H. CARMICHAEL & W. M. GROSVENOR.

APPARATUS FOR ASCERTAINING THE PROPERTIES OF FLUIDS.

APPLICATION FILED JULY 11, 1914.

1,192,861. Patented Aug. 1, 1916.

2 SHEETS—SHEET 1.

Fig. 1,

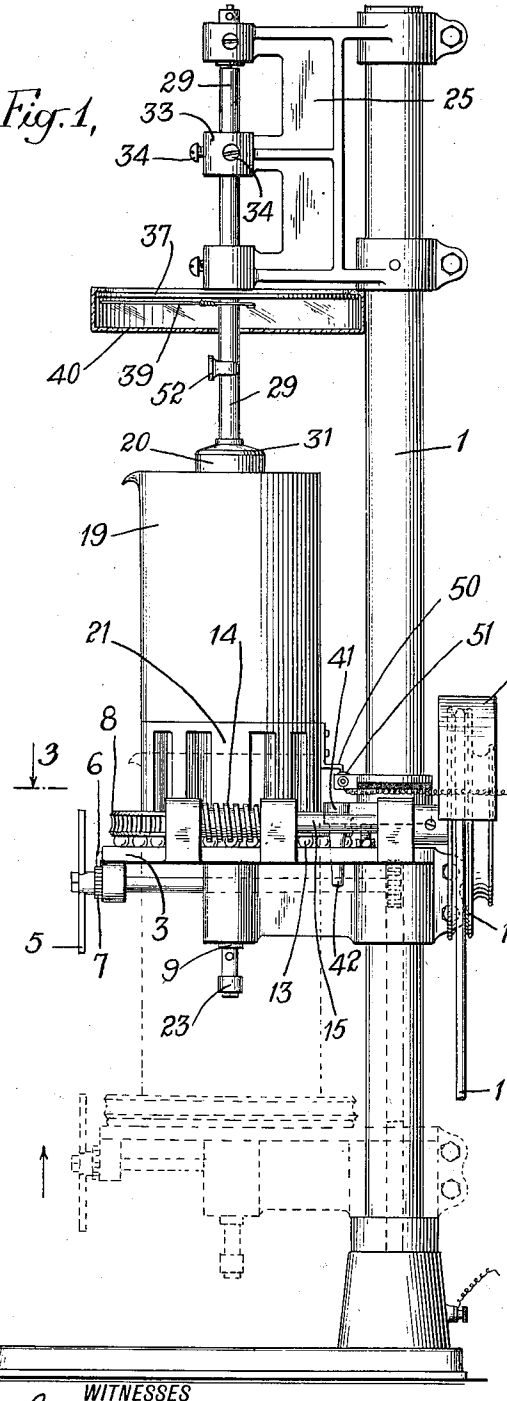
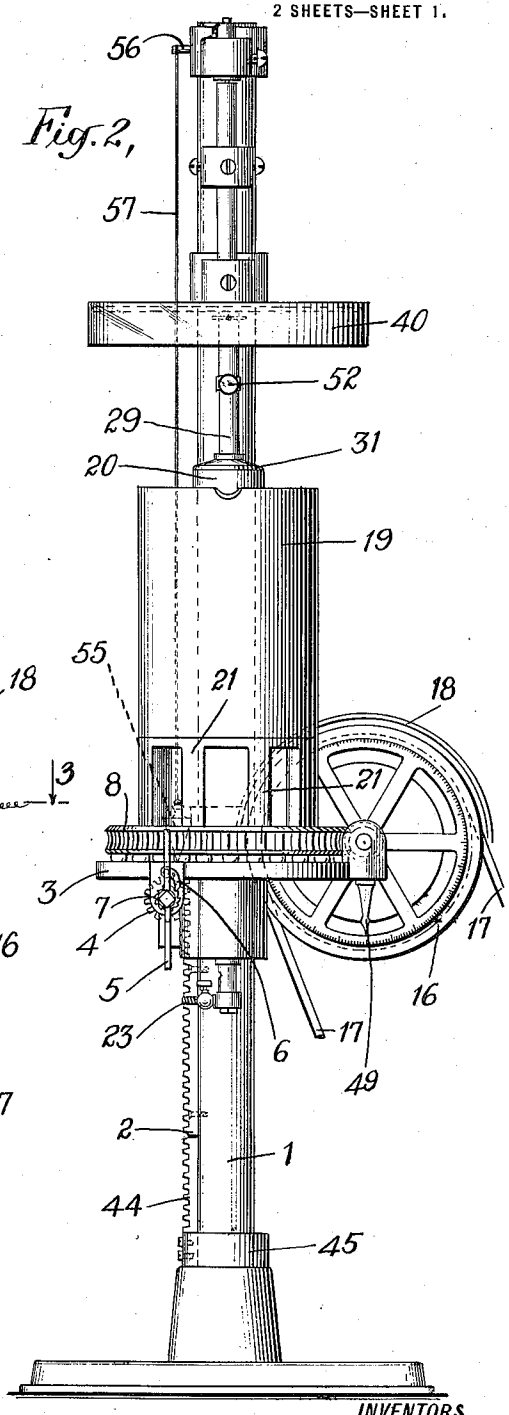


Fig. 2,



WITNESSES

Geo. M. Harris.

John O. Lempler

INVENTORS

Henry Carmichael

William M. Grosvenor

BY

Kenyon & Kenyon

ATTORNEYS

H. CARMICHAEL & W. M. GROSVENOR.

APPARATUS FOR ASCERTAINING THE PROPERTIES OF FLUIDS.

APPLICATION FILED JULY 11, 1914.

1,192,861.

Patented Aug. 1, 1916.

2 SHEETS—SHEET 2.

Fig. 4,

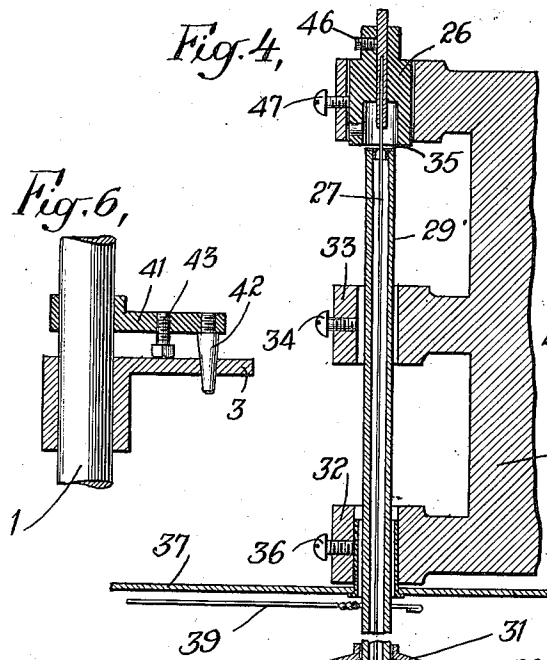
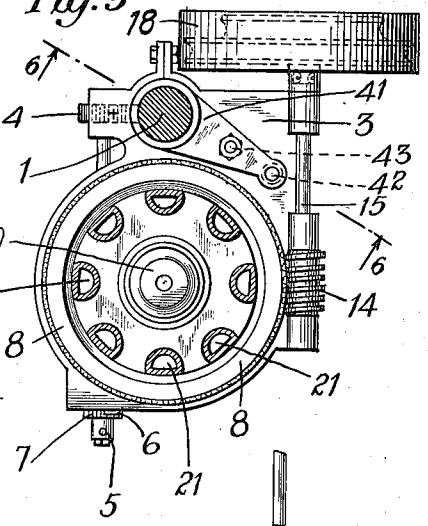


Fig. 6,

Fig. 3



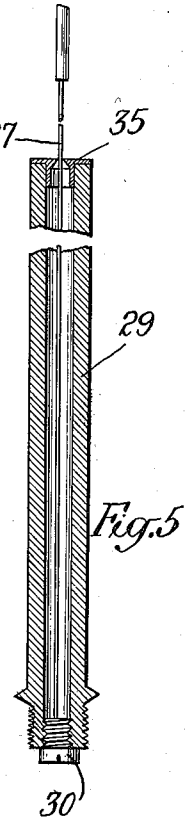


Fig. 5

WITNESSES

Geo. M. Davis

John O. Gunpler

INVENTORS

Henry Carmichael

William M. Grosvenor

BY

Kenyon & Kenyon

ATTORNEYS

UNITED STATES PATENT OFFICE.

HENRY CARMICHAEL, OF MALDEN, MASSACHUSETTS, AND WILLIAM M. GROSVENOR, OF RIDGEWOOD, NEW JERSEY, ASSIGNORS, BY DIRECT AND MESNE ASSIGNMENTS, TO PERKINS GLUE COMPANY, A CORPORATION OF PENNSYLVANIA.

APPARATUS FOR ASCERTAINING THE PROPERTIES OF FLUIDS.

1,192,861. Specification of Letters Patent. Patented Aug. 1, 1916.

Application filed July 11, 1914. Serial No. 850,328.

To all whom it may concern:

Be it known that we, HENRY CARMICHAEL, a citizen of the United States, and resident of Malden, in the county of Middlesex, State of Massachusetts, and WILLIAM M. GROSVENOR, a citizen of the United States, and resident of Ridgewood, in the county of Bergen, State of New Jersey, have invented certain new and useful Improvements in Apparatus for Ascertaining the Properties of Fluids, of which the following is a specification.

The invention relates to improvements in apparatus for ascertaining the properties of fluids, by which is meant to be included solid suspensions, highly viscous colloids, gelatinous and semi-fluid solids and the like. The properties more particularly desirable to ascertain are viscosity, elasticity and solidity and the change of viscosity with change of speed of flow, as well as elastic fatigue.

What is generally considered the viscosity of a liquid appears not to be true viscosity (varying as a right linear function of the rate of translation $\frac{dx}{dt}$), but varying as a curvilinear function, and this small deflection from true viscosity (even below what are called "critical velocities") is believed to be dependent upon the homogeneity of the fluids, and that, therefore, it is important to determine viscosities at accurately known velocities or speeds and at a series of different velocities. Also, for comparing viscosities of different liquids, precisely the same velocities should be used. Therefore, it is highly desirable to equate mathematically or graphically the variations of viscosity with velocity and by interpolation ascertain the viscosities at definite speeds for comparison.

The main object of the present invention is to provide an improved, simple and efficient apparatus for accomplishing the above purposes.

More specific objects, features and advantages will appear from the detail description given below, taken in connection with the accompanying drawings, which form a part of this specification.

In the drawings, Figure 1 is a side elevation of an apparatus embodying the invention in one form; Fig. 2 is an elevation of the same taken at right angles to Fig. 1; Fig. 3 is a horizontal section taken on the line 3—3 of Fig. 1; Fig. 4 is a vertical section of parts of the apparatus; Fig. 5 is a detail of parts of the suspension; and Fig. 6 is a detail section taken on the line 6—6 of Fig. 3.

Referring to the various figures, 1 represents a suitable supporting post, having fixed on one side of its lower portion a rack 2. Slidable up and down on the post 1 is a table 3, carrying a pinion 4, operated by a handle 5, which pinion engages with the teeth of the rack 2. A pawl 6, carried upon the table 3, is adapted to engage the teeth of a ratchet 7, in order to maintain the table in its raised position, and locking it in various adjusted positions. Carried upon the table 3 is a turn-table 8, adapted to rotate about a central stud 9, extending through the table 3, and having a head 10 on its upper end, ball bearings 12 and 13 being provided between the head 10 and the table 8 and the table 3 and table 8 respectively. The table 8 is provided with gear teeth on its periphery, engaged by a worm 14 on a shaft 15, having fixed on its outer end a pulley 16, which may be driven in any suitable manner, as by a belt 17, from any suitable source of power adapted to drive the table 8 at various but constant fixed speeds. The pulley 16 is provided with a guard 18, extending over the top thereof, and, together with the shaft 15, worm 14 and table 8, is adapted to be raised and lowered with the table 3.

Removably secured and carefully centered upon the top of the table 8 is a cylindrical vessel 19, having also removably secured therein and carefully centered therein a cylindrical container 20. The space between the outside of the container 20 and the inside of the vessel 19 acts as a jacket for heating or cooling water or other fluid. At its lower end, the vessel 19 is provided with hollow legs 21, and the central stud 9 is provided with a central passage 22, through which a flame or hot gases from a burner 23 may pass to the underneath side of the vessel 19 and so, if desired, heat the water or other fluid in the legs 21 and vessel 19. Passages

24 are provided underneath the cylindrical container 20, in order to provide free circulation for the heating or cooling fluid.

Carried upon the upper end of the post 1, is a frame 25, in the upper end of which is carried a block 26, having a central vertical passage in which is secured the upper end of a suspension having a torsional wire 27. Situated centrally in the cylindrical container 20 is a solid body 28, having a cylindrical outer surface. The cylindrical body 28 is relatively long as compared with its diameter, in order that, should the fluid examined contact with the ends of the cylinder, the area of such contact is minimized. The body 28 is deeply recessed on its bottom face, as at 29′, and is also deeply recessed at its top, so as to provide a substantially hollow cylinder. Extending down into this hollow cylinder 28 is a hollow rod 29, screwthreaded into the bottom portion of the cylinder 28. The torsion wire 27 is secured in the bottom end of the hollow rod 29, as by means of a nut 30. The hollow rod 29 passes loosely through a split cap 31, forming a cover for the container 20, and also passes loosely through guides 32 and 33 on the frame 25. Screws 34 are provided in the guide 33 for adjusting the limits of guidance of the rod 29. Secured in the top of the rod 29, is a split bushing 35, having a small central aperture, through which the wire 27 loosely passes.

Secured to the guide 32, as by a screw 36, is a fixed index plate 37, having index characters thereon, coöperating with a pointer 39 adjustably and removably secured to the rod 29. Surrounding the underneath side of the index plate 37 and pointer 39, is a casing 40, which may be of transparent material, and which is for the purpose of preventing the pointer being affected by air currents or the like.

In order that the table 3, and consequently the table 8 carried thereby, may be carefully centered when it is raised, there is provided, rigidly secured to the post 1, a bracket 41, carrying a tapered plug 42 and a set-screw 43 on its underneath side. When the table has been raised to the desired predetermined height, the table 3 engages the set-screw 43, which acts as an adjustable stop therefor, and, at the same time, the tapered plug 42 snugly engages a coöperating hole in the table 3, so that the latter is accurately and rigidly centered. When the table 3, with the parts supported thereby, is lowered, it will be seen that, with the cover 31 removed, the cylinder 20 will be withdrawn from the cylinder 28. When the table 3 is at its lower position, as shown in dotted lines in Fig. 1, the pinion 4 engages a rack 44, which is secured to a collar 45, rotatively mounted upon the post 1, so that, when in this position, the table 3, together with the rack 44, may be oscillated or shifted laterally about the post 1. Thereupon, when the table 3, with its supported parts, is lowered and moved about the post 1 from beneath the cylinder 28, the vessel 19, with the container 20, may be removed from the table 8 and emptied or filled, as desired. Also, the container 20 may be removed without removing the vessel 19.

When it is desired to assemble the apparatus for operation, the wire having the proper torsional value for measuring the properties of the particular liquid is selected and its lower end secured in the bottom end of the rod 29, as by means of nut 30. The bushing 35 is then placed around the end of the wire extending through the rod 29, and the end of the suspension secured in the block 26 by means of screw 46, the block 26 being securely held in adjusted position by means of the screw 47. Thereupon the solid cylindrical body 28 is screwed upon the lower end of the rod 29, as clearly shown in Fig. 5. Then the table 3, with its supported parts, is raised until it engages the screw 43 and pin 42, as above described. Thereupon screw 46 is loosened and the suspension lowered until the lower end of the body 28 just engages the point of a pin 48, which pin is screwthreaded through the lower end of the container 20. This gives the proper vertical adjustment for the suspended parts, and the screw 46 is tightened up to retain them in this position. The table 3 is then lowered, the container 20 removed, and the pin 48 taken out, and a similar pin inserted without any point, or any other suitable plug inserted to fill the screwthreaded aperture in the bottom of the container 20. The liquid, the properties of which it is desired to ascertain, is then placed in the container 20 and the parts raised, as shown in Fig. 4, the cover 31 being finally inserted in place. Obviously, any other suspension may be used and all such suspensions are intended to be included in the term "torsional suspension."

In order that the apparatus may be adjusted accurately vertical, a plumb bob 55 (Fig. 2), coöperating with a point on the table 3, is suspended from the top of the apparatus at 56, as by a wire 57.

The operation of the apparatus may be described as follows:—First, if it is desired to determine the solidity of the fluid or semi-solid or the like, the pulley 16 is given a definite movement with respect to the pointer 49, which is fixed with respect to the table 3. This imparts a predetermined movement to the rotary table 8, causing the container 20 to be moved through a definite arc of rotation. The apparatus is then brought to a stop and there held. According to the solidity of the fluid or semi-solid, the body 28 will be dragged about for a certain distance, thus causing a certain move-

ment of the pointer 39 with respect to the index on scale 37. The time which it takes for the pointer 39 to reach its final position and the differences in the arc through which the container 20 is turned and the pointer 39 is moved serve to indicate the solidity of the material. Now, if it is desired to measure the elasticity of the fluid or the like, the pulley 16 is returned to its original position, thus returning the table 8 and container 20 to their original positions, whereupon the elastic force stored up in the fluid by the previous distortion will be indicated by the angle to which the pointer 39 is carried beyond the zero to which it would be expected that the pointer should return. Now, if it is desired to measure the viscosity of the fluid or the like, it is best to measure the viscosities at several different velocities or speeds of rotation of the container 20 above and below the desired speed which is accepted as standard. Assume that the standard speed is that corresponding to one revolution of the container 20 in six seconds. The pulley 16 will be rotated at such a speed, for example, as to give the container 20 one rotation in four seconds, one rotation in five and one-half seconds, one rotation in five and three-quarters seconds, and one rotation in seven seconds, without making any special effort to adjust the speed to any precise constant value, but carefully determining in each case the exact speed of rotation and the corresponding deflection of the pointer 39. By plotting or by calculation, the deflection which would have been produced at the precise speed of one revolution in six seconds can be interpolated. The torsional constants of the wire, the diameter of the body 28, its length and the diameter of the vessel 20 being known, the viscosity or force required to slide two solid surfaces with the fluid in between, which surfaces are one centimeter square and one centimeter apart, past one another with a velocity of one centimeter per second can be calculated. Ordinarily speaking, however, viscosities are expressed relative to the viscosity of water, in which case, by comparing successive wires which can easily be inserted in the instrument, from the finest wire adapted to use with water to the heaviest wires adapted for use with pitch, to determine fixed constants for the different wires, a direct comparison may be made between the viscosity of all fluids, no matter how viscous, with water.

In the previous preferred method of determining viscosity at exact speed, the necsary data have already been obtained for comparing viscosities at various speeds and determining the change of viscosity with certain changes in speed.

It will be understood that the recess at the bottom of the body 28 is practically filled with air and that the level of the fluid in the container comes to the top of the body 28, any excess flowing into the recess in the top of the body 28, so that the main body of the fluid does not contact with ends of the cylinder 28 and cause errors in the measurements.

For precise determination of speeds, finger 50 is provided, secured to the vessel 19, adapted to engage with a mercury globule 51 carried upon but insulated from the post 1, so that, whenever the pointer 50 engages the globule 51 once during each rotation of the container 19, an electrical circuit may be closed, which may be made to operate a signal or recording instrument for recording the revolutions per second of the vessel 19 and container 20, such as a recording chronometer.

By securing the wire suspension to the bottom of the body 28, the height of the apparatus is materially shortened, while the hollow rod 29, being secured to the body 28 and surrounding the wire, forms an efficient means for keeping the body 28 in vertical position, as well as forming a convenient means to which to attach the pointer so that the movement of the body 28 may be noted.

For precise determination of angular movement of the rod 29, carrying the pointer 39, a mirror 52 may be secured to the rod 29 and beams of light reflected therefrom and the angular movement of these beams accurately determined by well-known methods.

By constructing the bottom of the vessel 19 in the form of water legs, forming the central stud 9 with a bore extending therethrough, a simple and efficient arrangement is provided for heating the water or other fluid in the vessel 19.

If it is desired to make any of these measurements at different temperatures, the fluid may be raised to the desired temperature by means of the heating jacket arrangement above described, provided with any of the well-known means for accurate control of the temperature and agitation of the heating or cooling fluid to cause the temperature to be uniform throughout the fluid examined.

Having fully and clearly described the invention with respect to the preferred embodiment thereof, what is claimed and desired to be secured by Letters Patent is:—

1. In an apparatus for ascertaining properties of fluids or the like, the combination of a rotatable cylindrical container for the fluid, a cylindrical body adapted to be suspended in the fluid in the container, said cylindrical body being deeply recessed from its top face, a wire suspension secured at its upper end to a suitable support, means for securing the suspension at its lower end to the said cylindrical body near the bottom of said recess, and means for measuring the

effect produced on the said cylindrical body by the rotation of the liquid in the container.

2. In an apparatus for ascertaining properties of fluids or the like, the combination of a rotatable cylindrical container for the fluid, a cylindrical body adapted to be suspended in the fluid in the container, said cylindrical body being deeply recessed from its top face, a wire suspension for said body secured at its upper end to a suitable support and at its lower end near the bottom of said recess, a hollow rod secured to said body near the bottom of said recess and extending up and about said wire suspension nearly to the top thereof, and means carried by said rod for measuring the effect produced on the said cylindrical body by the rotation of the liquid in the container.

3. In an apparatus for ascertaining properties of fluids or the like, the combination of a rotatable container for the fluid, a body adapted to be suspended in the fluid in the container, said body being deeply recessed from its top face, a wire suspension for said body secured at its upper end to a suitable support and at its lower end near the bottom of said recess, and means for measuring the effect produced on the said body by the rotation of the liquid in the container.

4. In an apparatus for ascertaining properties of fluids or the like, the combination of a rotatable container for the fluid, a body adapted to be suspended in the fluid in the container, said body being deeply recessed from its top face, a wire suspension for said body secured at its upper end to a suitable support and at its lower end near the bottom of said recess, means secured to said body and loosely engaging said wire suspension to keep the body in proper upright position, and means for measuring the effect produced on the said body by the rotation of the liquid in the container.

5. In an apparatus for ascertaining properties of fluids or the like, the combination of a rotatable container for the fluid, a body adapted to be suspended in the fluid in the container, said body being deeply recessed from its top face, a wire suspension for said body secured at its upper end to a suitable support and at its lower end near the bottom of said recess, a hollow rod also secured to said body near the bottom of said recess and extending up and about said wire suspension nearly to the top thereof, and means carried by said rod for measuring the effect produced on the said body by the rotation of the liquid in the container.

6. In an apparatus for ascertaining properties of fluids or the like, the combination of a rotatable container for the fluid, a body adapted to be suspended in the fluid in the container, said body being deeply recessed from its top face, a wire suspension for said body secured at its upper end to a suitable support and at its lower end near the bottom of said recess, a hollow rod also secured to said body near the bottom of said recess and extending up and about said wire suspension nearly to the top thereof, means carried by said rod for measuring the effect produced on the said body by the rotation of the liquid in the container, and means for adjusting the guiding surface of said rod, as screws 34.

7. In an apparatus for ascertaining properties of fluids or the like, the combination of a rotatable table, a vessel supported upon and carried by said table, a container for the fluid to be examined carried by and within said vessel, a solid body suspended in said container, the bottom of said vessel being formed with downwardly-extending water legs, and means for applying heat to the bottom of said vessel to heat a fluid therein to raise the temperature of fluid in the said container.

8. In an apparatus for ascertaining properties of fluids or the like, the combination of a rotatable table, a vessel supported upon and carried by said table, a container for the fluid to be examined carried by and within said vessel, a solid body suspended in said container, a central hollow shaft extending downwardly from said table, and means for applying a heating fluid through said hollow shaft to the bottom of said vessel.

9. In an apparatus for ascertaining properties of fluids or the like, the combination of a rotatable table, a vessel supported upon and carried by said table, a container for the fluid to be examined carried by and within said vessel, a solid body suspended in said container, a central hollow shaft extending downwardly from said table, and means for applying a heating fluid through said hollow shaft to the bottom of said vessel, the bottom of the vessel being formed with downwardly extending legs to permit of the escape of the heating fluid therebetween, and means for measuring the effect on the said body produced by the rotation of the fluid in the said container.

10. In an apparatus for ascertaining properties of fluids or the like, the combination of a cylindrical container for containing the fluid to be examined, a cylindrical body torsionally suspended in the fluid in said container, and means rotating the container relatively to the said body, said cylindrical body being relatively long as compared with its diameter, and having a recess in its bottom in which air may be entrapped to prevent any material contact surface between the liquid and the bottom of the body.

11. In an apparatus for ascertaining properties of fluids or the like, a suitable framework, a rotary table carried thereby, a container carried on and rotated by said table

for containing the fluid to be examined, a body suspended in the fluid in said container, and means whereby said table and container may be raised and lowered independently of the said body.

12. In an apparatus for ascertaining properties of fluids or the like, a suitable framework, a rotary table carried thereby, a container carried on and rotated by said table for containing the fluid to be examined, a body suspended in the fluid in said container, and means whereby said table and container may be raised and lowered independently of the said body, said means embracing a rack and pinion and means for locking the table in various adjusted positions.

13. In an apparatus for ascertaining properties of fluids or the like, a suitable framework, a rotary table carried thereby, a container carried on and rotated by said table for containing the fluid to be examined, a body suspended in the fluid in said container, and means whereby said table and container may be raised and lowered independently of the said body, and means whereby said table and container may be shifted laterally from under the said body when the table is lowered.

14. In an apparatus for ascertaining properties of fluids or the like, a suitable framework, a rotary table carried thereby, a container carried on and rotated by said table for containing the fluid to be examined, a body suspended in the fluid in said container, and an electrical contact member carried rigid with the said container and adapted to close an electrical circuit as the container rotates to measure the speed or number of revolutions.

15. In an apparatus for ascertaining properties of fluids or the like, a rotatable table, a vessel removably secured to said table, a cylindrical container removably fixed in and to said vessel for containing the liquid to be examined, a cylindrical body supported in said container, means for varying the temperature of a fluid in said vessel to vary the temperature of the fluid in said container, and means for measuring the effect on said body produced by rotation of the fluid in said container.

16. In an apparatus for ascertaining properties of fluids or the like, a suitable framework, a rotary table carried thereby, a container carried on and rotated by said table for containing the fluid to be examined, a body suspended in the fluid in said container, and a removable pin extending through the bottom of the container by means of which the position of the body in the container may be adjusted.

17. In an apparatus for ascertaining the properties of fluids or the like, the combination of a cylindrical container containing the fluid to be examined, a cylindrical body suspended in the fluid in said container, means rotating the container relatively to said body, said cylindrical body being relatively long as compared with its diameter, and having a recess in its bottom in which air may be entrapped, to prevent any material contact surface between the liquid and the bottom of said body and means measuring the relative rotative effect produced upon said body.

In testimony whereof, we have signed our names to this specification, in the presence of two subscribing witnesses.

HENRY CARMICHAEL.
WILLIAM M. GROSVENOR.

Witnesses:
EDWIN SEGER,
JOS. F. X. HAROLD.