispheric shape display surfaces which are rotatably mounted on a pair of canted shafts secured to a support housing for providing a pitch indication. The support housing itself is rotatably supported by a shaft which extends between the display surfaces for providing a roll indication. The display surfaces are operably connected; e.g., by gear teeth or friction drive means so that movement of one display surface will effect the movement of the other. The positions of the display surfaces in pitch and roll are controlled by conventional servo loops, with the pitch position servo loop being closed by the meshing of the display surfaces.

This invention relates generally to indicator systems and, more particularly, to an improved indicator for displaying the attitude of a dirigible craft.

Prior art indicators of this type have achieved extensive use in the aerospace industry and are often placed in the cockpits of present-day aircraft to provide the pilot with a visual indication of his ship's attitude. These indicators basically function by using a gyroscope to sense the position of an aircraft and emit control signals to a servomechanism which, in turn, positions a visual display to indicate the aircraft's attitude.

Generally, such indicators fall into two categories; i.e., case contained and remote reading. Case contained indicators are those in which the gyro sensing means is located internally of the visual display means. In contradistinction, remote reading indicators are those in which the gyro sensing means is positioned outwardly of and remote from the visual display means.

Unfortunately, both the case contained and remote reading attitude indicators of the prior art have many inherent deficiencies. The case contained indicators particularly suffer from problems of size, weight and accuracy while the remote reading attitude indicators are especially prone to vibration, shock and size problems. Thus, it was in response to the above-outlined deficiencies of prior art attitude indicators, that the present invention evolved.

Accordingly, it is an object of the instant invention to provide a smaller and lighter attitude indicator than heretofore available.

Another object of this invention is to provide an attitude indicator that is more reliable and easier to inspect and service than prior art indicators.

It is another object of this invention to provide a less expensive and more reliable attitude indicator than previously available.

A further object of this invention is to provide an attitude indicator having improved tolerance to shock and vibration.

Other objects and many of the attendant advantages of

the present invention will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in conjunction with the accompanying drawings illustrating one embodiment of the instant invention, wherein:

FIG. 1 is a simplified perspective of a prior art remote reading attitude indicator;

FIG. 2 is a simplified perspective of the subject invention, partly in section;

FIG. 3 is a front elevation of the present invention;

FIG. 4 is a simplified cross section of the present invention taken along line IV—IV of FIG. 3; and

FIG. 5 is a simplified cross section of the present invention taken along line V—V of FIG. 3.

Before proceeding, it should be noted that the above drawings particularly illustrate the prior art with respect to one axis; e.g., the pitch axis of a dirigible craft and the present invention with respect to both the roll and pitch axes of such a craft. Accordingly, it should be appreciated that the concepts described hereinbelow apply with equal force to the other axes of such a craft.

Referring again to the drawings, and more particularly to FIG. 1, a prior art remote reading attitude indicator is shown generally at **10** and is controlled by signals from a gyro platform **12**. The platform **12** includes a pitch synchro transmitter **13** and is commonly positioned within a craft at a position remote from the indicator **10**.

The indicator **10** includes a shaft **15** which functions to provide a roll indication on the indicator in a well-known manner. The shaft **15** is connected to a yoke **17** which serves as a gimbal frame for a visual display **19**. The display **19** is fixed to a shaft **21** which extends diammetrically therethrough and is rotatably supported within the yoke **17**.

One end of the shaft **21** is connected to a control transformer **23** and the other end of said shaft **21** is connected to a DC torque motor **25**. The control transformer **23** is electrically connected to the pitch synchro transmitter **13** and through a forward transmission network to the DC torque motor **25**.

Basically, when the craft undergoes a change in pitch, a signal is sent by the transmitter **13** to the control transformer **23** where the position of the shaft **21** (and of course the display **19**) is compared with the position indicated by the signal from the transmitter **13**.

If the shaft position and the signal position do not correspond, an error signal is sent through the servo-loop to the DC torque motor which will rotate the shaft **21** and its associated display **19** to the position indicated by the transmitter **13**. Obviously, the angular position of the display **19**, about an axis extending through the shaft **21**, will be indicative of the pitch of the craft. For a more detailed explanation of this prior art remote reading type indicator system reference may be had to copending U.S. patent application, Ser. No. 643,685, filed June 5, 1967.

Returning to the present invention, and referring again to FIG. 2, a remote reading attitude indicator is shown generally at **30** including a case **32** having a viewing window **34**. A mounting plate **36** is fixedly mounted within the rear portion of said case **32** and supports a hollow shaft **38** which is affixed thereto at one end portion and extends axially within said case **32** toward said window **34**.

As best seen in FIG. 4, the shaft **38** extends axially

through a support housing **40** which extends outwardly of said shaft **38** to face plates **42** and **44**, respectively, said housing **40** being rotatably supported by said shaft **38**. The plates **42** and **44** are affixed to and form a part of the housing **40** and are canted with respect to one another so as to converge toward the window **34**.

A DC torque motor **46** and a follow-up synchro or control transformer **48** are disposed within said support housing **40**, and extend outwardly of the shaft **38** in opposite directions. The torque motor **46** and the control transformer **48** include rotor shafts **50** and **52**, respectively, which extend outwardly of the support housing **40** in opposite directions. The torque motor **46** and the control transformer **48** are fixed to the opposite face plates **44** and **42**, respectively, and the shafts **50** and **52** extend outwardly of and normal to said face plates **44** and **42** so that their axes are canted.

As best seen in FIGS. 2 and 4, first and second display surfaces **54** and **56**, of generally oblate hemispheric shape, are fixedly mounted at their poles to the canted rotor shafts **50** and **52**, respectively, and are rotatable therewith.

The display surface **54** extends to a female lip **58**, about the inner periphery of which a plurality of teeth **81** are disposed. The display surface **56** extends to a male lip **62** which includes a plurality of teeth **64** disposed about its outer periphery.

The display surfaces **54** and **56** are canted with respect to each other, and diverge in a direction, along the axis of the shaft **38**, toward the mounting plate **36** so as to permit the shaft **38** to extend between them without contact.

Referring now to FIGS. 2 and 3, both of the display surfaces **54** and **56** are shown to include indicia **66** thereon. A portion of the male lip **62** of the display surface **56** is received by a portion of the female lip **58** of the display surface **54** so that their respective teeth **64** and **81** mesh and the indicia on said displays **54** and **56** align to provide a uniform display when viewed through the window **34**. Obviously, any suitable friction drive means between the surfaces **54** and **56** may be substituted for the meshing teeth **64** and **81**.

Suitable control signals may be provided to the DC torque motor **46** and the control transformer **48** by electrically connecting them to an external signal source; e.g., a pitch synchro transmitter (not shown) by passing electrical conductors from such source through the hollow shaft **38** to a slip ring assembly **68** affixed thereto. Electrical connection between the slip ring assembly **68**, and both the DC torque motor **46** and the control transformer **48** may be made in a well-known manner, as by brush blocks (not shown) affixed to the housing **40** and in contact with the slip ring assembly **68**.

As best seen in FIG. 5, the housing **40** includes a pair of oppositely-directed support plates **70** and **72** rotatable therewith and which extend outwardly of the shaft **38** and the display surfaces **54** and **56**. It will be recalled that said display surfaces **54** and **56** are canted with respect to each other and diverge toward the mounting plate **36**. This divergence is such as to admit the support plates **70** and **72** between the surfaces **54** and **56** without any contact.

A second control transformer **74** and a second DC torque motor **76** are fixed to the support plates **70** and **72**, respectively. The control transformer **74** and the torque motor **76** include rotor shafts **78** and **80**, respectively. The shaft **80** includes a plurality of teeth disposed about the periphery thereof to form a pinion which engages a gear **82** fixed to the shaft **38**. A gear **84** is fixedly secured to the shaft **78** and engages a gear **86** which is fixedly secured to the shaft **38** and the gear **82**.

Suitable control signals may be provided to the DC torque motor **76** and the control transformer **74** by electrically connecting them to an external signal source, e.g., a roll synchro transmitter (not shown), by passing

electrical conductors from such source through the hollow shaft **38** to the slip ring assembly **68**. Electrical connection between the slip ring assembly **68**, and both the DC torque motor **76** and the control transformer **74** may be made in a well-known manner as by brush blocks (not shown) affixed to the housing **40** and in contact with the slip ring assembly **68**.

Referring again to FIG. 3, a bezel **88** is shown surrounding the window **34** and includes a plurality of radially disposed reference markings **90** thereon. Additionally, generally horizontal reference markings **92** appear on the face of the window **34**. Further, a pointer assembly **94** is affixed to each of the support plates **70** and **72** and extends over one of the display surfaces **54** and **56** inwardly of the bezel **88**. The pointer assemblies **94** rotate with the housing **40** and the display surfaces **54** and **56** about the hollow shaft **38**.

In operation, control signals from; e.g., the pitch synchro transmitter, may be applied to the control transformer **48**. Said transformer **48** is connected to the display surface **56** which, in turn, is geared to rotate with the display surface **54** about the canted axes of the shafts **52** and **50**, respectively.

Thus, the angular position of the display surface **54** (about the axis of the shaft **50**) will be sensed by the control transformer **48** and compared with the signal from the pitch synchro transmitter.

If there is a discrepancy between the position of the display surface **54** (and, of course, the display surface **56**) and that dictated by the pitch synchro transmitter signal, then an error signal will be provided by the control transformer **48** to the DC torque motor **46**.

The DC torque motor **46** will rotate the display surface **54** to the position indicated by the pitch synchro transmitter. The display surface **56** will rotate with the display surface **54** and will also rotate the shaft **52** (to which it is affixed) so as to null the control transformer **48**.

In an analogous manner, position signals may be sent; e.g., from a roll synchro transmitter (not shown), to the control transformer **74**. Said transformer **74** will, via the gears **84** and **86**, sense the angular position of the housing **40** and the display surfaces **54** and **56** (which rotate therewith) with respect to the shaft **38**. The angular position of the housing **40** and said surfaces **54** and **56** will be compared with that indicated by the signal from the roll synchro transmitter. If there is a discrepancy, an error signal will be transmitted by the control transformer **74** to the DC torque motor **76**, which, via the pinion **80** and gear **82**, will rotate the housing **40** and the display surfaces **54** and **56** to the position indicated by the roll synchro transmitter signal so as to null the control transformer **74**. Obviously, the support plates **70** and **72** (and the transformer **74** and motor **76** respectively attached thereto) will rotate with the housing **40** and the display surfaces **54** and **56**.

Of course, as best seen in FIG. **3**, rotation of the display surfaces **54** and **56** about the axes of the shafts **50** and **52**, respectively, will be indicated by the position of the indicia **66** with respect to the reference markings **92**. Analogously, rotation of the display surfaces **54** and **56** about the shaft **38** will be indicated by the position of the pointer assemblies **94** with respect to the reference markings **90**.

It should be emphasized at this point that the rotation of the display surfaces **54** and **56** about the axes of the shafts **50** and **52**, respectively is independent from the rotation of said display surfaces **54** and **56** about the shaft **38** and may occur simultaneously therewith. Also, rotation of said display surfaces **54** and **56** about the axes of the shafts **50** and **52**, respectively, may be representative of a change in the attitude of a dirigible craft with respect to either the roll, pitch or azimuth axis of the craft. Likewise, rotation of the display surfaces **54** and **56** about the shaft **38** may be representative of a

change in the attitude of a dirigible craft with respect to any of its axes.

Having considered the structure and operation of one embodiment of the invention, it is appropriate to note that the conventional gimbal rings or yokes (see 17 in FIG. 1) of the prior art (used, for example, to provide pitch gimbaling) are eliminated by the subject invention. Accordingly, the invention may be characterized as being internally gimbaled due to the absence of any gimbaling ring or yoke surrounding the gimbaled structure or display means.

Obviously, many modifications and variations of the present invention are possible in the light of the above teachings and it will be readily apparent to those skilled in the art that various changes in form and arrangement of components may be made to suit requirements without departing from the spirit and scope of this invention. Accordingly, it is to be understood that within the scope of the appended claims the present invention may be practiced in a manner otherwise than is specifically described herein.

What is claimed is:

1. An indicator for displaying the position of a dirigible craft including:

support means;

first display means connected to said support means and rotatable relative thereto about an axis fixed therein; and

second display means connected to said support means and rotatable relative thereto about an axis fixed therein canted with respect to that of said first display means, said second display means cooperable and in contact with said first display means so as to provide a continuous and unified visual display.

2. The invention as set forth in claim 1, further including means for rotatably mounting said support means, whereby each of said display means may resolve about an axis oblique to its respective axis of rotation.

3. The invention of claim 1, wherein said first and second display means are operably connected so that rotation of one of them will effect like rotation of the other of them.

4. The invention as set forth in claim 3, further including means for rotatably mounting said support means, whereby said display means may revolve about a common axis oblique to their respective axes of rotation.

5. The invention as recited in claim 4, additionally including:

means connected to one of said display means for generating a signal indicative of the angular displacement of the other of said display means for a predetermined position; and

means connected to said other of said display means and to said signal generating means for rotating said other of said display means to said predetermined position thereby nulling said signal generating means.

6. The invention as set forth in claim 5, wherein said first and second display means each comprise a graduated generally hemispheric surface.

7. The invention as recited in claim 6, wherein one of said hemispheric surfaces extends to a male lip having a plurality of teeth disposed about the periphery thereof, and the other of said hemispheric surfaces extends to a female lip having a plurality of teeth disposed about the periphery thereof, said hemispheric surfaces cooperable to enable their respective teeth to mesh.

8. The invention of claim 7, wherein said signal generating means comprises a control transformer and said display means rotating means comprises a DC torque motor.

9. The invention as recited in claim 3, additionally including:

means connected to one of said display means and to said support means for generating a signal indicative of the angular displacement of the other of said display means about its said rotational axis from a predetermined position relative to said support means; and

means connected to said other of said display means and to said support means and operably connected to said signal generating means for rotating said other of said display means to said predetermined position thereby nulling said signal generating means.

10. The invention as set forth in claim 9, wherein said first and second display means each comprise a graduated generally hemispheric surface.

11. The invention as recited in claim 10, wherein one of said hemispheric surfaces extends to a male lip having a plurality of teeth disposed about the periphery thereof and the other of said hemispheric surfaces extends to a female lip having a plurality of teeth disposed about the periphery thereof, said hemispheric surfaces cooperable to enable their respective teeth to mesh.

12. The invention of claim 11, wherein said signal generating means comprises a control transformer and said display means rotating means comprises a DC torque motor.

13. In an indicator for displaying the attitude of a dirigible craft in response to signals from an external source, the combination including:

plural display means in contact with and rotatable relative to one another and each having indica on the surface thereof and together providing a unified visual display and forming an enclosure at the reverse side thereof;

gimbaling means internally of said enclosure for supporting each said display means for rotation relative thereto about an axis fixed in said gimbaling means, and

means for rotatably mounting said gimbaling means.

14. The invention as set forth in claim 13, wherein said plural display means comprises first and second portions each having an axis of rotation canted with respect to that of the other and wherein said gimbaling means is supported by said mounting means so that said first and second portions may each turn relative to said mounting means about an axis in said mounting means oblique to its respective axis of rotation.

15. The invention as set forth in claim 14, additionally including:

means connected to one of said display means portions for generating a signal indicative of the angular displacement of the other of said display means portions from a predetermined position; and

means connected to said other of said display means portions and operably connected to said signal generating means for rotating said other of said display means portions to said predetermined position,

said one and said other of said display means portions being operably connected so that rotation of one of them will effect like rotation of the other of them.

16. A remote reading attitude indicator, including:

plural display means having indicia on the surface thereof in contact with and rotatable relative to one another and each capable of rotation about an axis so as together to provide a continuous and unified visual display;

means connected to one of said display means for generating a signal indicative of the angular displacement of the other of said display means from a predetermined position, and

means connected to said other of said display means and operably connected to said signal generating means for rotating said other of said display means to said predetermined position,

said one and said other of said display means being operably connected so that rotation of one of them will effect like rotation of the other of them.

17. The invention of claim 16, wherein said plural display means comprises a pair of graduated generally hemispheric surfaces.

18. The invention of claim 17, wherein each of said pair of hemispheric surfaces rotates about an axis canted with respect to that of the other of said pair of hemispheric surfaces.

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U.S. Cl. X.R.

33—204; 40—53