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M. R. EUVERARD
DISPOSABLE VISCOSITY CUP
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Fig. 1.

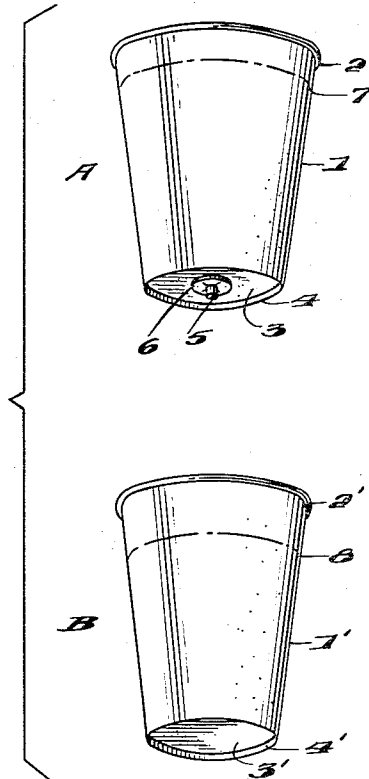


Fig. 3.

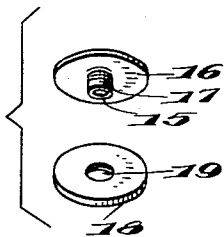
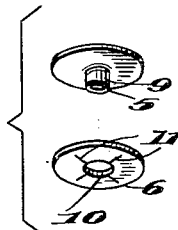


Fig. 2.



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DISPOSABLE VISCOSITY CUP

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2 Claims. (Cl. 73—55)

This invention relates to viscometers and other viscosity-indicating devices, and is concerned with the provision of a cup viscometer of the efflux type so economical to produce as to justify discarding the device after a single use.

The efflux type viscosity cup is used by many producers and consumers of chemical coatings for the control of this property. The most popular accepted standard cup available is the Ford type. This type cup is currently available in two ranges, the No. 3 and No. 4, and there is now consideration for the addition of two more ranges, the No. 1 and No. 10. The range of viscosity accommodated by these cups is roughly as follows:

Cup No.	Time in Seconds	Viscosity in Stokes
1.....	20 to 100	¹ 0.10 to 1.00
3.....	20 to 100	0.17 to 2.18
4.....	20 to 100	0.56 to 3.74
10.....	20 to 100	¹ 2.00 to 10.00

¹ Values not yet definitely established.

The mathematical equation which relates the factors involved is:

$$V_s = Kt - \frac{C}{t}$$

where

V_s is viscosity in stokes
 t is time of efflux in seconds
 K and C are constants

The constant K is a function of cup size and shape as well as orifice dimensions, while constant C is a function of turbulence induced into the material as it flows from the cup. It will be observed that the controlling portion of the above equation at large time values is Kt , since at large time values

$$\frac{C}{t}$$

becomes relatively small. Therefore, above a given minimum viscosity in any particular cup it is safe to assume that viscosity is directly proportional to efflux time.

The Ford type cup is formed by a vertical cylinder 1.982 inches in diameter and 1.705 inches high, below which cylindrical section is an inverted 60 degree conical section that leads to a removable orifice. These values are the same for all cup numbers, the only difference being in the dimensions of the removable orifices. On most cups of this type there is a trough surrounding the upper edge to accommodate overflow in filling. In manufacture, the Ford type cup is produced to approximate dimensions given above. The orifice is then adjusted to provide desired efflux characteristics. This is specified for the No. 4 cup by the following constants:

$$\frac{K=0.037}{C=4.0}$$

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In use this type cup is filled level full after the cup and material to be measured have been adjusted to the desired temperature. Time in seconds is then measured for the material to flow from the cup to the first break in the efflux stream at the cup orifice. Results may be specified simply in seconds in No. () cup and at () degrees temperature; or the results may be converted to kinematic viscosity in stokes by use of the cup equation. To find the centistoke value the stoke value is multiplied by 100.

Careful operators can use the Ford type cup described above with errors no greater than 2%. Therefore, for some purposes, especially as a reference standard, it is a very satisfactory and desirable instrument. However, there are three features that could be improved in an instrument of this type where numerous viscosity readings must be made and a very high degree of accuracy is not required. These are:

- (1) Reduction of instrument clean-up time.
- (2) Reduction of temperature change on material being measured caused by high heat content of large metal cup mass when cup is not properly adjusted to measuring temperature.
- (3) Reduction of errors when measuring non-Newtonian materials. This is caused in the standard type cup by clingage to the surfaces of the metal cup which drains off slowly and does not provide a well defined break in the orifice stream.

It is an object of the present invention to provide an efflux type viscometer having an accuracy comparable to that of the Ford cup but of such low cost as to justify discarding the device after a single use (i. e., a "one-shot" viscosity cup). It is a further inventive object to provide an efflux type viscometer which is devoid of error arising from a poorly defined break in the orifice stream. It is an object of the invention, also, to provide a viscometer, of reasonable accuracy, which does not require adjustment of the temperature of the device to that of the material being tested.

The above, and other, inventive objects are realized by the device of the present invention, which consists of a pair of disposable paper cups into the bottom of one of which—hereinafter called the "orifice cup"—there is fitted a suitable orifice member. Since it is desired that results from the one-shot cup be equivalent to the designated Ford type cup the volume held by the two cups should be in the same range. A "fill line" is applied about the inside periphery, near the top of the orifice cup. This is to insure that the same volume is used whenever measurements are made with this instrument, and also to eliminate difficulties encountered in filling any vessel just level full. The orifice may be of pressed metal, molded plastic, or other material on which internal dimensions can be held constant. As will be seen later, actual orifice dimensions are dependent on other cup factors, but in order to minimize turbulence and end effects the orifice length should be as large as or larger than the orifice diameter. The orifice may be permanently secured to the bottom of the cup by any suitable means.

A second disposable paper cup—hereinafter called the "receiver cup"—is furnished to receive the discharge of the orifice cup described above. This latter cup also has a "fill line," but the same is so located that the volume of the cup below this line is something less than 90% of the volume of the orifice cup below its fill line.

The methods of producing disposable paper cups are such that their volume has very little variation. The orifice selected for these disposable cups must also be held constant with respect to internal diameter and length. Preferably, the "fill line" is so located on the orifice cup in relation to the "fill line" in the receiver

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cup that the time of efflux from the orifice cup to fill the receiver cup to its "fill line" is equivalent to the desired number Ford type. The exact location of the "fill lines" must be experimentally determined in relation to the orifice selected. The one-shot cup viscometer may be made in more than one range. For example:

Equivalent Ford No. 1 ($K=0.010$)
 Equivalent Ford No. 3 ($K=0.024$)
 Equivalent Ford No. 4 ($K=0.037$)
 Equivalent Ford No. 10 ($K=0.100$)

If this is the case, location of the "fill line" should be adjusted on the orifice cup, only, to permit a common receiver cup to be used for all cup ranges. The cup range may be noted on the orifice cup, and instructions as to use may, if desired, be printed thereon.

The one-shot cup viscometer can be produced in quantity so that individual variation from the standard Ford type will be no greater than 5%. For production control and routine measurements a spot variation of as much as 10% could probably be tolerated.

Method of use

(1) Material to be measured is adjusted to desired temperature.

(2) The operator, while holding a finger over the orifice, fills the orifice cup to the indicated fill line.

(3) A stop watch is started at the same time the operator removes his finger from the orifice.

(4) The number of seconds for the efflux stream to fill the receiver cup to the fill line indicated thereon is observed.

(5) This number of seconds is recorded with the number of the cup used.

(6) The measured material is returned to its original container or discarded.

(7) The one-shot viscometer cups are discarded.

Inherent in the one-shot viscometer are the following advantages not found in other instruments:

(1) Elimination of instrument clean-up time since the cups are discarded after each measurement.

(2) No time is required to adjust the cups to desired measuring temperature.

(3) Errors due to temperature change are reduced, since the disposable cup is very low in heat content, and even though its temperature is widely different from that specified for the test there will be no appreciable effect on the material being measured. In addition, temperature change of cup contents due to the surrounding air is reduced, since the one-shot cup is a heat insulator.

(4) Error due to uncertain break in orifice stream is eliminated, since the end point is determined when the efflux volume fills the receiver cup to the "fill line", at which time 10% of the starting volume remains in the orifice cup.

(5) Errors due to orifice wear are eliminated. Errors from this source have been found to be quite serious in other cup type instruments especially where improper cleaning procedures have been practiced.

Illustrative of advantages 2 and 3 above are the following:

In most published works on viscosity measurements it has been stated that even for routine control purposes temperature should be controlled to within 0.5°C .

Assuming that the temperature of the paper cup has not been adjusted to the selected measuring temperature, the equilibrium effect of the difference between the temperature of the cup and the selected measuring temperature may be expressed in the basic equation:

$$t_2 = \frac{M_L S_L t + M_c S_c t_1}{M_c S_c + M_L S_L}$$

where

M_c is gram weight of cup

S_c is specific heat of cup

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t_2 is temperature of equilibrium

t_1 is starting temperature of cup

t is starting temperature of liquid

M_L is gram mass of liquid

S_L is specific heat liquid

The weight of a paper cup according to the invention is approximately 4 grams, and the specific heat of the paper is approximately 0.37. Let it be assumed that the test liquid is petroleum and that the gram mass to be considered is 90 (i. e., approximately 100 ccs.). The specific heat of petroleum is 0.511. Let it be assumed further that the temperature of the petroleum has been adjusted to a standard measuring temperature of 25.0°C . but that the temperature of the paper cup is 30.0°C . The resulting temperature, at equilibrium, will be:

$$t_2 = \frac{(90 \times 0.511 \times 25.0^{\circ}\text{C}) + (4 \times 0.37 \times 30.0^{\circ}\text{C})}{(4 \times 0.37) + (90 \times 0.511)}$$

or

$$t_2 = 25.15^{\circ}\text{C}.$$

In other words, a difference of 5.0°C . between the standard measuring temperature and the temperature of the paper cup effects a change of only 0.15°C . in the equilibrium temperature, or only about one-third of the permissible change. In contrast thereto, a representative brass cup with a gram weight of 93 would have effected a change of 0.8°C .; a representative aluminum cup with a gram weight of 57 would have effected a change of 1.0°C ., and a representative cup formed of mineral filler phenol-formaldehyde plastic composition with a gram weight of 36 would have effected a change of 0.9°C .

The heat conductivity of the paper cup of the present invention may be contrasted with heat conductivity of cups of brass, aluminum and plastic as per the following table wherein the various values are expressed in calories per second through a plate 1 cm. thick and having an area of 1 sq. cm., with a temperature differential of 1°C . across the thickness:

Aluminum	1.5040
Brass	0.2600
Plastic	0.0008 to 0.0020
Paper	0.0003

This factor of low heat conductivity is important as it reduces the rate of temperature change of the material being measured which may be caused by ambient conditions.

The one-shot viscometer provides a very convenient, low-cost means for making a very important physical measurement. As such it should promote more frequent measurement and closer control of viscosity, which will be beneficial to both the producer and consumer of paints and similar materials. The savings in cost of laboratory technician time for each viscosity measurement should, in most cases, be several times greater than the cost of the one-shot viscometer. This economic advantage and, in addition, the reduction of the most common sources of error in this type of measurement should make the one-shot viscometer a valuable addition to any industry involved with measurement of flow properties of materials in the range presently accommodated by the cup type instruments.

The invention will now be described with reference to the accompanying drawings, in which:

Fig. 1 is a perspective view of a viscometer according to the present invention, consisting of an orifice cup A and a receiver cup B;

Fig. 2 is an enlarged view showing the components of the orifice member of cup A of Fig. 1; and

Fig. 3 is an enlarged view of the components of an alternative orifice member adapted for use on the orifice cup A.

In Fig. 1 is shown a paper cup 1 of standardized size and dimensions, having the general form of an inverted

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truncated zone, with a rolled upper edge 2 and generally flat bottom 3 somewhat inset above a bottom edge 4. The orifice member, which is disposed axially of the cup in the bottom 3 of the latter, is constituted by a tubular part 5 extending downwardly through an opening (not shown) in the bottom of cup 1, and associated retaining disc 6, both being formed of molded plastic.

As shown in Fig. 2, the tubular part 5 is provided at its upper edge with an outstanding flange 9 for contacting a substantial portion of the inner bottom surface of cup 1. Retaining disc 6 has a centrally located opening 10 complementary to tubular part 5, and from opening 10 a plurality of spaced radial cuts 11, 11 extend a part of the distance from said opening to the periphery of the disc; retaining disc 6 is adapted to be forced over tubular part 5, after the same has been positioned in the opening provided therefor in the bottom of cup 1, into contact with the outer surface of bottom 3 to retain the tubular part in fixed position.

A fill line 7 is printed, or otherwise applied, to the inner surface of cup 1 parallel to the top and bottom of the cup and at a slight distance below the top of the same.

Cup B is identical with cup A except that (1) it is not provided with an orifice member, and (2) its fill line 8 is disposed somewhat lower in the cup B than is fill line 7 in cup A, to represent a volume approximately 90% of that represented by fill line 7 of cup A.

The use of this assemblage of orifice and receiver cups has been described hereinbefore and need not be repeated.

In lieu of the orifice member illustrated in Figs. 1 and 2 there may be used an orifice member such as that shown in Fig. 3, consisting of (a) a tubular part 15 having an outstanding flange 16 at its upper edge and threaded portion 17 immediately adjacent the flange, and (b) retaining disc 18 having an interiorly threaded central opening 19. This tubular part and its associated retaining disc are of pressed metal. In forming cup A according to this embodiment part 15 is located in the central opening in the bottom of the cup and is retained in place by running threaded retaining disc 18 thereonto until the same is tight against the bottom of the cup.

In further illustration, one specific viscosity cup embodying the present invention was a straight-sided, frusto-conical paper cup approximately 2.70 inches tall and having an internal diameter of 1.80 inches at the bottom and 2.40 inches at the top. The fill line represented a total volume of 125 milliliters. The tubular orifice member had an internal diameter of 0.160 inch and a length of 0.200 inch. The fill line on the companion receiver cup represented a test volume of 110 milliliters. A test volume of fluid flowed through the orifice member

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from the orifice cup into the receiver cup in 45 seconds, indicating the viscosity of the fluid to be 1.66 stokes.

For certain special purposes, it sometimes is desirable that the length of the tubular part of the orifice member be considerably greater than is the internal diameter of the same. Elongation of the tubular part has the effect of decreasing the rate of flow (or, in other words, of increasing the time of flow) of the test volume of fluid through the orifice member.

I claim:

1. A disposable or one-use efflux-type viscometer consisting of an orifice cup and a receiver cup, said orifice and receiver cups being formed of paper and being identical with each other in shape and size, said orifice cup having a substantially plane bottom, said bottom being provided with a tubular orifice member extending beneath the bottom of the cup and having a length greater than its internal diameter, said orifice and receiver cups having fill lines, parallel to and intermediate the tops and bottoms of the cups, the fill line of the orifice cup representing an arbitrary standard volume of liquid the viscosity of which is to be determined and the fill line of the receiver cup representing a volume somewhat smaller than said standard volume.

2. A disposable or one-use efflux-type viscometer consisting of an orifice cup and a receiver cup, said orifice and receiver cups being formed of paper and being identical with each other in shape and size, said orifice cup being in the form of an inverted truncated cone having a substantially flat bottom closure at its smaller end and provided in its bottom with a tubular orifice member extending beneath the bottom of the cup, said tubular orifice member having a length greater than its internal diameter, said orifice and receiver cups having fill lines, parallel to and intermediate the tops and bottoms of the cups, the fill line of the orifice cup representing an arbitrary standard volume of liquid the viscosity of which is to be determined and the fill line of the receiver cup representing a volume somewhat smaller than said standard volume.

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