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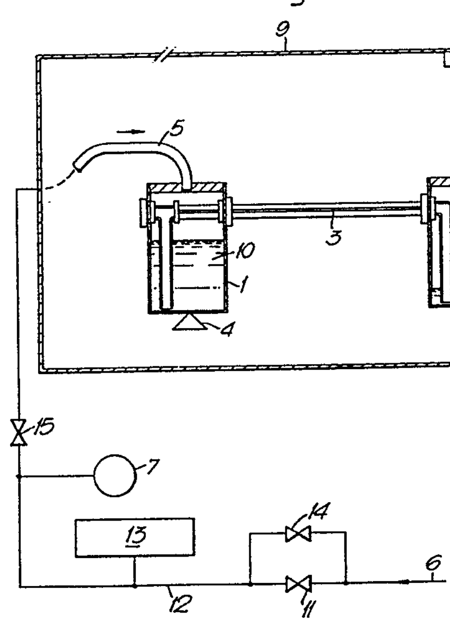
UK CL (Edition K) **G1S SDB SEB SEC SED SEP SEQ SER SEX SGA SGX SOA**
INT CL[5] **G01N**

(54) **A capillary rheometer**

(57) A capillary rheometer has first and second fluid reservoirs 1, 2 interconnected by a capillary tube 3 to form a balance module which is mounted in a glove box when radioactive fluid or slurry is investigated. The first reservoir 1 is balanced on a knife edge 4 and the second reservoir is suspended from a weighing means, such as a load cell 8. Fluid is forced under controlled measured pressure from the first to the second reservoir and the flow rate is determined by measuring the loads on load cell 8 at discrete time intervals. In an alternative embodiment, the capillary tube may have a permeable wall, and permeate flow through the wall of the capillary may be measured by the load cell. In another embodiment a filter in reservoir 1 collects the solid contents of a slurry, the liquid contents of the slurry being forced by applied pressure to the second reservoir 2.

Fig.1.




The claims were filed later than the filing date within the period prescribed by Rule 25(1) of the Patents Rules 1982.

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Fig.1.

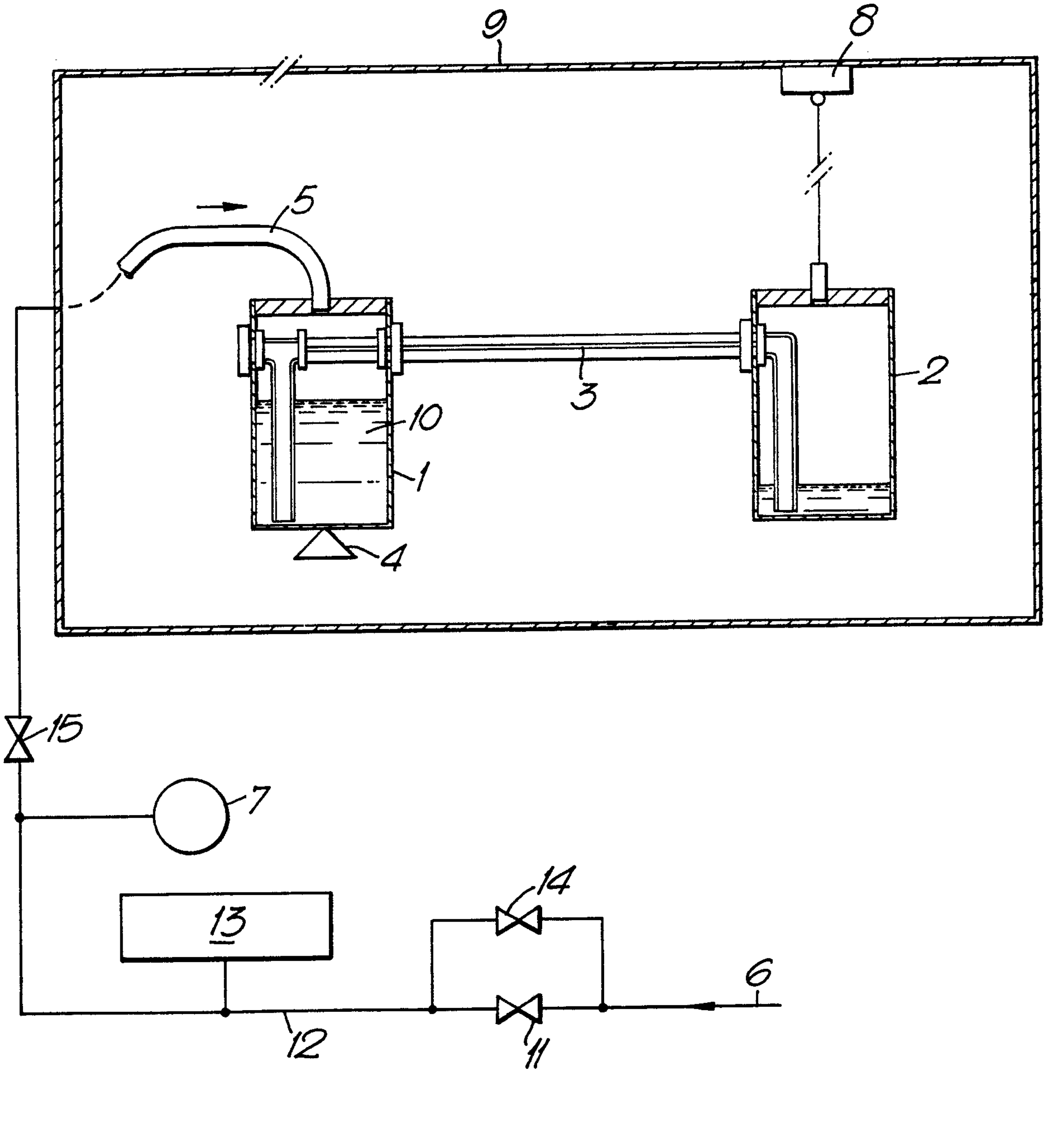


Fig. 2.

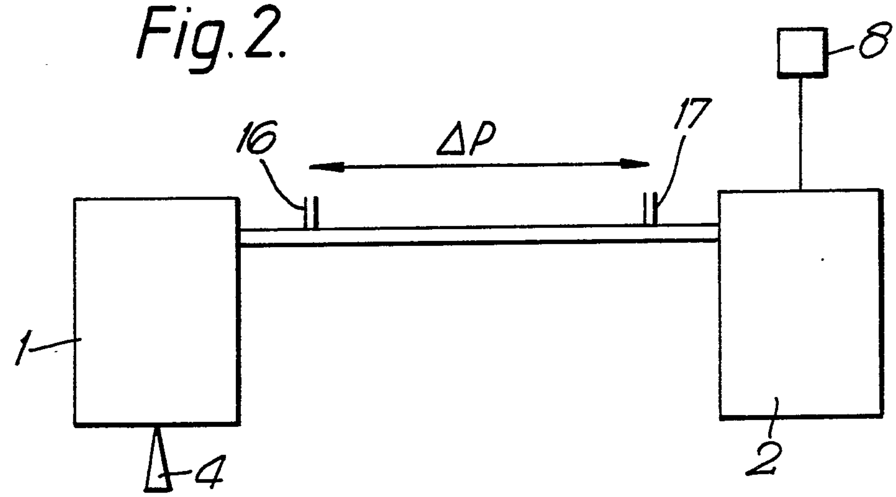



Fig. 3.

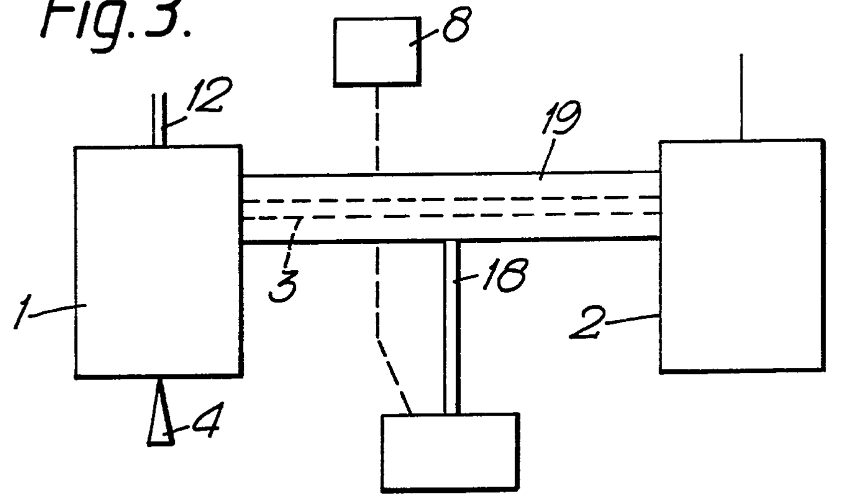
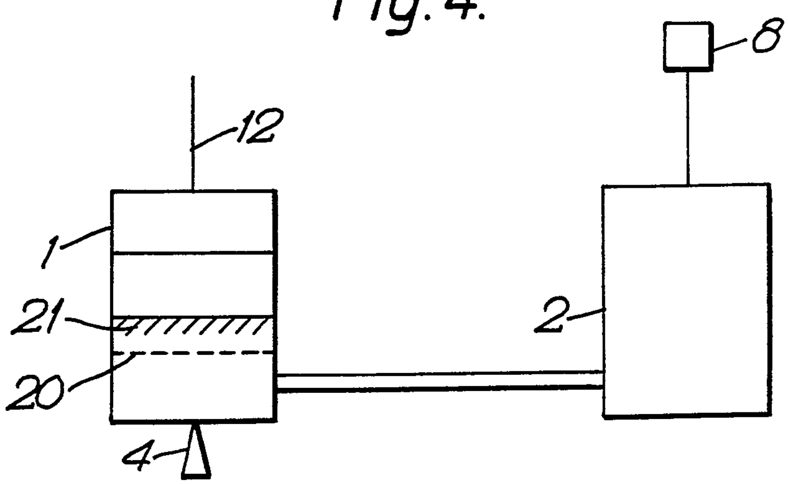



Fig. 4.



A Capillary Rheometer

The present invention concerns a capillary rheometer.

According to the present invention a capillary rheometer comprises first and second fluid reservoirs interconnected by a capillary tube to form a balance module, the first reservoir being balanced on a knife-edge, the second reservoir being suspended from a weighing means and means for applying known pressures to the first reservoir for forcing fluid therein through the capillary and into the second reservoir.

Preferably, the weighing means comprises a load cell and the weight of fluid transferred into the second reservoir as determined by the load cell is monitored as a function of time. The time derivative of the weight divided by the fluid density gives a measure of the flow rate of the fluid into the reservoir.

Conveniently, the module is attached to a computer for automatic, remote presentation of results. The balance module can be housed in a glove-box when a radioactive fluid or slurry is under investigation.

The reservoirs are reversible that is after transfer of fluid from the first to the second reservoirs the operation can be repeated after repositioning of the reservoirs such that the filled second reservoir is now located on the knife-edge and the emptied first reservoir is connected to the load cell. Preferably however, and for ease of use especially with radioactive liquids or slurries, the reservoirs can be pressurised alternately to achieve fluid transfer therebetween.

The invention will be described further, by way of example, with reference to the accompanying schematic diagrammatic drawings; in which:

Figure 1 illustrates a first embodiment of a capillary rheometer for measuring fluid flow; and

Figures 2, 3 and 4 illustrate further embodiments of capillary rheometers according to the invention.

In Figure 1, a capillary rheometer comprises a capillary balance module having first and second fluid reservoirs 1 and 2 respectively interconnected by a capillary tube 3. Reservoir 1 is balanced on a knife-edge 4 and is connected by a flexible pipe 5 to a pressure source, conveniently a compressed air supply 6 and a pressure transducer 7. Reservoir 2 is suspended from a load cell 8. The balance module is located within a glove box 9 having usual ports (not shown) in the walls thereof.

In operation fluid 10 in reservoir 1 is forced under controlled pressures along the capillary tube 3 into the reservoir 2. Thus, when a pressure is applied to the reservoir 1, the flow rate of the fluid into the reservoir 2 is determined by measuring the loads on the cell 8 at discrete time intervals. The time derivative of the weight divided by the fluid density gives a measure of the flow rate Q of the fluid into the reservoir 2. The rheometer is linked to a computer and several operational modes can be written into the computer software to permit remote operation.

Briefly, the operational modes can comprise the following:

1. Calibration Mode

The voltage ooutput response of both the pressure transducer 7 and the load cell 8 are essentially linear. To calibrate the load cell 8 the tare signal is first obtained and a known weight is added. The pressure transducer signal is read and a pressure applied which can be read by a digital pressure meter.

2. Set-up Mode

The capillary diameter and length are entered into the computer. The diameter of the capillary can be measured using a travelling microscope and mercury technique outside the glove box.

3. Run Modes

Runs can be performed automatically. With reference to Figure 1, compressed air from supply 6 flows through automatic valve 11 in flow line 12 to a chamber 13. A manual needle valve 14 can be arranged in the line 12 across the valve 11. A second automatic valve 15 is located in the line 12 between the pressure transducer 7 and the fluid reservoir 1.

In "manual mode" runs are performed by pressurising the chamber 13 with the valve 15 closed. Upon reaching a desired pressure in the chamber 13 the valve 11 is closed and the valve 15 is opened to commence a run. It is possible to increase the pressure by manually operating the valve 14. In the automatic mode a series of required pressures are preselected and the computer performs the runs by operating the valves 11 and 15 in a required order.

4. <u>Density Measuring Mode</u>

A piece of metal is attached to the load cell and weighed. It is reweighed in water and then immersed in the fluid. The computer uses Archimedes principle to determine the fluid density.

5. <u>Data Acquisition Mode</u>

The pressure and weight measurements are used to calculate T (shear stress) and y (strain rate) where:

$$T = \frac{\bar{P}d}{4L} \quad \text{and} \quad y = \frac{32\ (dw/dt)}{\rho d^3}$$

$\bar{P}$ = mean pressure $\qquad$ $\rho$ = fluid density

d = capillary diameter $\qquad$ L = capillary length

dw/dt = time derivative of weight measured on the load cell.

Data pairs $T_i$, $y_i$ are arranged in order of increasing shear rate and stored.

6. <u>Analysis Routine Mode</u>

The data pairs are analysed using a least squares technique to fit the data to different rheological models.

Figures 2, 3 and 4 are diagrammatic sketches of further embodiments to measure flow properties and filtration characteristics of slurries.

In Figure 2, to reduce possible end effects at the capillary the pressure is measured across two fixed points 16 and 17 spaced apart on the capillary tube.

In Figure 3, the capillary tube 3 can be formed with a permeable wall in the manner of an ultrafilter. Permeate can be collected at outlet 18 from housing 19 about the capillary tube 3. A measure of permeate flow can be derived by recording its weight on the load cell 8.

Finally, in Figure 4 the reservoir 1 contains a perforated support or filter 20 which collects solids 21 present in a slurry. The liquid content of the slurry is forced by the pressure applied to the reservoir along the capillary tube and into the reservoir 2 for weighing.

In addition to application in the study of the flow properties of radioactive fluids and slurries the capillary rheometer can also be used to study flow properties of other fluids such as, for example, paints.

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Claims

1. A capillary rheometer comprising first and second fluid reservoirs interconnected by a capillary tube to form a balance module, the first reservoir being balanced on a knife-edge, the second reservoir being suspended from a weighing means and means for applying known pressures to the first reservoir for forcing fluid therein through the capillary and into the second reservoir.

2. A capillary rheometer as claimed in Claim 1 in which the weighing means comprises a load cell and the weight of fluid transferred into the second reservoir as determined by the load cell is monitored as a function of time.

3. A capillary rheometer as claimed in Claim 1 or 2 in which the module is attached to a computer for automatic, remote presentation of results.

4. A capillary rheometer as claimed in any preceding claim in which the balance module is housed in a glove-box or other enclosure.

5. A capillary reservoir as claimed in any preceding claim in which the reservoirs are reversible.

6. A capillary rheometer as claimed in any of preceding Claims 1 to 4 in which the reservoirs are pressurised alternately to achieve fluid transfer therebetween.

7. A capillary rheometer constructed, arranged and

adapted to operate substantially as herein described with reference to and as illustrated in the accompanying drawings.

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