April 1, 1958 H. C. VON ROSENBERG 2,828,621

VISCOSIMETER

Filed Oct. 28, 1953 5 Sheets-Sheet 1

Fig. 1.

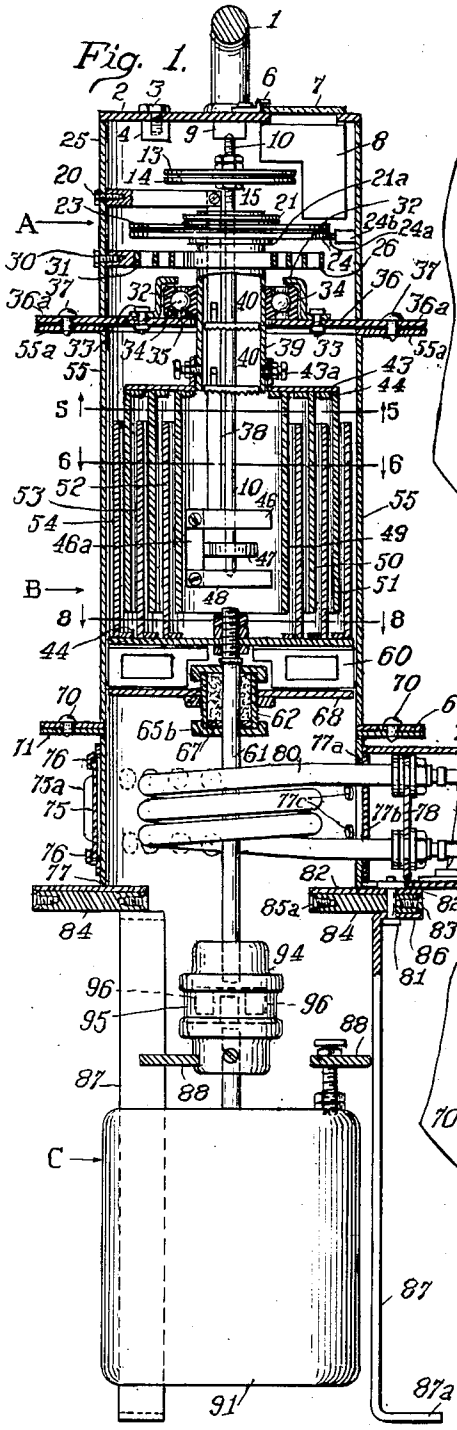


Fig. 5.

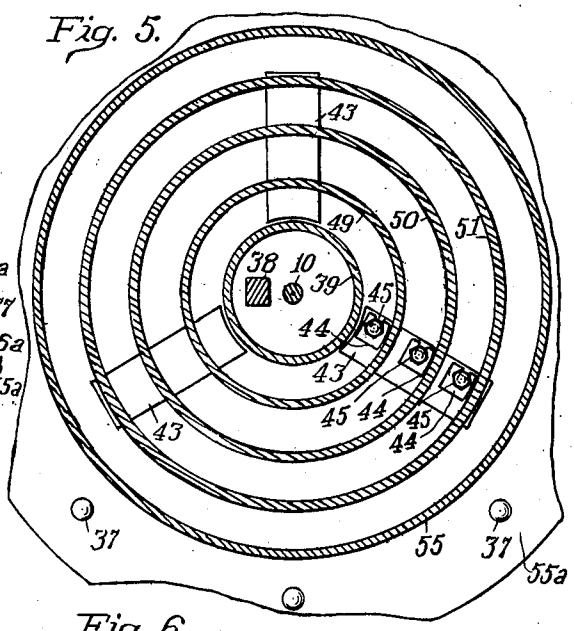
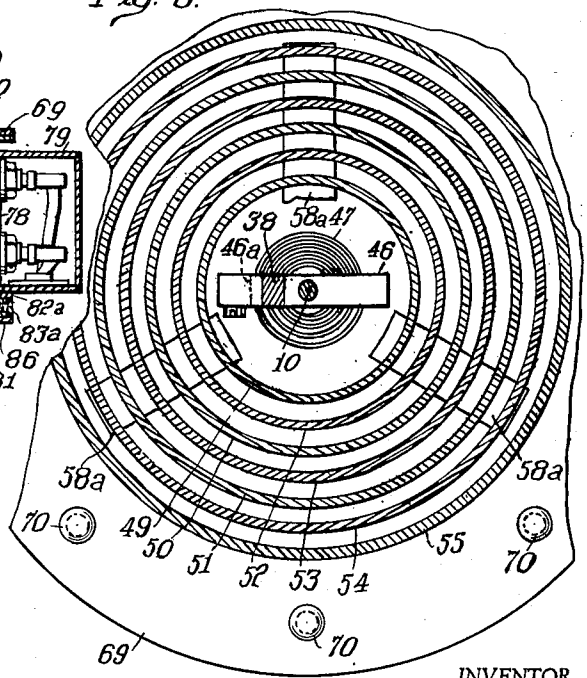


Fig. 6.



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VISCOSIMETER

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Fig. 2

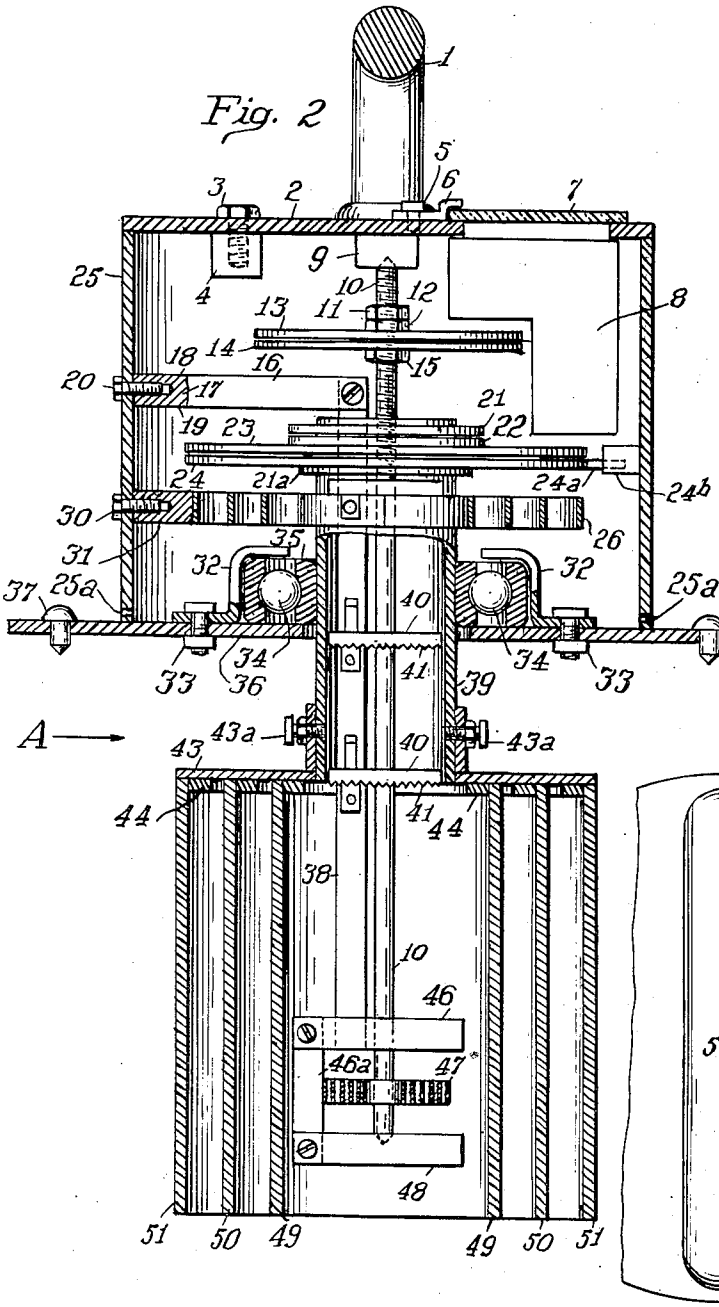


Fig. 9.

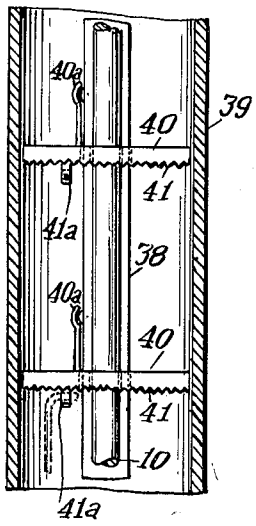
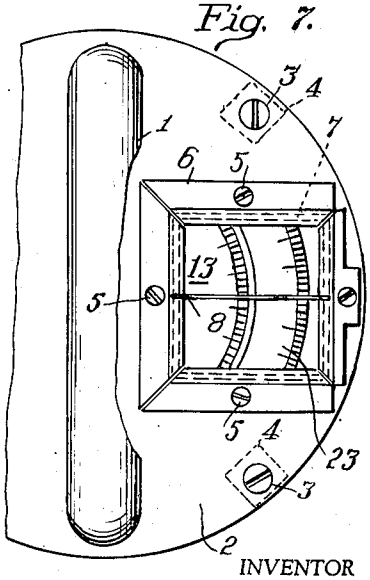


Fig. 7.



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VISCOSIMETER

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Fig. 3.

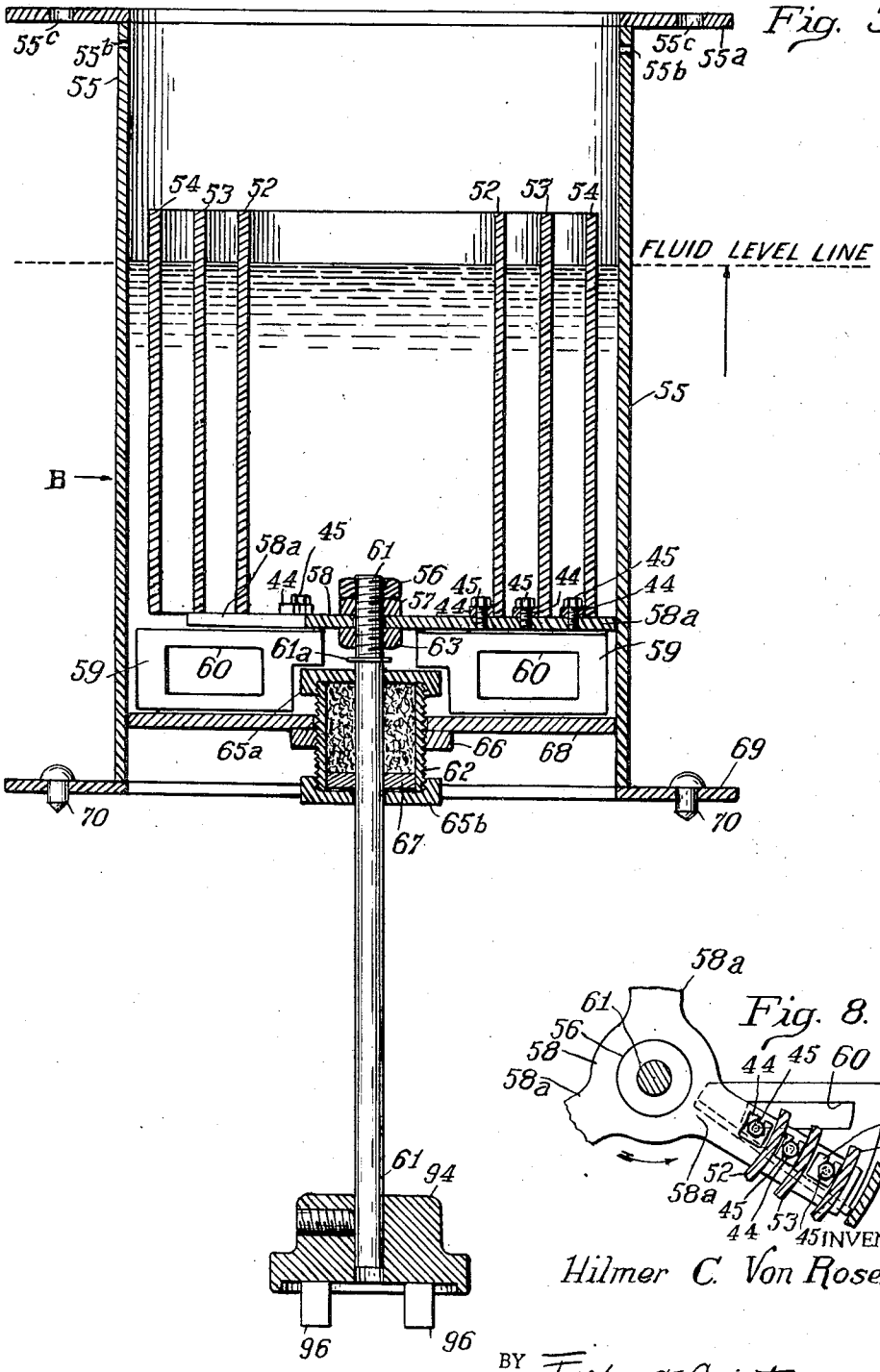


Fig. 8.

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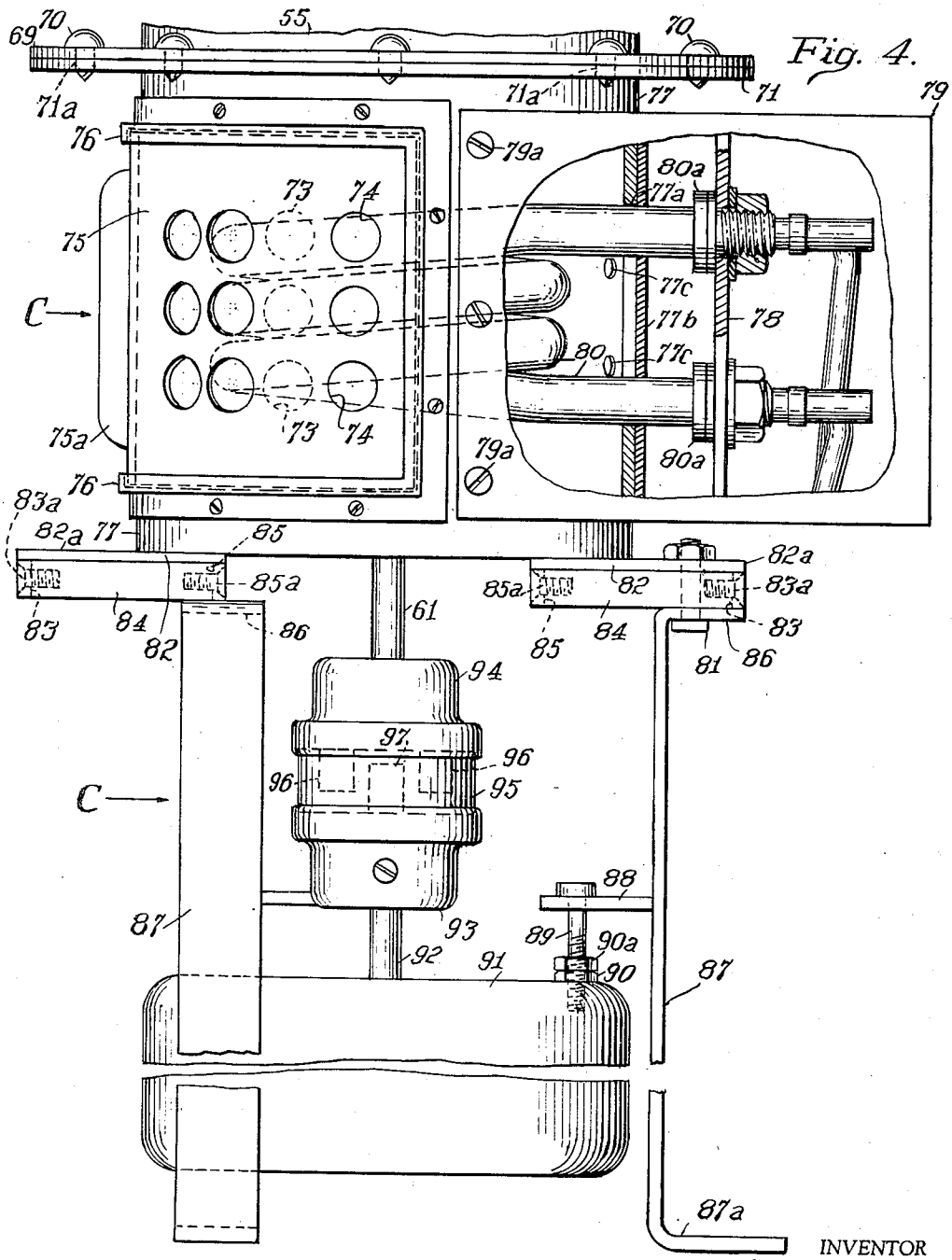
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Fig. 4.



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VISCOSIMETER

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Fig. 4A.

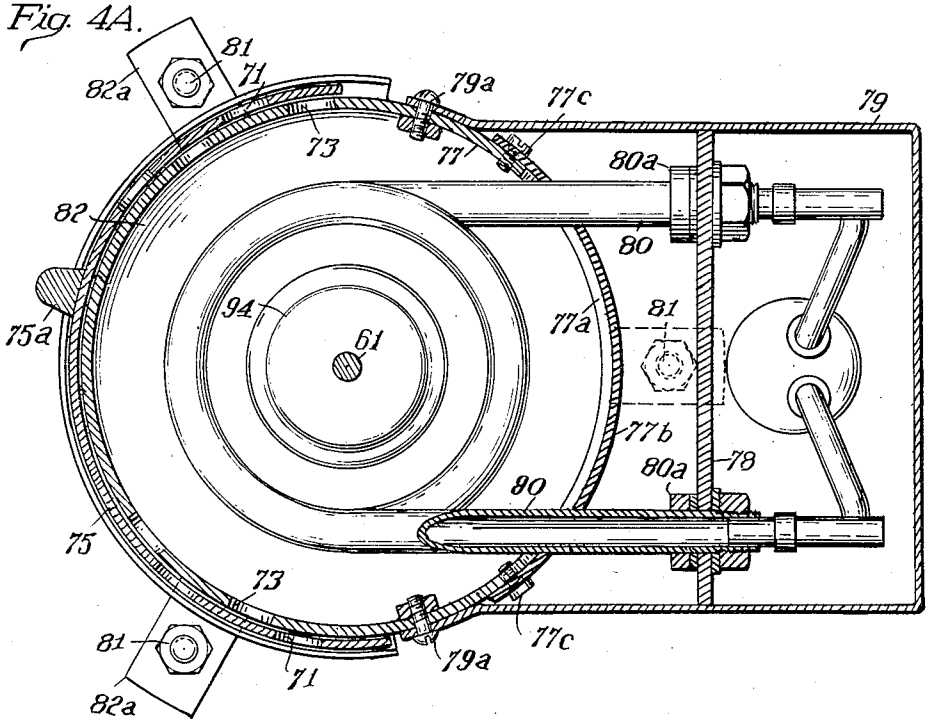


Fig. 3A.

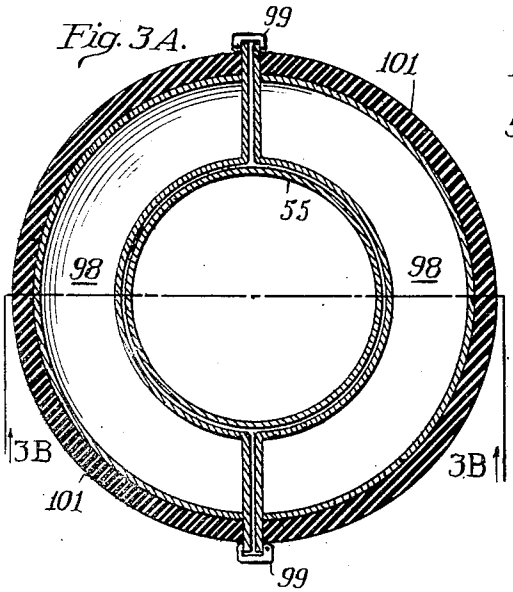
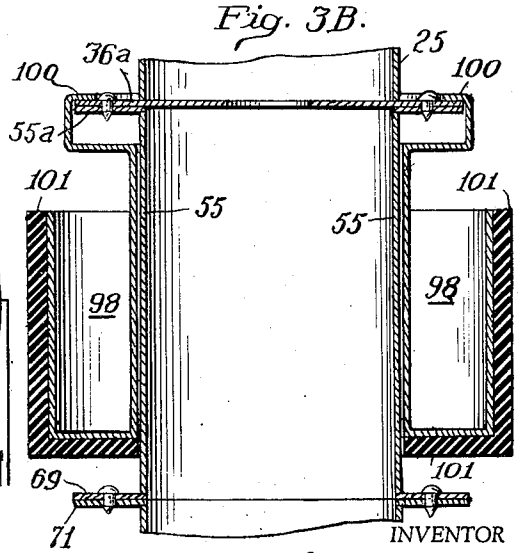


Fig. 3B.



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United States Patent Office 2,828,621 Patented Apr. 1, 1958

2,828,621

VISCOSIMETER

Hilmer C. Von Rosenberg, San Antonio, Tex.

Application October 28, 1953, Serial No. 388,796

17 Claims. (Cl. 73—59)

This invention is an instrument, generally known as a viscosimeter or viscometer, for measuring the viscosity of fluids.

The principal objects of the invention are:

(1) To provide a viscosimeter which is compact, rugged and readily portable so it can be used on the job or in the field by a person of ordinary training or skill.

(2) To provide a viscosimeter which will quickly and accurately indicate the viscosity of fluids at different temperatures. Heating means are provided for heating fluids to various temperature levels above atmospheric. Cooling means are provided for cooling fluids to various temperature levels below atmospheric.

(3) To provide a viscosimeter wherein one or more driving cylinders, mounted at the bottom, are interrested or meshed with one or more driven cylinders, suspended at the top, said driving and driven cylinders being partially immersed in a fluid being measured and wherein one or more driving cylinders set the fluid in rotation; the viscosity of the fluid causes one or more driven cylinders to rotate. The driven cylinders are attached to the lower end of a torsion tube while a torsion spring is attached to the upper end of this tube, said spring acting to counter-balance the force due to the viscosity of the fluid being measured. Therefore, the angularity of the tube twist is a function of the viscosity, at a given temperature.

(4) To provide a viscosimeter having two dials, or the like, each with a detachable scale-face and being positioned so that both scales may be read simultaneously. The top scale is graduated in temperature units and the lower scale is graduated in viscosity units.

(5) To provide a viscosimeter whereby the temperature and viscosity scales position themselves automatically during a testing cycle over a temperature range. Time in seconds for reference purposes is not a function in this invention. The instrument embodies means for rapid or slow heating or cooling of the fluid. The time used by an operator will depend upon his choice of manipulating the heating or cooling arrangements.

(6) To provide a viscosimeter consisting of three main units or assemblies which may readily be put together into operating relationship and which also may readily be separated, one from the other, for placing and removing fluids, for varying the number of cylinders to be used, changing thermometer or torsion springs of different ranges or ratings respectively and other reasons as the operator may choose.

These three assemblies are:

A. An upper assembly having a cylindrical housing, a top disk and a bottom disk inclosing one or more driven cylinders concentrically spaced and suspended from radially extended arms attached to a torsion tube working against a torsion spring. The angular displacement of the torsion tube supporting a scale indicates the viscosity. Also inclosed is a thermometer assembly with a scale, indicating temperature. Both scales are positioned to be read simultaneously through a sighting window in the top disk.

B. A central assembly having a cylindrical housing, open at the top and closed at the bottom, surrounding one or more driving cylinders concentrically spaced and mounted on radially extending arms fastened to a driving shaft having a coupling-half at its lower end. Propeller or agitator blades are attached to and below the arms and curved upwardly so as to clear a hot-plate fastened in a leak-proof manner near the lower end of the housing. A bushing unit, concentrically located in the hot-plate, allows the drive shaft to rotate in a leak-proof manner.

C. A lower assembly comprising an electric heater for varying the temperature of the fluid as desired and a motor having a drive shaft for detachable coupling with the drive shaft of the central assembly. Legs are provided for supporting the motor as well as the instrument when all assemblies are placed in an operative position.

(7) To provide a viscosimeter wherein one or more driving cylinders in the central assembly may be combined in various combinations with one or more driven cylinders in the upper assembly, thereby developing an instrument having a wide operative range, depending on the number of driving and driven cylinders used and depending on the positioning of the cylinders on their respective arms.

(8) To provide a viscosimeter wherein torsion springs of different torque limits, in one turn, may be used. Also wherein thermometer springs of different temperature ranges may be used. These features, in conjunction with heating and cooling arrangements, as well as various cylinder combinations, gives this instrument a unique advantage for covering a wide range in measuring fluids of widely different viscous characteristics over a wide range of temperature.

(9) To provide a viscosimeter wherein major parts, such as the motor, the heater coil and the ball-bearing unit are of standard design. Parts, such as the torsion and the temperature springs, are to be of proven quality to assure longevity and repeated accuracy.

More specifically:

The viscosimeter of this invention is preferably termed a Visco-Thermo-Scope, having VTS units.

Chambers' Technical Dictionary defines a viscometer as: "(Phys.) An instrument for measuring viscosity." Continuing "many types of viscometers employ Poiseuille's formula (q. v.) for the rate of flow of a viscous fluid through a capillary tube." Said reference defines viscosity as: "(Phys.) Internal friction due to molecular cohesion in fluids . . . Viscosity varies inversely with temperature."

As a result of research, the inventor concludes that numerous erroneous conceptions exist, regarding instruments in this category. Even though this invention is primarily presented as outlined in paragraph #1 above, it has been observed that numerous skilled technicians and engineers deviate from basic information concerning the types of viscometers. In order to assist in clarifying the situation, the following condensed information from Encyclopedia Britannica is being offered wherein condition No. 2 is the fundamental principle upon which this invention is based.

Condition No. 1.—Two indefinitely extended parallel plates between which a liquid is contained and that the upper plate moves with a constant velocity in a direction of its own plane while the bottom plate remains in a fixed position.

Condition No. 2.—Two parallel plates may be rolled up so the two parallel plates will become two concentric cylinders having a liquid between them and that the outer

cylinder rotates at a constant velocity while the inner cylinder remains at rest or in a fixed position.

Condition No. 3.—By allowing a liquid to flow through a cylindrical tube of small bore and sufficient length, as long as the velocity does not exceed certain limits.

Condition No. 4.—By observing the velocity of a small sphere of known diameter and mass as it falls into a liquid.

In 1842, Poiseuille published the law governing the flow of liquids or fluids through capillary tubes, as found in classical investigation. He did not deduce coefficients of viscosity. This was done later by several physicists who treated the problem mathematically by working out the conditions of flow and then followed by integration. Thus, Poiseuille's investigation was later developed into a formula, wherein the coefficient of viscosity is expressed in centimetre-gramme-second units. This coefficient equals 1.000 in these units and is known as a poise and its hundredth's part is known as a centipoise (in honor of Poiseuille).

The invention in its simplest form comprises: A container with fluid wherein is immersed a driving cylinder mounted on a vertical axis directly connected to a constant speed motor and wherein is also immersed a vertical concentrically positioned driven cylinder suspended from arms attached to the lower end of a torsion tube held in a vertical position in an anti-friction bearing housing. To the upper end of the torsion tube is affixed a torsion spring as well as a torsion scale disk. Temperature being an important factor in viscosity measurement, a thermometer, preferably of the torsion type, has its spring placed in the fluid and a scale disk positioned adjacent the torsion scale. Fluid heating and cooling means are provided. Thus, as the motor drives the driving cylinder, due to adhesion of the fluid to the cylinder surface, the fluid molecules, because of cohesion, cause the fluid to attain a vertical rotary movement. Thus again, the fluid portion in contact with the suspended cylinder and because of adhesion causes said cylinder to tend to rotate. This tendency of the suspended cylinder to rotate is checked during a part of a full turn by a torsion spring of appropriate capacity, such angle being indicated on the scale face being a function of the viscosity at atmospheric temperature. By heating means the temperature may be raised above atmospheric and by cooling means it may be lowered below atmospheric temperature. The two scales being adjacent, they may be read simultaneously through a sighting window in the top of the instrument.

The angular displacement of the suspended (driven) cylinder is directly dependent upon such factors as the speed of rotation of the motor, the sizes of the respective cylinders, the temperature of the fluid at the moment of the test as well as the space between the cylinders and the respective number of cylinders in use. The term "thermometer," as used herein in its broad sense, is used to cover any suitable type of temperature measuring device, such as; a thermo-couple, expensible fluid type or any other type of thermometer.

Further details of structure and operation will be set forth in the following detailed description of the invention, wherein:

Figure 1 is a vertical cross section of the viscosimeter of the present invention,

Figure 2 is a vertical cross section, on a larger scale, of the upper assembly or upper portion of the viscosimeter,

Figure 3 is a vertical cross section of the central assembly or central portion of the viscosimeter,

Figure 3A is a horizontal cross section of a modification, showing a cooling jacket,

Figure 3B is a vertical cross section on line 3B—3B of Figure 3A,

Figure 4 is a vertical cross section of the lower assembly or lower portion of the viscosimeter,

Figure 4A is a horizontal cross section of Figure 4, taken just above the heating coil,

Figure 5 is an enlarged sectional view looking upwardly on line 5—5 of Figure 1,

Figure 6 is an enlarged sectional view looking downwardly on line 6—6 of Figure 1,

Figure 7 is an enlarged plan view of a portion of the top of Figure 1.

Figure 8 is an enlarged sectional view, on line 8—8 of Figure 1, showing a propeller or agitator blade and three detachable driving cylinders,

Figure 9 shows an enlargement of part of Figure 2 for affixing condensation traps, being a view from the right.

DESCRIPTION OF CONSTRUCTION

Upper assembly A

This assembly, designated generally at A, Figures 1 and 2, comprises a cylindrical housing **25**, a top disk **2**, a bottom disk **36** and a handle **1**. Bottom disk **36**, being greater in diameter than cylindrical housing **25**, provides an annular flange **36***a* to which is fastened positioning pins **37**. A torque transmitting tube **39** is press-fitted or otherwise vertically positioned on the inner raceway **35** of a ball bearing assembly, including balls **34**. Raceway **35** is concentrically placed on bottom disk **36** and held thereon with sectional braces **32** and bolts **33**. An opening is provided in bottom disk **36**, reserving enough surface to support the bearing assembly. Viscosity scale face **23** and disk **24** are properly positioned on tube **39** by means of nuts **21** and **21***a* with lock washers **22**. Scale face **23** will be graduated in viscosity units within a range of 360 angular degrees. To prevent the tube from being turned over this limit, scale disk **24** is provided with a stop pin **24***a*, adapted to strike a fixed abutment **24***b*, thereby indicating that the torsion spring **26** should be replaced by one of a higher torque rating. The inner end of the torsion spring **26** is fastened to tube **39** while the outer end is fastened to an arm **31** which is attached to housing **25** by bolt **30**. This spring may be of any desired metal or alloy having tenacious characteristics, preferably one little affected by changes in temperature, of a known type having self temperature compensating characteristics.

To the lower end of torque transmitting tube **39** is secured, as by set screws **43***a*, radially extended arms **43**. Suspended from these arms **43** and detachably secured thereto by means of supports **44** and **45**, shown in Figure 5, is one or more driven or follower cylinders **49**, **50** and **51**, concentrically positioned. The fact that these cylinders **49**, **50** and **51** are readily attachable and detachable enables the operator to use one, two, three or more cylinders, as desired. When these driven cylinders are immersed in and subjected to rotary fluid, torque transmitting tube **39** is twisted against torsion spring **26** to turn the viscosity scale **23** through an angle proportional to the viscosity of the fluid at a particular temperature. This angular displacement of scale **23** is affected by or is directly proportional to such important factors as: changes in torsion spring ratings or torques; changes in the speed of rotation of the motor; changes in the length or height or diameter of the follower cylinders; changes in the length or height or diameter of the driving cylinders; changes in the space between the driving and the follower cylinders; and changes in the amount of fluid placed in the container housing **55** of Figure 3.

In order to measure temperature, a thermometer in the form of a thermally responsive spiral spring **47** is provided, the inner end of which is fastened to thermometer shaft **10**, and the outer end of which is fastened to a vertical arm **46***a* supporting a horizontal arm **48** having a conical seat for positioning shaft **10** and allowing it to turn. Spring **47** is of an alloy and of a size to have an operating range appropriate to the temperature range

desired. Furthermore, this spring, as well as other parts coming in contact with acid-containing fluids, may be plated to prevent corrosion, etc. These springs having a narrow width or height, as well as a relatively small overall diameter, may be placed one above the other and all ranges fastened to thermometer shaft **10** and the vertical arm **46***a*. The upper end of thermometer shaft **10** is rotatably mounted in a block **9**, functioning similarly to horizontal arm **48**. Shaft **10** carries a disk **14** to which is attached a scale face **13**, calibrated in temperature units. Scale **13** and disk **14** are securely positioned on shaft **10** with nuts **11** and **15** and lock washer **12**.

Thermometer spring **47**, support **46***a* and support **48** are suspended from horizontal arm **46** which is fastened to a vertical supporting bar **38**. This bar passes up through and out of torque transmitting tube **39** and is positioned in a fixed manner to freely clear shaft **10** and torque transmitting tube **39**. The upper end of supporting bar **38** is attached to a horizontal arm **16** which is held in position by preferably being welded to three braces **17**, **18** and **19** to assure firm support against strains up or down or sideways, said three braces being fastened to housing **25** by means of bolts **20**. Fig. 6 shows a plan view of thermometer spring **47** and brackets or arms **46**, and **46***a*, together with other details.

Figure 9 shows condensation disks **40** in torque transmitting tube **39** and having spring clips **40***a* riding over a burr or catch on supporting bar **38**. Properly spaced openings in these disks allow them to move freely up or down for cleansing purposes when moved by a curve tipped wire or the like to fit in an eyelet **41***a* at the bottom of the disk. At the bottom of the disks **40**, knurled or otherwise roughened surfaces **41** are provided to collect condensed vapors. If sweating occurs in housing **25**, apertures as at **25***a* may be provided for temperature balances or to serve as a drain for such condensation, if necessary.

Several blocks **4** are preferably welded to housing **25**, as shown in Figure 7.

Bolts **3** hold top **2** to these blocks.

A sighting window **7** in top **2** is shown enlarged in Fig. 7. A glass pane or the like **7** extends over the opening in top **2**. Part **7** is secured in position by guards **6** and bolts **5**. A sighting vane **8**, as in Figure 2, is shown in Figure 7 as a guide for the observer in reading the graduations on the viscosity scale **23** and the thermometer scale **13**, both being readable simultaneously. The viscosity scale **23** is graduated preferably for 1440 (4×360 angular degrees) VTS units, being empirical, while the temperature scale **13** is graduated preferably through 360 angular degrees from −50° F. through 750° F.

Central assembly B

This assembly Figure 3, designated generally at B of Fig. 1, comprises a cylindrical open topped fluid housing **55**, having upper and lower annular flanges **55***a* and **69**, respectively. The upper flange **55***a* is provided with registering holes **55***c* to receive positioning pins **37** of Figure 2 of the upper assembly. The lower flange **69** carries securely fastened positioning pins **70**. A bushing unit comprises the following combination: a suitable section **62** of bushing stock, threaded on the outside, is screwed into an opening at the center of disk **68**, which might be termed a hot-plate, and is shown relatively thin for this purpose for reasons explained later herein; a threaded cap **65***a*, having a central opening to clear shaft **61** is screwed on upper end of bushing **62**; an interiorly-threaded ring **66** is screwed up on bushing **62** to rigidly hold the bushing in hot-plate **68** which is positioned in housing **55** in a manner to be leak-proof. Packing material fills bushing **62** and around shaft **61**. Cap **65***b*, similar to cap **65***a*, except having knurled edges, serves to press a packing ring **67** against the packing. Adjustment for compression of packing against shaft **61** may be made by hand-checking free movement of shaft **61** while cap **65***b* is properly positioned for the amount of packing used to assure a leak-proof fit.

On the upper end of shaft **61** is positioned radially extending arms **58***a*, being secured by nuts **56** and **63** and lock washer **57**. When this assembly is not in an operating position, shaft **61** and its attached parts would not necessarily remain in a fixed position in the bushing unit because in handling this assembly, the weight of cylinders and the coupling-half would tend to make it slidable through the packing, through which it normally rotates freely. Therefore, a shallow groove is provided in shaft **61**, into which is fitted an expansible spring-type clip as **61***a*, thus limiting the movement of shaft **61**.

The radially extended arms **58**a carry one or two or three or more— three being shown—concentrically spaced driving cylinders **52**, **53** and **54**, preferably detachably secured to arms **58***a* as by means of securing clips or brackets **44** and bolts **45**, shown enlarged in Figure 8. The fact that the cylinders **52**, **53** and **54** are readily attachable and detachable enables the operator to use one, two, three or more cylinders, as desired. This figure also shows one of several arms to the underside of which is secured an angled propeller or agitator blade **59**, having an opening **60** in the curved portion of the blade to retard the possible effects of eddy currents which may occur in some instances. Such openings would be standard for the assembly.

To the lower end of shaft **61** is attached a coupling-half of standard design indicated as **94**, having two prongs as **96**. A recess is provided for a regular insert, but for this invention a heat insulating insert would be used to retard heat transfer along the shaft **61** from the heater coil to the motor shaft, as described later.

At the upper end of housing **55** is provided one or more apertures **55***b* for pressure relief, etc. as previously referred to. A fluid level line to be marked in the same location for all central assemblies.

Lower assembly C

This assembly, designated generally at C, Figures 1 and 4, comprises a cylindrical housing **77** with an open top, having an annular flange **71** at the upper end with registering holes **71***a* to receive positioning pins **70** of the central assembly B. Housing **77** incloses the heat generating portion of an electrical heating coil **80** of the "calrod" type, where the heat generating portion of the coil is about 17 inches inward in this selected type. An additional housing **79** is affixed to housing **77** by means of bolts **79***a* so it about halfway covers housing **77**. In standard design of the heater unit, its shoulder **80***a* is straight, therefore, to simplify its secure positioning, a vertical partition **78** is provided in housing **79**. In order to place coil **80** in housing **77**, such housing may be provided with an opening **77***a*, this opening being closed, after the coil is in place, by a detachable filler **77***b* provided with passages for the two ends of coil **80**. Filler **77***b* is fastened to housing **77** by bolts or screws **77***c*. Heater coil **80** is primarily supported by partition **78** of Fig. 4A, by nuts and washers, and coil shoulder **80***a*, but it will receive extra support by the bottom of the passage opening in filler **77***b*. In addition to securely positioning the heater ends, housing **79** serves as a guard for the operator preventing contact with "live" terminals and protects the terminals against mechanical injury and provides a suitable location for positioning the heater and the motor switches. Conventional electrical connections will be used to supply power to the heater, coil **80** and the motor **91**. The heater is designed so that extra electrical insulating for the coil is unnecessary.

To the remaining portion of housing **77** a damper arrangement is applied for covering and uncovering holes **73** in housing **77**. Near the outer edge of this perforated

area, is placed sections of guides **76** (illustrated as solid) under which is placed a curved plate **75** conforming to the curvature of housing **77**. Plate **75** has holes **74** of the same size and pattern as the holes **73** in housing **77**, so when plate **75** is manipulated "to and fro" by handle **75***a*, a damper effect is attained by bringing holes **74** and **73** either in or out of registration. Thus, the operator may hasten heating time or lessen cooling time of the fluid, after the heater switch has been opened.

To the lower end of housing **77** is attached a disk **82**, having a concentric opening and an extension in the form of an annular flange **82***a*. Below disk **82** is placed a heat insulating disk **84**, shaped similar to disk **82**, except having a slightly smaller diameter to permit an inner protecting ring **85** and an outer protecting ring **83**, each being held in position by means of bolts **85***a* and **83***a*, respectively, with rings fitting flush with disk **82**. The openings in disk **82** and disk **84** permit suitable space for passage in and out for the coupling-half **94** of the central assembly.

All structures above disks **84** and **82** are supported by legs **87**, having an upper flange **86** and a lower flange **87***a* or the like. Bolts **81** with nuts are placed to rigidly hold parts **82**, **84** and **86** in position. A motor **91**, preferably of the synchronous (constant speed) type, having a speed, in this instance, of 75 R. P. M. and a normal load torque of 75 ounce-inches continuously, is suspended in a vertical position from legs **87**. Arms **88**, attached to legs **87**, support bolts **89** which are screwed into the motor body in a manner so the vertical axis of the motor shaft **92** will be concentric with all assemblies when in an operative position. Bolts **89**, nuts **90** and locknuts **90***a* assist in retaining adjustment. The motor being relatively heavy in relation to other parts results in a low center of gravity of the instrument, thereby providing ample stability of the instrument. Shaft **92** of the motor carries, at its upper end, a quick detachable coupling-half **93**, comprising a heat insulating disk **95** having recesses in its bottom to fit over prongs **97**. Disk **95** is cemented, or otherwise permanently affixed, to coupling-half **93**. Insulating disk **95** also has recesses in the top to receive prongs **96** of the central assembly coupling-half **94**. Inserts are to be placed in top recesses to decrease wear and tear. Top and bottom recesses are positioned only part way into disk **95** and no opening is provided for either shaft **61** or **92**, as they fit with ample space into their respective coupling-halves. If electricity is not available in remote regions, other means of heating and driving may be substituted instead. Shaft **61** and legs **87** will be of a length sufficient to avoid excessive transfer of heat downward toward the motor.

PRELIMINARY INSTRUCTIONS FOR OPERATING

(1) *Introduction.*—It is intended that this invention, as one unit of three assemblies or bodies, shall have means for testing for viscosity of fluids slightly more viscous than water up to and including such viscous matter as gums, tars, etc. over a wide range of temperature. This is possible by using, as previously referred to for structural and descriptive purposes, a motor, one or more driving and driven cylinders, one or more torsion springs, one or more temperature springs, a heating means, and a cooling means. In order to assist the operator in obtaining the wide coverage referred to, specific examples will be outlined which will not, however, be considered to be fixed limitations for this invention.

(2) *Motor.*—The motor to be of the constant speed type (synchronous), rated at 75 ounce-inches, having a speed of 75 R. P. M. and operating at 115 volts, single phase and for 60 cycles, A. C. and to be mounted in a vertical position.

(3) *Cylinder combinations.*—Referring to Figures 1, 2 and 3, illustrating three driving and three driven cylinders, detachably secured in place, the following combinations are mechanically possible:

a. Driving cylinder **52** with driven cylinders **49**, **50** or **51**, separately; with both **49** and **50**, with both **49** and **51** or with both **50** and **51**.
b. Driving cylinder **53** with driven cylinders as in "*a*."
c. Driving cylinder **54** with driven cylinders as in "*a*."
d. Driven cylinder **49** with driving cylinders **52**, **53** or **54** separately; with both **52** and **53**; with both **52** and **54** or with both **53** and **54**.
e. Driven cylinder **50** with driving cylinders as in "*d*."
f. Driven cylinder **51** with driving cylinders as in "*d*."

Thus, by the mentioned examples, 49 combinations are feasible on the basis that the following conditions are fixed; cylinder lengths, cylinder diameters, space between cylinders, a fluid level line and a constant speed motor. It is obvious that this instrument by design for flexibility, should be applicable for an innumerable number of industries, and as just mentioned that various changes could make it still more flexible.

(4) *High torque tension springs.*—Referring to Figs. 1 and 2, it is presumed that the friction in the packing and the ball bearing unit is nil, at least whatever friction exists will be repeated and constant and therefore is ignored in this design, meaning that 75 ounce-inches are delivered to the torsion shaft if a driving cylinder and a driven cylinder are in a locked position. Assume a torsion spring of 80 ounce-inches (the motor being capable of such overload) to be affixed to the torsion tube. Assume a molten mass at a known temperature to have enough viscosity to cause the torsion tube to twist through 360 angular degrees, then the 1440 or 1439 VTS units will be the viscosity of the fluid or mass by this viscosimeter under the condition of this spring and the cylinders in use.

(5) *Low torque torsion springs, referring to Figures 1 and 2.*—This spring rating could be as low as a "hair spring" or less. For example, a 1 ounce-inch rating will be considered, meaning that at an angular movement of 360 degrees stop-pin **24***a* will be caused to abut arm **23***b*. Thus with the three illustrated driving and driven cylinders (or more of each spaced closer together, etc.) and a very low torsion spring, this invention should be able to indicate viscosities of fluids having very little viscosity at high temperature levels. The 1 ounce-inch rating was referred to here to apply to item No. 6.

(6) *Temperature springs, referring to Figure 2.*—Thermometer springs will vary in overall diameter and thickness and face widths for temperature ranges from —50° F. to 100° F. or from 60° F. to 750° F., as could be examples for these instructions. Part **46***a* may have extended arms of different lengths to support the outer end of such different springs. Thus, various suitable parts as **46***a* may be affixed to parts **46** and **48** by bolts or screws, as shown.

(7) *Cooling method.*—Where it is desired to test the liquid at temperatures below atmospheric, a cooling jacket is provided around the fluid container **55** of Fig. 3, as shown in Figs. 3A and 3B, which figures omit the interior features of container **55**. This cooling jacket is in the form of two semi-cylindrical annular troughs **98**, latched together by any suitable latches **99**, so that the troughs may readily be removed or applied, as desired. The inner walls of the two trough parts **98** are extended upwardly and provided with inturned flanges **100**, which engage over flange **36***a* of Fig. 2 to support the parts **98** of Fig. 3B. The trough parts **98** may be filled with coolerants, such as ice and salt, or Dry Ice. Dry Ice is capable of reducing the temperature to approximately —110° F. and would require close observation and careful handling. Therefore, the outer walls and bottoms of each trough **98** are insulated with an appropriate material **101**.

(8) *Thermal equilibrium and readings at intervals.*—

This invention is designed to have the minimum of "residual" heat or cold. Agitator or propeller blades, together with rotating driving blades and moving fluid, should result in a quick movement of the normally hot fluid at the bottom toward the normally cooler fluid at the top. It is presumed that the thermometer spring can be positioned in conjunction with the size and shape of the agitator blades in a manner so readings at "thermal equilibrium" (stationary scale positions) will be in accord with readings taken intermittently. This being true, the operator will only be concerned with intermittent readings. Otherwise, instructions will be given which are not relevant to these specifications.

(9) *Retainer rings.*—Retainer rings, two each, will be provided to be clamped around annular flanges, for example, to readily permit portability of the instrument.

(10) *Electrical load.*—The heater, in this instance, is rated for 500 watts and the motor at less than 100 watts, so both may safely be connected to terminals of the usual No. 12 house wiring circuits.

OPERATING PROCEDURE

Heating method

(1) Motor and heater switches are in the open position while the damper is in the closed position.

(2) Place central assembly B on the lower assembly C.

(3) Fill the central assembly housing with fluid to the marked level line.

(4) Place the upper assembly on the central assembly. Through the sighting window, observe that the temperature scale indicates atmospheric temperature, while the VTS scale is at the zero position.

(5) While sighting through the window and upon closing the motor switch, observe that the temperature scale remains stationary while the VTS scale rapidly takes a position to indicate the viscosity of the fluid under test for atmospheric temperature. Thus, reading No. 1 is established and is to be recorded, giving reference to the torsion spring number and the designations of the cylinders in use.

(6) With the motor operating continuously throughout the test, the heater switch is now closed. From here on to the highest desired temperature level, the operator has no further duties other than to read and record readings Nos. 2, 3, etc., readings being made simultaneously.

(7) Open the heater and the motor switches and the test cycle may be considered completed for routine test.

(8) However, if more readings are desired for a smoother curve, open the heater switch and the damper and additional readings may be taken at intervals during the cooling cycle. Opening the motor switch will conclude the testing.

Cooling method

Note: Follow the procedure for establishing reading No. 1 for the heating method.

(6) with the motor operating continuously throughout the test, place the cooling jacket around the container. Observe through the window that the VTS units gradually increase while the temperature units gradually decrease.

(7) Undoubtedly the operator will refer to the Selection Chart for information.

(8) Proceed with interval readings Nos. 2, 3, etc.

(9) Having reached the minimum desired temperature, the operator may remove the jacket and continue readings back to atmospheric, if desired.

While the invention has been described in considerable detail, it should be understood that the invention is not to be limited to the construction shown, but may be carried out in other ways.

I claim as my invention:

1. A viscosimeter comprising in combination a liquid container, a driving cylinder in said container, a motor for driving said driving cylinder, a follower cylinder suspended in said container adjacent said driving cylinder and coaxial therewith, means, including a torque transmitting tube, for mounting said follower cylinder for limited rotational movement, a spring for resisting the rotational movement of the follower cylinder, a calibrated dial carried by the torque transmitting tube, a thermometer including a shaft and a thermally responsive spring for immersion in the liquid, said thermometer shaft extending upwardly through said torque transmitting tube, and a calibrated dial carried by the upper part of said thermometer shaft.

2. The combination of claim 1 wherein said two calibrated dials are of different diameters, are superposed and concentrically mounted and so are simultaneously readable.

3. The combination of claim 1, further including a sighting vane positioned closely adjacent both said dials for simultaneous reading thereof.

4. The combination of claim 1 wherein said motor has a shaft which is coaxial with the axes of the driving and follower cylinders and passes vertically through the bottom of said container.

5. The combination of claim 1, further including an agitator blade in said container positioned below both said cylinders and coaxial therewith and driven by said motor.

6. The combination of claim 1 further including an electric heater positioned between motor and said liquid container.

7. The combination of claim 1 wherein said motor has a shaft which is coaxial with the axes of the driving and follower cylinders and further including an electric heater coil located below said liquid container and encircling said motor shaft.

8. A viscosimeter comprising a central body portion including a liquid container, a driving cylinder in said body portion, and a driving shaft for said driving cylinder; and a readily separable upper body portion comprising: a follower cylinder, a torque transmitting tube for suspending the follower cylinder in coaxial and adjacent relationship with the driving cylinder, a calibrated dial carried by said torque transmitting tube, spring means for resisting rotation of the follower cylinder, a thermometer including a shaft and a thermally responsive spring for immersion in the liquid in the container, said thermometer shaft extending upwardly through the torque transmitting tube, and a calibrated dial carried by the upper part of the thermometer shaft, the upper part of central body and the lower part of said upper body portion being provided with juxtaposed flanges having matching apertures, positioning pins passing through said apertures, said upper body portion constituting a unitary assembly which may be applied to and removed from the central body portion as a unit and the operating elements thereof readily accessible for replacement and repair.

9. The combination of claim 8, further including an annular compartment around said housing for a cooling medium.

10. A viscosimeter comprising a liquid container, a plurality of concentrically mounted driving cylinders mounted in said container, a motor having a vertically extending driving shaft, said motor shaft being substantially coincident with the axis of said driving cylinders and connected thereto for rotating said cylinders, a plurality of concentrically mounted follower cylinders interleaved between the several driving cylinders and coaxial therewith, a torque transmitting tube above said follower cylinders for mounting said follower cylinders, spring means connected to said torque transmitting tube for resisting rotation of the follower cylinders, a thermometer including a thermally responsive spring for immersion in the liquid and a shaft operated by said thermal spring and extending vertically upwardly through said torque

transmitting tube, two calibrated dials carried respectively by said torque transmitting tube and said thermometer shaft and means for detachably securing said driving and driven cylinders in operative position, whereby said cylinders may be removed and replaced and assembled in various combinations for varying the number of driving and driven cylinders used.

11. The combination of claim 10 wherein said two calibrated dials are of different diameters and are superposed and coaxially mounted with respect to said cylinders and simultaneously readable.

12. The combination of claim 11 further including a sighting vane positioned adjacent and above said dials for reading them simultaneously.

13. The combination of claim 10, wherein said driving and follower cylinders are provided with transversely extending flanges, and detachable securing elements cooperating with said flanges whereby the several cylinders are readily removable and replaceable.

14. A viscosimeter comprising a liquid container, concentric, interleaved driving and follower cylinders of varying diameters of said container, a motor having a vertically extending shaft coaxial with respect to said cylinders and connected to the driving cylinders, a spring for resisting movement of said follower cylinders, said spring being concentric with the axis of said follower cylinders, an electric heating coil encircling said motor shaft below said liquid container, a housing around said heating coil and temperature regulating means cooperating with said housing, said temperature regulating means including air admitting apertures in the housing and a movable shutter provided with apertures to be brought into and out of registry with said apertures in the housing.

15. A viscosimeter comprising a liquid container, a plurality of concentrically mounted driving cylinders in said container, a motor having a vertically extending driving shaft passing through the bottom of the container and concentric with respect to said cylinders, for rotating said driving cylinders, a fluid tight bearing in the bottom of said container for accommodating said driving shaft, a housing mounted above the container, a plurality of concentrically mounted follower cylinders respectively interleaved between the several driving cylinders and coaxial therewith, torque transmitting means carried by said housing above said follower cylinders for suspending said follower cylinders from above in operative relation with the driving cylinders, a spring connected with said torque transmitting means and concentric therewith, for resisting rotational movement of said follower cylinders, and a dial operatively connected to the torque transmitting tube, for indicating the extent of movement of said follower cylinders, whereby said torque transmitting means, said housing with said spring and said dial and follower cylinders may be separated as a unit from the driving cylinders by vertical upward movement thereof without affecting the mounting of the lower driving cylinders.

16. The combination of claim 15 further including an electric heating coil below said liquid container and encircling said motor shaft.

17. The combination of claim 15 further including an agitator blade carried by said motor shaft and positioned in the bottom part of said container below all said cylinders.

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