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King

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[54] **RELATIVE MOVEMENT SYSTEM HAVING ALARM MEANS**

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[51] **Int. Cl.** **G05d 1/04,** G01j 1/36

[58] **Field of Search** ..... 340/27 R, 27 NA, 27 AT; 250/204, 210, 237 R; 318/640, 565; 73/178 R, DIG. 11

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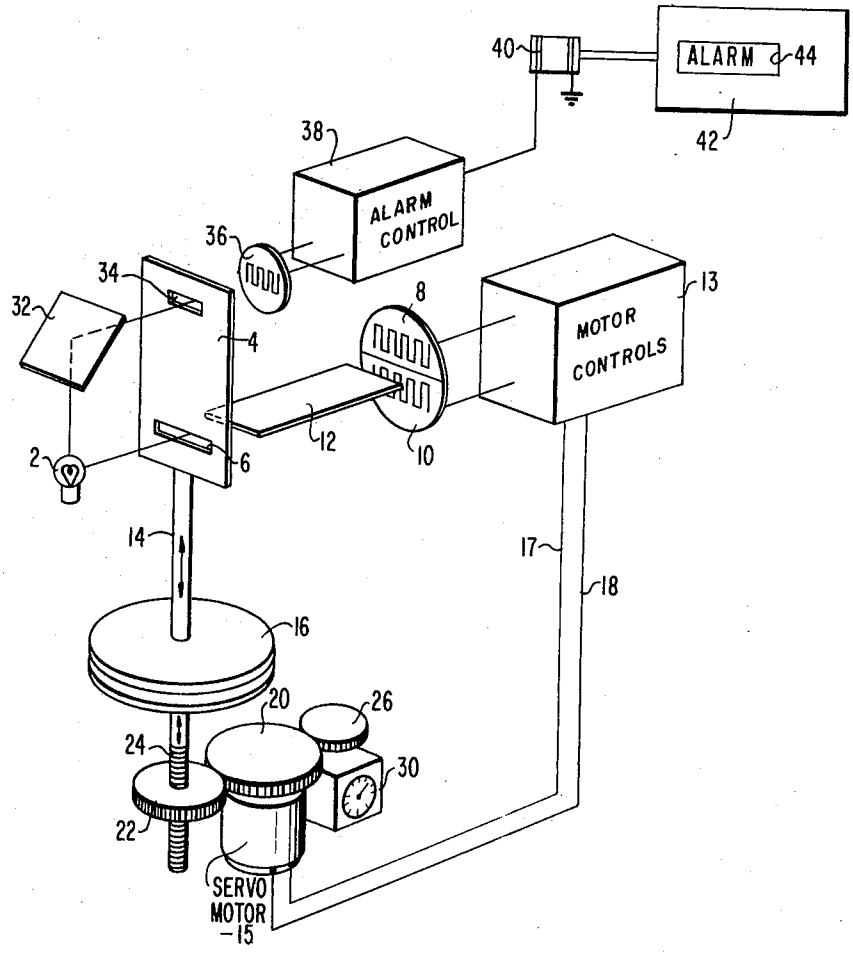
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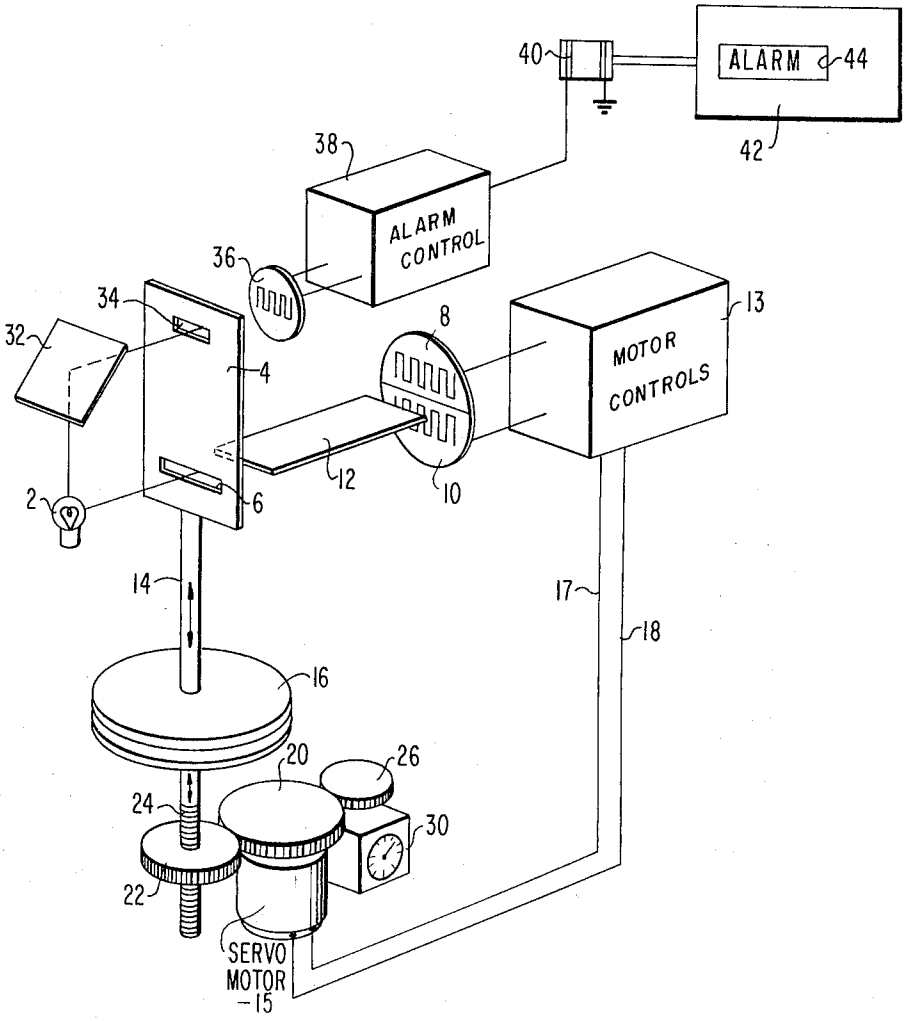
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[57] **ABSTRACT**

A primary beam of light is directed on a pair of photosensitive elements. Relative movement causes the beam to move with respect to the photosensitive elements. The movement of the beam actuates a restorative means which repositions the beam at its initial position. The extent of movement of the restorative means indicates the amount of primary beam movement. The improvement of this invention is an alarm means which assumes a malfunction-indicating condition when the primary beam is extinguished or and when the primary beam is displaced from its initial position by a distance greater than the small excursions of movement experienced during normal operations. In the disclosed embodiment, an alarm-actuating means includes a photosensitive element located in the path of a secondary beam of light which emanates from the same source and moves concurrently with the primary beam.

8 Claims, 1 Drawing Figure




40
ALARM
44
42
38
ALARM CONTROL
36
34
32
4
8
MOTOR CONTROLS
13
2
6
12
10
14
17
18
16
20
26
24
30
22
SERVO MOTOR 15

RELATIVE MOVEMENT SYSTEM HAVING ALARM MEANS

This invention relates to a malfunction-indicating alarm which preferably is used in conjunction with a relative movement detector and system of the general type disclosed in my U.S. Pat. No. 3,612,881.

Relative movement detectors of this type operate on the principle that relative movement between a pair of bodies causes the movement of a beam of light with respect to the faces of two photosensitive elements. Such movement causes a change in the relative amount of illumination of the photosensitive elements and causes an unbalanced condition in a bridge circuit which creates an error signal. The error signal actuates a servo motor which returns the beam to its initial position with respect to the photosensitive elements. The extent of movement of the servo motor is indicative of the extent of relative movement between the bodies. In the normal operation of devices of this type, the beam is returned to its initial position by means of the bridge circuit and the servo motor which are collectively referred to herein as a restorative means.

The usual type of malfunction-indicating alarm for instrumentation has involved a malfunction-indicating device which is actuated upon failure of the primary power of the system. Such devices utilize a normally-energized solenoid which holds a malfunction-indicating flag in a concealed position. When primary power is lost, the solenoid is deenergized and the malfunction-indicating flag is moved by a spring or other means to a visible position.

According to the present invention, the malfunctioning of the system is indicated not only upon the loss of primary power, but also when the light beam is displaced significantly from its initial position with respect to the photosensitive elements; i.e., when the beam moves beyond the small excursions of movement which are encountered during normal operations. This condition of malfunction can be caused by failure of a variety of elements of the system, for example when there is a failure of one or both of the photosensitive elements, a failure of the circuitry which creates the error signal when the photosensitive elements are not equally illuminated, a failure of the servo motor which restores the beam to its initial position, a failure of the beammoving mechanism connected to the servo motor, or a failure of a lamp which is the source of the beam of light. Further, if the solenoid of the malfunction-indicating alarm is defective, the observer will be alerted to this condition.

According to the invention, the malfunction signalling means is actuated in response to relative movement between the photosensitive elements and the primary beam of light. Alarmactuation occurs when this movement exceeds the small excursions of movement which are normally offset or nullified by a properly functioning restorative means.

For a more complete understanding of the invention, reference is made to the accompanying drawings which show, in diagrammatic form, a system which operates according to the invention.

In the drawings, it will be seen that a primary beam of light is created by a lamp **2** and a vertically movable baffle **4** which has a transparent area **6** defining the boundaries of the beam. The beam is directed onto a pair of adjacent photosensitive elements **8** and **10.** A

beam splitting shield **12** may be used as described in my previous U.S. Pat. No. 3,612,881, but it is not essential to the practice of this invention.

In its initial position, baffle **4** will direct the primary beam of light in a given ratio, usually one-to-one, onto the photosensitive elements **8** and **10.** The baffle **4** is mounted on the upper end of a vertically movable support rod **14** which is connected to the upper face of an aneroid bellows **16.** Changes in the surrounding pressure will cause expansion and contraction of the aneroid bellows **16,** resulting in vertical movement of the rod **14,** the baffle **4** and the light beam established thereby. In an altimeter system, increases in altitude cause the aneroid bellows **16** to expand, raising the baffle **4** and moving the beam relative to the photosensitive elements. This increases the area of illumination of the photosensitive element **8** and decreases the amount of illumination of the photosensitive element **10.** These photosensitive elements are connected electrically to a motor control circuit **13** which senses any change in the relative amounts of illumination of the elements **8** and **10.** An unbalanced condition creates an error signal which actuates a servo motor **15** connected to the control circuit **13** by the conductors **17** and **18.** It will be understood that upward movement of the baffle **4** and the resulting increased illumination of the photosensitive element **8** will create an error signal which produces servo movement tending to drive the baffle **4** downwardly so that the photosensitive elements **8** and **10** will again receive a balanced amount of illumination from the primary beam of light. This downward movement of the baffle is produced by lowering the expanded aneroid bellows **16.** The servo motor **15** is provided with a gear **20** which meshes with the gear **22.** An aperture in the center of gear **22** is internally threaded to receive the threaded lower portion of the non-rotatable bellows-supporting rod **24.** Rotation of the gear **22** will move the primary light beam as a result of vertical movement of the rod **24** and consequent vertical movement of the entire aneroid bellows **16,** shaft **14** and baffle **4.**

In the normal use of apparatus such as described above, the baffle **4** is continually being returned to its initial or null position where the transparent area **6** is positioned to provide the appropriate illumination to the photosensitive element **8** and **10.** Of course, there is some departure from this initial position in the time interval before the error signal is capable of actuating the servo motor. However, these excursions from the initial position are relatively small, and the extent of relative movement is, in fact, determined by the extent of movement of the rod **24** which is moved to offset the movement produced by the expansion and contraction of the aneroid bellows **16.** The extent of movement of the rod **24** may be indicated in a number of ways, one being shown as a simple gear arrangement **26** for driving the dial indicator of an altitude-indicating device **30.**

According to the preferred and illustrated embodiment of the invention, the malfunction alarm is actuated in response to relative movement between the primary light beam and the photosensitive element which is greater than the small excursions of relative beam movement which are encountered during normal operation of the apparatus. This malfunction alarm system includes a mirror **32** which is located in the path of light from the illumination lamp **2.** The light which strikes

the mirror **32** is directed horizontally through a second transparent area **34** in the baffle **4,** to establish a secondary beam of light which is directed against a malfunction-sensing photosensitive element **36.** During normal operations, the secondary beam of light will strike the photosensitive element **36** which, through the alarm control circuitry **38,** normally actuates the solenoid **40.** When actuated, the solenoid **40** holds the flag of the alarm signaling device **42** in a concealed position. However, upon the deenergization of the solenoid **40,** the flag will move to a visible position in the window **44** to provide a visible indication that the device is not functioning properly.

The relationship between the secondary beam of light and the photosensitive element **36** is such that the alarm control circuit **38** will be shifted to a malfunction-indicating condition when the quantum of light striking the photosensitive element **36** becomes less than a threshhold amount. This occurs upon failure of the light source or upon movement of the baffle **4** an excessive distance from its initial or null position. For example, this will happen when the primary power is lost since the lamp **2** will be extinguished. It also will occur when the lamp **2** becomes burned out. A malfunction will be indicated when there is a failure of either or both of the primary photosensitive elements **8** or **10** since this will result in improper repositioning of the baffle by the restorative means. Similarly, defects in the motor control system **13,** the electrical servo motor or the mechanisms which are used to raise and lower the aneroid bellows **16** under the influence of the servo motor will result in an inaccurate repositioning of the bellows. Even when the alarm solenoid **40** fails, the alarm flag will move to the malfunction-indicating position in the window **44.**

When the device is used as an altimeter, even a momentary failure to indicate the amount of bellows expansion will be indicated to the observer. For example, if an aircraft loses altitude at a rapid rate so that the servo motor cannot operate quickly enough to restore the baffle **4** to its null position, the malfunction device will assume its malfunctionindicating condition. When the servo motor "catches up" so that the altimeter reflects the correct altitude, the alarm solenoid **40** will again be actuated to indicate to the observer that the altitude reading is correct.

Those skilled in the art will readily be able to construct a device operating according to the principles of this invention. The photosensitive elements **8** and **10** may be photoemissive, photoresistive, photoconductive elements, the latter type of which may be the hermetically sealed dual element cell of the type CL 705 L/2 manufactured by Clairex Corporation of New York, New York. These cells are of the cadmium sulfide type and the resistance varies from 50,000 ohms to 7,500 ohms as the light striking them varies from total darkness to 2 foot candles. The motor control circuit **13** is preferably a balancing circuit of the bridge type which creates an error signal in a well known manner. Similarly, a bridge circuit is suitable for detecting the non-illumination or reduced illumination of the secondary cell **36** which is struck by the secondary beam of light. The alarm itself is preferably of the flag type but the malfunction signalling means may direct its signal only to some non-human element capable of shifting the system automatically to a standby system if desired. The beams may be created in other ways, and move through other instrumentalities such as mirrors rather than baffles. A single transparent area in a baffle might be used to create a beam which serves both as the primary position-indicating beam and the secondary alarm-actuating beam. The ratio between the quantities of light striking the photosensitive elements when the apparatus is at its null or balanced position may vary from the 1:1 ratio described above. Some systems may include a means to shift the null position of the baffle **4,** but the shifted null position will still be within the small permissible excursions of the baffle. In lieu of or in addition to the indicator device **30,** an altimeter system may have an altitude-indicating means in the form of an autopilot system or a transponder which transmits an altitude indicating radio signal to a remote station. In view of these and other modifications and variations to the illustrated system, it is emphasized that the invention is not limited only to the disclosed embodiment, but is encompassing of a wide variety of systems which fall within the spirit of the following claims.

I claim:

1. In an apparatus for sensing relative movement between a pair of bodies, said apparatus having

a pair of photosensitive elements,

means for directing a primary beam of light onto both of said photosensitive elements, said primary beam having a null position where the quantities of light striking said photosensitive elements are balanced in a given ratio, means for moving the primary beam through small excursions in response to relative movement between said bodies to change the ratio of light striking the photosensitive elements,

restorative means responsive to signals from the photosensitive elements for moving the bodies to reestablish the balanced condition where the quantities of light striking the photosensitive element are in said given ratio,

an improvement comprising an alarm means for indicating malfunction of the apparatus,

said alarm means including a malfunction signalling means having a normal operational condition and a malfunction-indicating condition, and

alarm actuating means for shifting the alarm means to its malfunction-indicating condition in response to displacement of the primary beam beyond a predetermined limit of said small excursions, said alarm actuating means includes a circuit having an alarm-actuating photosensitive element,

means for directing a secondary beam of light on the alarm-actuating photosensitive element only when the primary beam of light is at a distance less than said predetermined limit of said small excursions from its null position, said means for moving the primary beam also moving the secondary beam.

2. The apparatus of claim **1** wherein said means for directing a primary beam of light includes an illumination means and a primary baffle interposed between said illumination means and said pair of photosensitive elements, said primary baffle having a light-pervious area which forms the primary beam, said primary baffle being movable by the restorative means and the means for directing a secondary beam includes a baffle portion interposed between said illumination means and the alarm-actuating photosensitive element, said baffle portion having a light-pervious area for directing the secondary beam on the alarm-actuating photosensitive element only when the primary beam of light is at a dis-

tance less than said predetermined limit of said small excursions from its null position.

3. The apparatus of claim 2 wherein said primary and secondary baffles are concurrently movable and are immovable with respect to each other.

4. The apparatus of claim 1 having aneroid bellows means for moving the primary beam of light whereby the apparatus functions as an altimeter.

5. The apparatus of claim 4 having indicating means for indicating the amount of movement of the restorative means.

6. The apparatus of claim 5 wherein the indicating means provides an altitude input indication to an altitude-indicating transmitter.

7. The apparatus of claim 5 wherein the indicating means provides an altitude input indication to an autopilot system.

8. In a photometric altimeter system having means for directing a light beam from a light source onto a pair of photosensitive elements, said means directing said light on said photosensitive elements in a predetermined ratio, altitude responsive means for moving the light beam relative to said photosensitive elements to change the ratio of light striking said photosensitive elements, means responsive to the changed ratio for moving the beam of light to reestablish said predetermined ratio, the improvement comprising a malfunction alarm system including means independent of said balanced bridge circuit for producing an alarm signal, said means for producing an alarm signal being responsive to and actuated by relative movement of the beam beyond a predetermined limit, and means responsive to said alarm signal for indicating an alarm condition in said photometric altimeter system.

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