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(54) DAMPING MECHANISM IN A FLUID DAMPED MEASURING INSTRUMENT

(71) We, TIMEX CORPORATION, a Corporation organised under the laws of the State of Delaware, United States of America, of Waterbury 20, Connecticut, United States of America, do hereby declare the invention, for which we pray that a Patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to measuring instruments and more particularly to a damping mechanism in a fluid damped measuring instrument, for example a gyroscope.

Gyroscopes employed in the guidance systems of airplanes and rockets normally include a gimbal in the suspension of the rotor. The increased technical sophistication of such guidance systems, and particularly their use in small rockets, has created a demand for gyroscopes which are relatively lighter in weight and smaller in size.

It has been difficult to obtain savings in weight and size because the motor, gimbal and pick-off arrangement require a certain size. In addition, many gyroscopes utilize a fluid within the case and surrounding at least part of the gimbal to dampen the movement of the gimbal. Such damping prevents the gimbal from oscillating due to the vibration of its vehicle and enables the gimbal movement to be smooth and linear in relation to the force causing such movement. The fluid, due to the wide variation in temperature to which the gyroscope may be subjected, may expand or contract. An expandable and collapsible bellows may be provided to compensate for the difference in volume of the fluid due to temperature variations. The damping of the gimbal may be obtained, primarily, by having the fluid pumped through a controlled opening. A paddle, vane or blade, or other surface on the gimbal structure in a first chamber, pushes the fluid against a fixed wall structure causing the fluid to be propelled through an opening into a second chamber. Various valve and channel structures have been proposed for the damping device; however, generally they add to the size of the gyroscope and particularly add to its length in the direction of the axis of movement of the gimbal.

In accordance with the present invention there is provided a measuring instrument including a casing, a movable member within said casing having connected thereto a plurality of moving paddles, fixed paddles within said casing, means to suspend said movable member, a damping plate fixed to said casing and having a plurality of ports, the moving paddles and fixed paddles and damping plate forming a plurality of chambers changeable in size by motion of the moving paddles and being filled with a damping fluid, a fluid reserve chamber in said casing, said ports in said damping plate communicating with the reserve chamber, temperature responsive means which respond by movement to temperature variation and a plurality of plungers connected to said temperature responsive means, a said plunger being positioned within each of the said ports.

In a preferred embodiment of the present invention the instrument is a gyroscope. A set of the moving paddles is attached to, or is formed integral with, the gimbal of the gyroscope. The casing has fixed to it an opposite set of the fixed paddles. The moving paddles and fixed paddles form, between them, a set of fluid filled pumping chambers. Each pumping chamber has a port communicating with a fluid filled reserve chamber containing a bellows. An elongated plunger with one end fixed to the bellows, operates in each port. The surface of each of the plungers is selectively shaped to provide each of the

ports with a varying controlled opening, which opening depends upon the distance the bellows advances or retracts the plunger in the port. The varying openings compensate for variations in the viscosity of the fluid caused by temperature changes. Preferably the ports are formed in a single plate, a portion of the plate acting as a fixed wall in each of the fluid filled pumping chambers.

A gyroscope constructed in accordance with the present invention avoids the use of fluid channels between the pumping chambers and the reserve chamber, thereby decreasing the complexity of the damping mechanism and shortening the length of the gyroscope along the axis of movement of the gimbal.

A preferred embodiment of the present invention will now be described in detail with reference to the accompanying drawings in which:

Fig. 1 is a side sectional view of a gyroscope, showing the bellows extended;

Fig. 2 is an enlarged side sectional view of a portion of the damping mechanism showing the bellows withdrawn;

Fig. 3 is an exploded perspective view of the damping mechanism with the torque coil enclosure in sectional view; and

Fig. 4 is a sectional end view taken along line A-A of Fig. 1, but extended to show a complete cross-section of the gyroscope.

The integrating gyroscope of Fig. 1 includes a cylindrical casing 10 within which the gyroscope is positioned. A closure member 11, having electrical terminals 12, 13 and 14, closes one end of casing 10. A bearing 15 is rotatably mounted in closure member 11. A rod 16, whose ball-like end is the bearing member, supports one end of a gimbal 17. A magnetic member 18, mounted on gimbal 17, is the moving member of a microsyn pick-off. The fixed members of the pick-off include a laminated plate member 19, fixed relative to casing 10, and a plurality of coils 20 whose leads are connected to the terminals.

The gimbal 17 consists of a cylindrical tubular shell 21 and, connected thereto, end plates 22 and 23. The gimbal is filled with an inert gas, such as helium, and floats in a damping fluid, such as a silicone oil. First and second inward protruding support members 24 and 25 respectively are attached to end plate 22. A small rotating electric motor 26 is mounted at its one end on support member 24 and at its other end on support member 25. The axis of rotation of motor 26 is shown as 27. The end plate 23 has a rod 28 supporting it, whose end is a ball-like bearing 29. The bearing 29 is held in a cylindrical portion 30 of a damping plate 31. The damping plate 31 is fixed within casing 10 and defines therewith a fluid reserve chamber. A rigid tube 32, having an internal wire, connects motor 26 to a flexible lead 33.

The damping mechanism includes a bellows 34, which may be spring-loaded, within the fluid reserve chamber. The bellows, at its fixed back end, is attached to an end closure plate 35, which plate 35 is fixed to casing 10. The bellows 34 has a central member 36 at the centre of its expandable end. The central member 36 carries a plate 37. Eight elongated valve plungers (only two of which, 38 and 39, are shown in Fig. 1) are fastened at their rear ends to plate 37.

The gimbal plate 23 carries a thin cylindrical wall coil container 42 which fits in the gap between case 10 and a magnet structure. The container 42 has within it a set of coils 43 which are used for applying torque to the gimbal.

As shown in Fig. 4, a magnet structure cooperates with the torque coils 43, the coils being connected in series. The magnet structure includes a cylindrical shunt member 45 of iron, and four radially extending arm members 46,47,48 and 49 which are fixed paddles of the fluid pumping system. The fixed paddles are magnets, for example, of an alnico alloy or a ceramic ferrite, which are poled alternatively as to field and radially, with regard to the centre of shunt 45, as to orientation. The fixed paddles perform two functions:

(1) they create magnetic fields for the torque coils, and
(2) they act as fixed paddles for pumping the damping fluid.

Four moving paddles (vanes) 50,51,52 and 53 are fixed to the gimbal and rotate with it. The moving paddles and fixed paddles form two walls in each of the eight pumping chambers 54,55,56,57,58,59,60 and 61. The gimbal plate 23 and damping plate 30 form the other containing walls of those pumping chambers.

Each of the pumping chambers 54 to 61 has a port 62,63,64,65,66,67,68 or 69 respectively extending between it and the fluid reserve chamber and within which one of the shaped elongated valve plungers moves. Each of the ports 62 to 69 is fixed in size; however, the extent to which it is opened, i.e., the space between its plunger and the wall of the port, is determined by the contour of the plunger and the length it is inserted through the port. Varying port openings are provided in accordance with the varying contour of the surface of the plunger.

In operation, upon a rise in temperature, the damping fluid becomes thinner and the bellows contracts. The plungers are withdrawn partially and their contours are

ped to effectively decrease the size of the ports. More pressure is consequently required to pump damping fluid through the effectively smaller ports so that the effect of the thinner fluid is counteracted and the effective damping remains constant.

The embodiment of the invention described above is an integrating gyroscope. However, the invention is also applicable to other instruments which utilize temperature compensated fluid damping, such instruments including some types of accelerometers and rate gyroscopes.

WHAT WE CLAIM IS:—

1. A measuring instrument including a casing, a movable member within said casing having connected thereto a plurality of moving paddles, fixed paddles within said casing, means to suspend said movable member, a damping plate fixed to said casing and having a plurality of ports, the moving paddles and fixed paddles and damping plate forming a plurality of chambers changeable in size by motion of the moving paddles and being filled with a damping fluid, a fluid reserve chamber in said casing, said ports in said damping plate communicating with the reserve chamber, temperature responsive means which respond by movement to temperature variation and a plurality of plungers connected to said temperature responsive means, a said plunger being positioned within each of the said ports.

2. A measuring instrument as claimed in claim 1 wherein the temperature responsive means is a bellows.

3. A measuring instrument as claimed in claim 1 or claim 2 wherein the surfaces of the plungers have a varying contour along their length to provide varying openings in said ports.

4. A measuring instrument as claimed in claim 1, claim 2 or claim 3, wherein the instrument is an integrating gyroscope including a rotatable motor mounted in a gimbal, the said moving member being the gimbal.

5. A measuring instrument as claimed in any one of the preceding claims wherein the plurality of fixed paddles are magnets and the instrument includes a torque coil fixed to the moving member which is adapted to move in the field of the magnets.

6. A gyroscope substantially as hereinbefore described with reference to the accompanying drawings.

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