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(54) VISCOMETER

(71) We, DE BEERS INDUSTRIAL DIAMOND DIVISION (PROPRIETARY) LIMITED a company registered according to the laws of the Republic of South Africa, of 45 Main Street, Johannesburg, Republic of South Africa 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:—

This invention relates to a viscometer, i.e. to a device for measuring the viscosity of a fluid.

One way in which the viscosity of a fluid has hitherto been measured is by the use of a rotor which is immersed in the fluid and then rotated in the fluid by means of a counterweight connected through an elaborate system of pulleys and gears to the test weight. With the aid of a stop watch the rotational speed of an indicating gear was then determined, a calibration chart being then consulted to obtain the viscosity corresponding to the calculated R.P.M.

Needless to say, a measuring technique of this nature is cumbersome and time consuming, and prone to errors caused by the frictional drag of the moving parts, and requires a certain amount of skill on the part of the operator.

It is an object of the present invention to provide an improved viscometer.

According to the present invention, there is provided a viscometer comprising a housing, a vertically oriented U-shaped chamber being formed in the housing, means to circulate fluid in the chamber downwardly in a first limb of the chamber and upwardly in a second limb of the chamber, a rotor of suitable shape which is immersible in the chamber in the second limb, electric motor means to rotate the rotor, and means to measure an operating characteristic of the electric motor which is dependent on the viscosity of the fluid.

In one form of the invention the viscometer includes means to operate the motor at a selected constant rotational speed and the armature current is indicative of the fluid's viscosity.

In a second form of the invention the motor is operated at a constant torque and the rotational speed of the motor is indicative of the fluid's viscosity.

In this form of the invention the viscometer includes a constant current source to supply the power requirements of the motor.

The invention is further described by way of example with reference to the accompanying drawings in which:

Figure 1 illustrates the physical arrangement of a viscometer according to the invention,

Figure 2 is a block diagram of an electrical circuit of the viscometer according to one form of the invention, and Figure 3 is a diagram of an electrical circuit of the viscometer according to a second form of the invention.

Figure 1 shows a viscometer 10 which consists of a rotor 12, which is circularly cylindrical and conically shaped at both ends, suspended from the shaft 14 of an electric motor 16, and hanging inside a first limb 18 of a U-shaped chamber 20 formed inside an aluminium housing 22.

The second limb 24 of the chamber houses a propellor 26 which drives the fluid in the chamber 20 in a clockwise direction (in the drawing) around the chamber and through a baffle 28 near the base of the limb 18. The propellor 26 is driven by means of a rotor 30 which is mounted together with the motor 16 on a support 32 which is adjustable in the vertical direction upwardly or downwardly.

The two limbs of the U are separated

from each other by a wall 34. Beneath the chamber 20 a passage 36 is formed which in use is connected to a source of water which is held at a constant temperature.

The shaft 14 extends upwardly through the motor and a disc 38 which is formed with a series of holes is attached thereto. A U-shaped device 40 straddles the disc. The upper limb 42 of the device has a source of light which is directed onto the disc, and the lower limb 44 has a suitable detector arranged to detect the light beam as it is chopped by the rotating disc 38.

The apparatus in Figure 2 consists of an amplifier 46, a Schmidt trigger 48, a monostable multivibrator 50, an integrator 52, a differential amplifier 54, and a variable voltage source 56. The output of the amplifier 54 is connected to the armature 58 of the motor 16. The current through the armature is passed through a standard resistance 60 and the voltage waveform across the resistance 60 is smoothed by an integrator 62 and then measured and displayed by means of a digital meter 64. The input to the integrator 62 may be switched to the output of the integrator 52.

In use of the viscometer fluid, for example water with a suspension of ferrosilicon particles, is poured into the chamber 20 and the motor 30 is operated so that the fluid is pumped upwardly past the baffle 28 and the rotor 12. Dispersion of the particles is assisted by the baffle 28, which also ensures a laminar flow of the fluid. This is important because any swirling of the fluid affects the torque required to rotate the rotor 12 and thus results in loss of accuracy.

In this form of the invention the motor 16 is run at a constant speed and the circuit of Figure 2 is used to control the motor speed.

The disc 38 and device 40 are used to generate a series of pulses at a rate which is proportional to the motor speed, and after the pulses are suitably shaped by the components 46, 48 and 50, the pulses are applied to the negative input of the differential amplifier 54. The positive input of the amplifier is connected to the voltage source 56, the value of the voltage applied to the positive input being varied to adjust the motor's rotational speed. The signals at the inputs of the amplifier are compared to generate an error signal and this is used to alter the current which is generated at the output of the amplifier and which is passed through the armature 58, to control the motor speed, and hence the rotational speed of the rotor, at the selected constant value.

Ideally the motor 16 has a linear torque/armature current characteristic, or at the very least this characteristic is known to a fair degree of accuracy. By switching the integrator 62 to measure the signal applied to the negative input of the amplifier, and the voltdrop over the resistor 60, the speed of the motor and the armature current respectively, can be measured.

The current drawn by the armature is proportional to the drag exerted on the rotor by the fluid, and so is dependent on the fluid viscosity. The meter 64 is preferably digital and it is then an easy matter for an operator to take a reading and consult a prepared calibration chart to obtain a viscosity reading.

In an alternative form of the invention shown in Figure 3 the motor 16 is run at a constant armature current, the current being generated by a constant current source 66. The drag on the rotor 12, which is dependent on the viscosity of the fluid, influences the rotational speed of the rotor and the speed is thus proportional to the viscosity of the fluid. Speed readings are indicated on the meter 64 and are correlated with viscosity, again by means of a calibration chart. The speed of the motor may be measured again by means of the device 40, together with the components 46, 48, 50 and 52, indicated collectively by the block 68 in Figure 3.

In each form of the invention the fluid is allowed to overflow the wall 34 which acts as a weir between the limbs 18 and 24. This causes the head of liquid above the rotor 12 to be steady, and permits accurately controlled operating conditions.

WHAT WE CLAIM IS:

1. A viscometer comprising a housing, a vertically oriented U-shaped chamber being formed in the housing, means to circulate fluid in the chamber downwardly in a first limb of the chamber and upwardly in a second limb of the chamber, a rotor of suitable shape which is immersible in the fluid in the second limb, electric motor means to rotate the rotor, and means to measure an operating characteristic of the electric motor which is dependent on the viscosity of the fluid.

2. A viscometer according to claim 1 which includes means to operate the electric motor means at a selected constant torque, and wherein the measured operating characteristic is the rotational speed of the electric motor means.

3. A viscometer according to claim 2 wherein the operating means includes a constant current source connected to the electric motor means.

4. A viscometer according to claim 1 which includes means to operate the electric motor means at a selected constant rotational speed, and wherein the measured operating characteristic is the current passed through the armature of the electric motor

means.

5. A viscometer according to claim 4 wherein the operating means comprises means to generate a first signal which is dependent on the actual rotational speed of the electric motor means, means to generate a second signal which is dependent on the selected constant rotational speed, and means to compare the first and second signals to generate the current which is passed through the armature.

6. A viscometer according to claim 5 wherein the comparison means includes a differential amplifier.

7. A viscometer according to claim 5 or 6 wherein the means to generate the first signal includes a disc which is attached to the shaft of the electric motor means, means to direct an electromagnetic beam of radiation towards the disc, the disc having at least one formation which is adapted on each revolution of the disc to interrupt and thereby chop the beam, and means to detect the chopped beam.

8. A viscometer according to any one of claims 1 to 7 wherein the rotor is directly attached to the shaft of the electric motor means.

9. A viscometer according to any one of claims 1 to 8 which includes baffle means arranged upstream of the circulating means to ensure a laminar flow of the fluid in the second limb.

10. A viscometer according to any one of claims 1 to 9 wherein the housing is of metal and includes a passage which passes through the housing and which is in use of the viscometer connected to a supply of liquid at a constant temperature.

11. A viscometer according to any one of claims 1 to 10 wherein the rotor is circularly cylindrical with conically shaped ends.

12. A viscometer according to any one of claims 1 to 11 wherein the electric motor means has a substantially linear torque to armature current characteristic.

13. A viscometer substantially as herein described with reference to the accompanying drawings.

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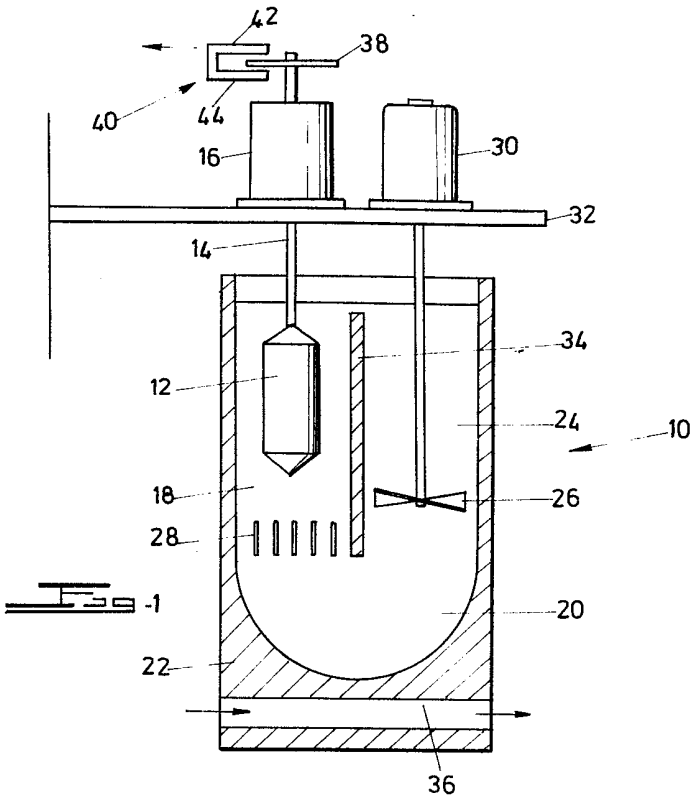

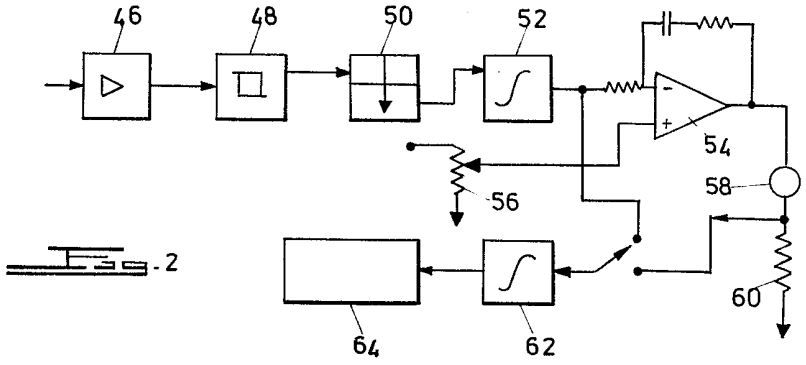

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Sheet 2