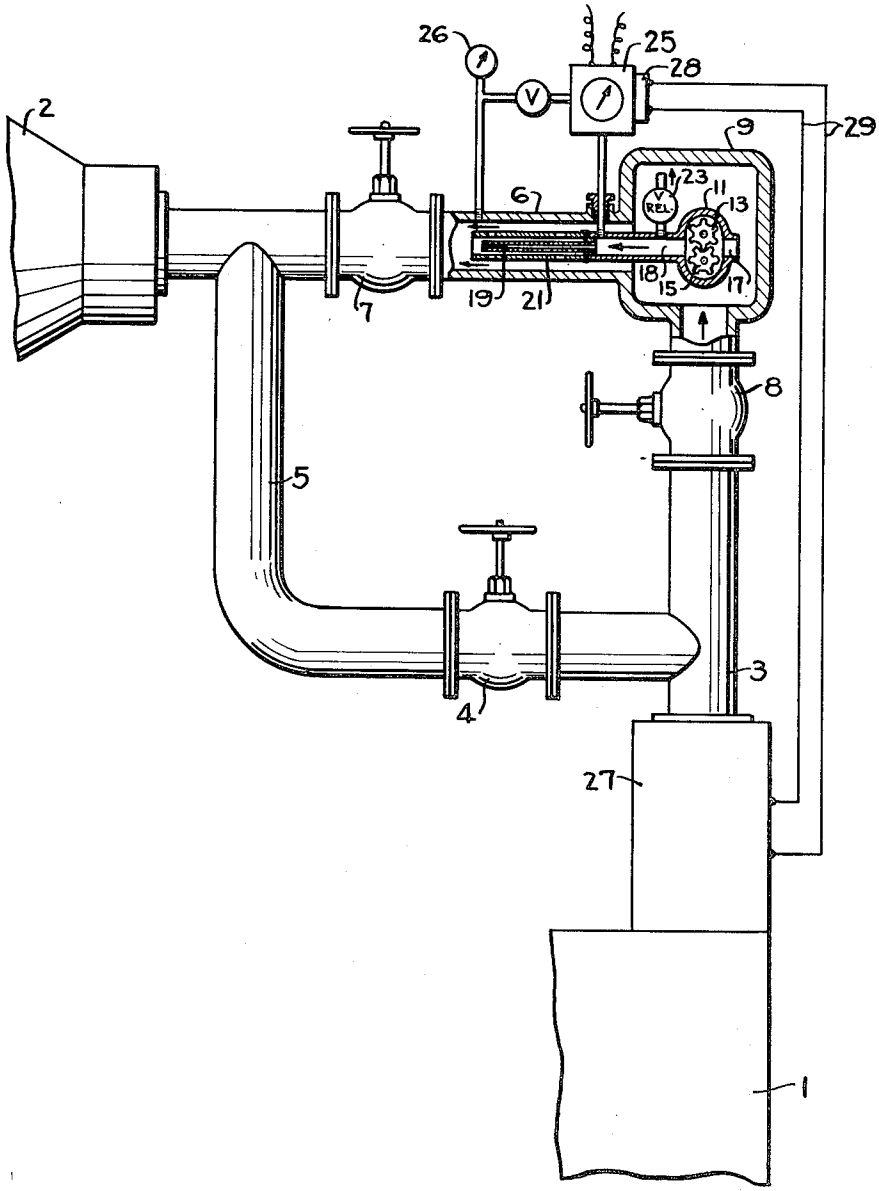
Nov. 27, 1956 J. BOUMAN 2,771,770

VISCOMETER SYSTEM

Filed June 3, 1954



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United States Patent Office 2,771,770 Patented Nov. 27, 1956

2,771,770

VISCOMETER SYSTEM

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Application June 3, 1954, Serial No. 434,242

Claims priority, application Netherlands June 8, 1953

5 Claims. (Cl. 73—55)

This invention relates to viscometers, and pertains particularly to a viscometer capable of continuously measuring the viscosity of a liquid, said viscometer comprising a capillary tube, means for pumping liquid through said tube, and means for indicating and/or recording the difference in pressure between two points in the capillary tube.

The specific object of the present invention is to provide a device by means of which the viscosity of a liquid flowing through a conduit can be continuously measured under the temperature conditions prevailing in said conduit.

It is also an object of this invention to provide viscometer wherein the liquid whose viscosity is being measured is also used as the viscometer bath liquid, the use of a special bath liquid being thus eliminated, and the viscometer inherently always operating at the desired temperature.

Continuous viscosity measurements are essential when supplying, for example, a liquid fuel to a burner installation, or to an injection engine, especially when the quality of fuel is likely to vary. Both the efficient operation of the burner or engine, and that of the pumping means required to supply the liquid fuel thereto depend to a great extent on the viscosity of the fuel. If this viscosity is too high, the delivery pressure of the pump may reach excessively high values, and the pumping of the fuel may consume disproportionately high amounts of energy, besides impairing the proper operation of the burner or engine.

To keep the viscosity within the desired range, heavy fuels may be heated prior to being delivered to an engine. It is obvious that, in order to avoid an unnecessary and wasteful overheating of the fuel, it is advantageous to maintain a continuous check on its viscosity.

The viscometer of the present invention, which is particularly suitable for this purpose, comprises a capillary tube located within the conduit through which the fuel is being delivered to a burner or engine. A small electric pump takes in a portion of the liquid flowing in the conduit and forces it through the capillary tube and back into the conduit, while the remainder of the main stream is by-passed around the capillary tube.

Since the capillary tube is located within the flow conduit, the temperature of the tube and of the sample stream will always be exactly the same as that of the main stream. Since the discharge of the capillary tube also opens to the main stream, the sample stream is not withdrawn from the system.

The present device is preferably made compact and has dimensions such as to fit readily in a conduit. The viscometer pump, for example, a small gear pump, is preferably also located entirely within the conduit, so as to eliminate the effect of pump temperature on the sample stream. As the capillary tube discharge is returned to the main stream, it may be sufficient to measure the pressure at the inlet end of the capillary tube only, provided the pressure in the main stream is constant.

These and other features of the present invention will be understood from the following description taken with reference to the attached drawing, the single figure whereof shows a diagrammatic view, partly in cross section, of an embodiment of the present viscometer system.

Liquid fuel from a reservoir or bunker **1** is supplied by a pump (not shown) to a burner or other engine **2** through pipes **3** and **5**. By closing valve **4** and opening valves **7** and **8**, the main fuel stream may be directed through a housing **9** containing the viscometer of the present invention. This viscometer comprises a pump such, for example, as a gear pump **11** having gears **13** and **15** connected to and driven from the outside by a constant speed electric motor (not shown). The pump **11** has an intake port **17** and an outlet port **18**, whereby the discharge of the pump is forced through a capillary tube **19**, which may be, if desired, provided with a perforated tubular guard member **21**. The pump outlet port **18** is in communication with a relief valve **23** adapted to return a fluid overflow to the housing **9**, thereby preventing excessively high pump discharge pressures which may be injurious to an indicating or recording device **25** adapted to register pressures at the inlet side of the capillary tube. The relief valve **23** may also be mounted outside the housing **9**.

In operation, the fluid flowing through the housing **9** surrounds the capillary tube viscometer and serves as a bath therefor, the viscometer thus being automatically maintained at the exact temperature of the liquid fuel, which is inherently also the temperature at which the viscosity of the fuel must be measured. A small amount of the fuel enters the pump through the port **17** and is forced at a constant rate through the capillary tube **19**, after which this sample stream is returned back to the main stream within the pipe **6**. The pressure developed at the inlet end of the capillary tube **19** and registered by the indicator or recorder **25** is a function or measure of the viscosity of the fuel, provided the pressure of the liquid in the conduit **6** has a substantially constant value. If the pressure in conduit **6** tends to vary, the pressure gage **25** must be of the differential-pressure manometer type, responsive to the difference between the pressures at the inlet and outlet ends of the capillary tube. A pressure gage **26** may also be used to measure within conduit **6**.

By way of an illustrative example, an embodiment of the present viscometer system was provided with a capillary tube having an inside diameter of 1 mm. and a length of 220 mm., and the output of the pump was 23 cc. per minute at 40 R. P. M. When the viscosity rose from 15 to 540 centistokes at 100° F., the fall in pressure in the capillary tube increased from a value of about 0.5 to 32 kg. per square centimeter. Since, in the case concerned, the object was to keep the viscosity of a heavy oil supplied to an injection engine at a value below 26 centistokes at 100° F., it was only necessary to use that portion of the indicating range of the device **25** which covers a fall in pressure of 4 to 5 kgs. per sq. cm.

The indicating device **25** may be provided with a calibrated scale for viscosity as well as for pressure readings. Furthermore since the viscosities of the various suitable fuels have been found to vary within the operational range in such a way that a change of temperature of 1° C. broadly corresponds to a change of viscosity of about 0.8 centistoke, the indicating device **25** can also be provided, in a manner well known in the art, with a calibrated scale permitting to read off directly, once the maximum permissible viscosity is exceeded, the number of degrees by which the temperature of the fuel must be raised to bring its viscosity within the desired range.

If desired, the present system may be used for automatically maintaining the viscosity of a liquid, particularly

a liquid fuel, within the desired limits by regulating the amount of heat supplied thereto. This can be achieved, for example, by suitably positioning a heater **27** with regard to the reservoir or bunker **1**, and regulating the operation of said heater by means of electrical signals applied thereto, through a control circuit **28** and conductors **29** from the indicator **25**.

I claim as my invention:

1. A viscometer system comprising conduit means confining a main liquid stream, a pump disposed within said conduit, a capillary tube disposed within said conduit, said pump having an intake opening to the inside of said conduit and a discharge connected to the inlet of said capillary tube, whereby a sample portion of the main stream is forced by said pump through said capillary tube while the rest of the main stream is by-passed around said pump and said capillary tube in heat-exchange contact therewith, and pressure indicating means connected to the pump discharge for indicating the pressure at the inlet of the capillary tube.

2. The system of claim 1 having a relief valve connected to the pump discharge adjacent said indicating device, said relief valve having an outlet opening to the space within said conduit.

3. The system of claim 1 having a relief valve connected to the pump discharge adjacent said indicating device, said relief valve being mounted outside said conduit and having an outlet opening to the space outside said conduit.

4. The system of claim 1, wherein the outlet of said capillary tubes opens to the space within said conduit, whereby the sample stream withdrawn from the main stream is returned thereto.

5. A viscometer system comprising a conduit confining a main stream of liquid, a pump and a capillary tube disposed within said conduit, said pump having an intake opening to the inside of said conduit and a discharge connected to the inlet of said capillary tube, the outlet of said capillary tube opening to said conduit, whereby a sample portion of the main stream is forced by said pump through said capillary tube while the rest of the main stream is by-passed around said pump in heat-exchange contact therewith, and differential pressure manometer means connected between the discharge of said pump and the space within said conduit.

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