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Published:

— *with international search report (Art. 21(3))*

LOW FRICTION RHEOMETER

FIELD AND BACKGROUND OF THE INVENTION

The present invention relates to rheometer instruments and similar apparatus for
5 measuring visco-elastic properties of fluent materials (e.g. viscometers), such as liquids,
gels, slurries, powder masses, plastics, elastomers, clays, foodstuffs and the like, and more
particularly to enabling a new paradigm of the field of achieving low friction and high
sensitivity without a complex or expensive apparatus arrangement. The sensing shaft
control sub-assembly of the invention is also useful for shaft elements of other kinds
10 including, e.g. probes, rotors or float parts, delicate medical and scientific instruments.

Rheometers measure flows of fluent materials (liquids, slurries, suspensions,
elastomers, plastics, gels, melts, (powdery masses), plastics, elastomers, clays, foodstuffs
and the like where adequate characterization demands more than a viscosity measurement
that can be made by a viscometer. The field of rheometers includes instruments using well
15 known per se rotational cylinders and cone-plate devices contacting the materials to be
measured and other forms (e.g. extrusional and capillary forms).

State of the art is summarized and advanced in U.S. patents 7,207,210 of D. J.
Moonay and U.S. patents 5,167,143 and 4,175,425 (all of common assignment with the
present application) and references cited therein, all incorporated herein by reference as
20 though set out at length herein.

SUMMARY OF THE INVENTION

The present invention (which can be applied to rotational cylinder, cone and plates
and other arrangements for interaction with materials) provides a driver element and a
25 sensing element, usually a shaft, the latter supported by flexural (flex) pivots and operating
on a small angle (hereinafter defined) to afford essentially frictionless operation, high signal
to noise ratio and high sensitivity, while enabling a simple, low cost arrangement which
allows movement axially and rotationally but is rigid radially. Readout of sensing shaft
axial or rotary deflection can be made by magnetic, field effect, electrostatic strain gage or
30 other means, but preferably is done for rotation with a microsyn transducer with field coils
and a rotor. Stop means are provided to limit sensing shaft axial and rotary deflection based
on shear response range of interest of the material being measured and protection of the
flexing elements.

Other objects, features and advantages will be apparent from the following detailed description of preferred embodiments taken in conjunction with the accompanying drawings in which:

5 BRIEF DESCRIPTIONS OF DRAWINGS

FIG. 1 is an isometric view of a rheometer instrument made in accordance with a preferred embodiment of the present invention;

FIG. 2 is a top view of it and FIG. 4 a side view;

FIG. 3 is a cross sectional view of it taken as indicated at A-A in FIG. 2.

10 FIG. 5 is a cross sectional view of it taken as indicated at B-B in FIG. 4; and

FIG. 6 is an enlarged view of its internal structure.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Referring to Figures 1-5, there is shown a housing H, a rotary motor M, a wheel DR1
15 driven by the motor and in turn driving a belt B to drive a wheel DR2. The driver wheel DR2 supports, via an attachment member AM, a cone-plate, rotational cylinder or spindle rod or other measured material contact member (not shown).

As shown in Figure 1A sensing shaft 12 is provided that is attached at its upper end from an upper pivot support 14 by an upper flex pivot 16 and at the 10 lower end to a lower sensing block 17 via a lower flex pivot 18. The lower flex pivot is also attached to a flex pivot axial limiter 20 which provides a limited movement of the sensing shaft in the axial direction due to engagement of the limiter with a stop bracket 22. The axial limiter is clamped to a lower flexing element 24 which provides rigid radial support while allowing for limited axial movement. The lower flexing element is clamped to cylinder 26 and
25 therefore controls the positioning of the lower flex pivot, which in turn controls the positioning of the lower sensing block. The radial clearance between the lower sensing block and the cylinder is kept small to prevent excessive radial movement which would damage the lower flex pivot.

The upper flex pivot is attached to the upper flex pivot support, which is further
30 clamped to the upper flexing element 28 by axial clamp 30. As with the lower flexing element this allows some axial movement of the sensing shaft but is rigid for radial movement. The upper flexing element is clamped to cylinder 26 to complete the suspension system for the sensing shaft. A microsyn transducer system 32 with a rotor 34 and field coil

36 is provided at the upper end of the sensing pivot. In order to assure alignment between the transducer components, especially as the sensing shaft moves axially, the microsyn rotor is clamped to the sensing shaft near the upper flex pivot support, while the microsyn field coil 36 is mounted directly to the upper flex pivot support thereby allowing no relative axial movement between the transducer field and rotor.

The above described arrangement allows axial movement of the sensing shaft within the limits defined by the stop bracket 22, and permits rotational movement of the sensing shaft through the flex pivots. The rotation of the flex pivots has to be limited to a small angle, so the clearance between the lower sensing block and the stop bracket in the rotational sense is established such that at an acceptable angle of rotation the two parts will engage in either direction and not permit further rotation. The amount of axial movement allowed is determined by the amount of movement necessary for full scale deflection of an appropriate load cell or other similar arrangements or device attached to the axial clamp for the purpose of measuring normal forces and to determine the hit point when using cone and plate geometry for establishing a known gap. Rotation of the sensing system against a stationary member or keeping the sensing system stationary and rotating the complementary member or even rotating both parts simultaneously are all feasible variants and desirable.

The limited rotation, axial movement, limited sensing sub-assembly of the present invention can be used in several contexts additionally to its presently described uses in rheometers (and viscometers). Single or multiple ranges of measured rotation calibration can be provided (e.g. to handle measurement of a fluid over single or multiple ranges of viscosity or shear stress change). Some of the other applications include fine control and detection of positions of probe ends or other parts (e.g. rotors or float parts) of scientific and medical instruments, motors and the like.

It will now be apparent to those skilled in the art that other embodiments, improvements, details, and uses can be made consistent with the letter and spirit of the foregoing disclosure and within the scope of this patent, which is limited only by the following claims, construed in accordance with the patent law, including the doctrine of equivalents.

Claims

1. A limited rotation sensing assembly comprising, in combination:
 - a sensing shaft of limited length suspended by flexural pivots, at two points
 - 5 sufficiently separated to ensure alignment,
 - a support structure,
 - means connected to the support structure for holding each flexural pivot in a manner to fix its lateral position but allowing axial and limited rotational movement, and
 - means for limiting such axial and rotational movement to define a measurement
 - 10 range.
2. The apparatus of claim 1 further comprising means for detecting the rotational movement of the shaft and constructed and arranged to be unaffected in such detection by the axial movement of the shaft.
3. The apparatus of claim 2 wherein the means for detecting comprises a microsyn
- 15 transducer.
4. The apparatus of any of claims 1-3 in combination with a fluent material (liquids, gels, slurries, powder masses, plastics, elastomers, clays, foodstuffs and the like) contact means to perform rheometry and/or viscometry functions.
5. The apparatus of claim 4 configured as a rheometer implementing shear stress
- 20 measurements and/or derivatives of such.
6. The apparatus of any of claims 1-3 and further comprising means for indicating limit of a selected range of allowed axial movement.

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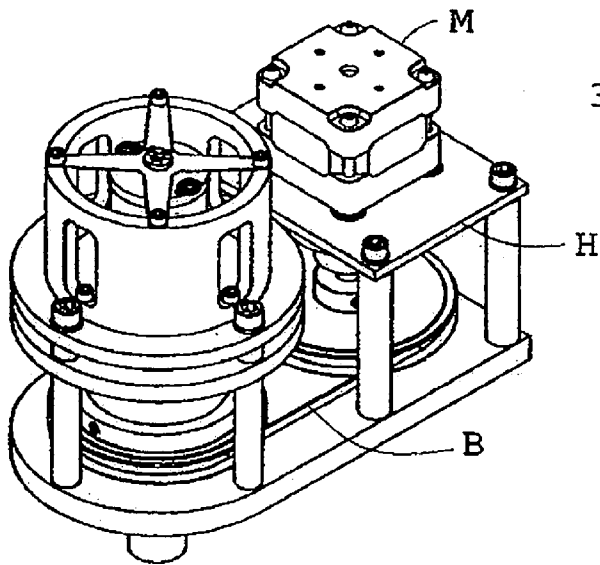


FIG. 1

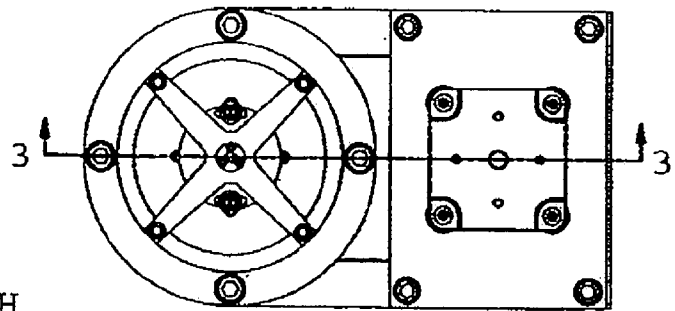


FIG. 2

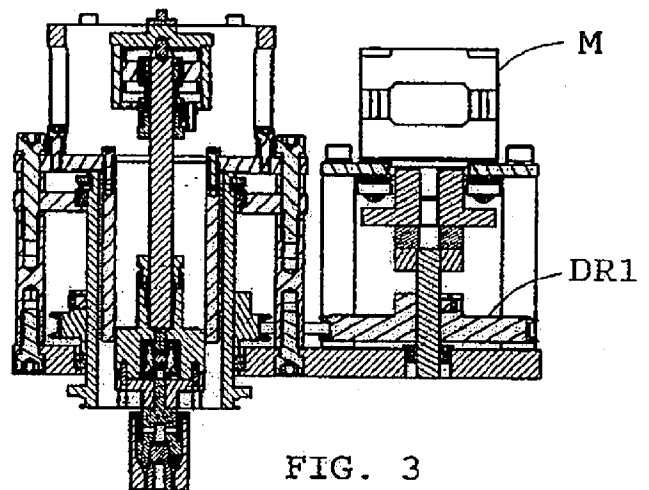


FIG. 3

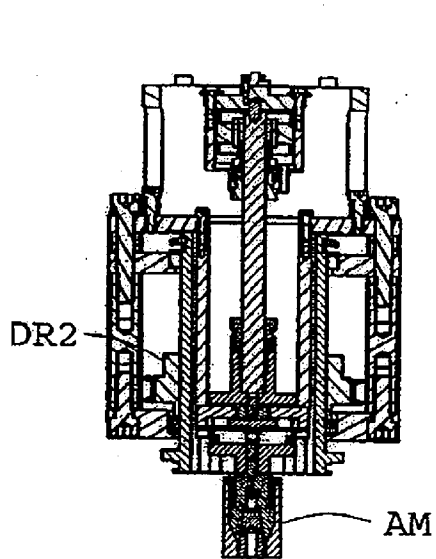


FIG. 5

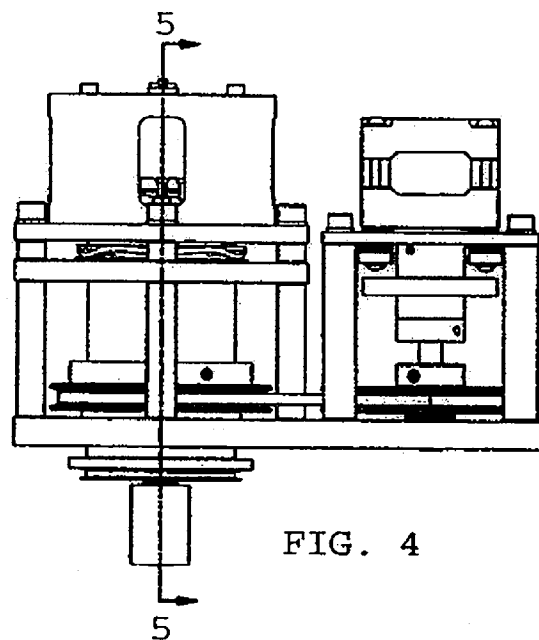
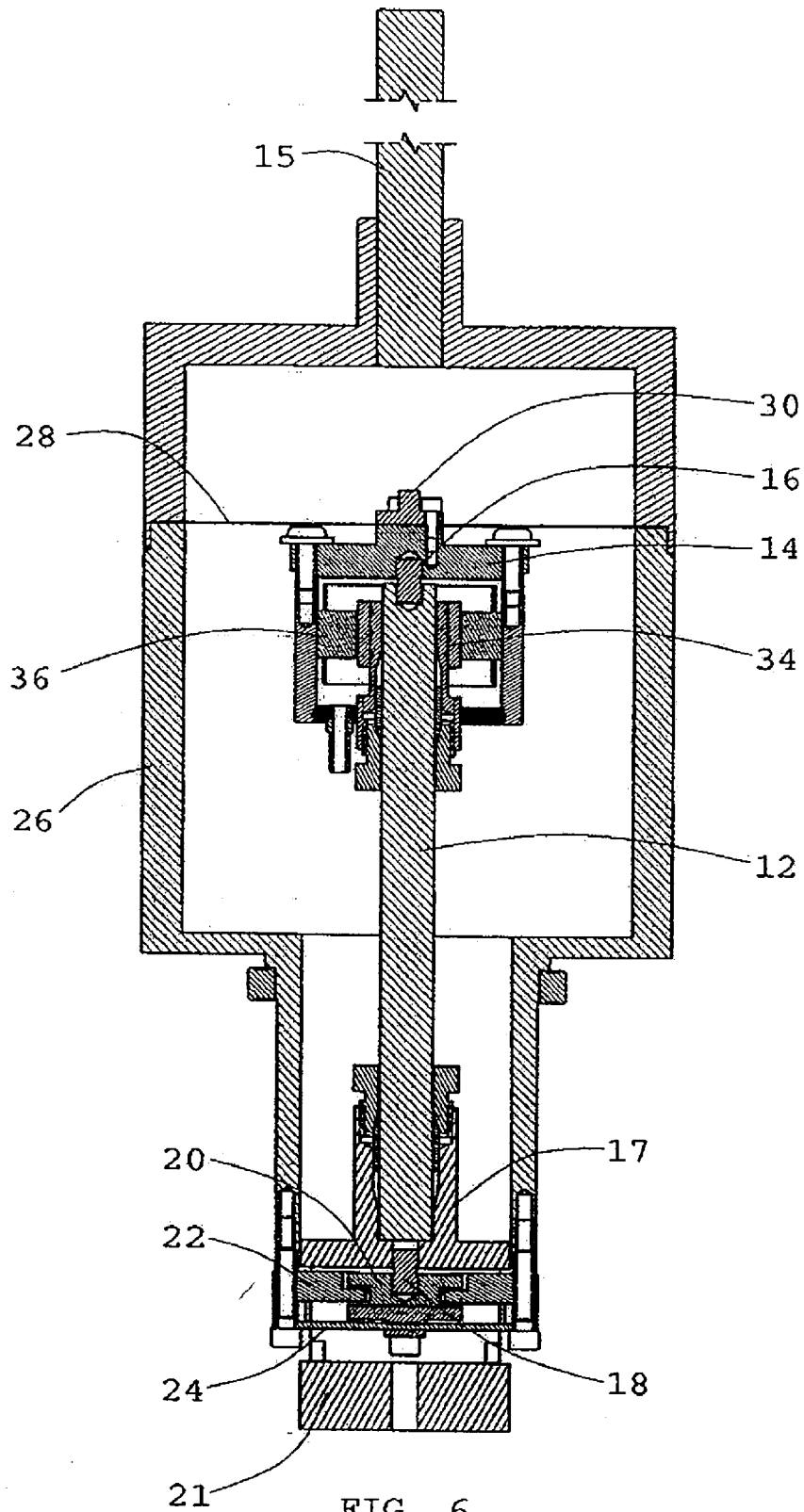


FIG. 4

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2012/033445

A. CLASSIFICATION OF SUBJECT MATTER IPC(8) - G01N 11/14 (2012.01) USPC - 73/54.28 According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) IPC(8) - G01N 11/10, 11/14, 11/16 (2012.01) USPC - 73/54.23, 54.28, 54.31 Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) PatBase, Google Patent Search, Google Scholar		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 5,167,143 A (BROOKFIELD) 01 December 1992 (01.12.1992) entire document	1-6
Y	US 2002/0046597 A1 (BROOKFIELD) 25 April 2002 (25.04.2002) entire document	1-6
Y	US 2,888,635 A (VOLK) 26 May 1959 (26.05.1959) entire document	3-6
A	US 5,531,102 A (BROOKFIELD et al) 02 July 1996 (02.07.1996) entire document	1-6
☐ Further documents are listed in the continuation of Box C. ☐		
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