A SIMPLE APPARATUS FOR DETERMINING CONTACT ANGLE OF WATER REPELLENT FABRICS

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ABSTRACT

A simple apparatus for the determination of fabric-water contact angle of water repellent fabrics is described. It is based on the tilting plate principle and the additional advantage that the end point can be sharply ascertained by optical means.

When a drop of liquid is placed upon a solid, it may either stay as a drop or spread indefinitely so as to cover the entire surface of the solid. The actual behaviour of the liquid in any given case will depend upon the relative magnitudes of the three interfacial tensions at the surfaces of contact of the three phases, *viz.*, solid, liquid and air. When the liquid rests as a drop, the molecular forces at the interfaces are in equilibrium and the surface of the liquid meets the solid surface at a definite angle. The magnitude of this inclination determines the degree of wettability of the solid by the liquid.

If a plane sheet of a solid is dipped vertically in a liquid, it is generally observed that the liquid surface on either side of the plane sheet is curved and by suitably inclining the plane sheet, the curvature of the liquid surface on one side of it may be made to vanish. In this position, the angle between the solid plane and the liquid surface measured inside the liquid, as illustrated in Fig. 1, gives the angle of contact. In the case of a solid and a liquid which wets it, the angle of contact is acute while an obtuse angle of contact indicates liquid repellency. High water repellency is associated with large angles of contact between water and the given solid surface. It is usual to refer to two angles of contact, as the advancing and the receding angles of contact. It is called an advancing contact angle if a relative motion between the solid and water results in fresh solid surface becoming covered with water while when the water surface recedes over the solid surface leaving more solid surface uncovered by water, it is referred to as the receding angle of contact.

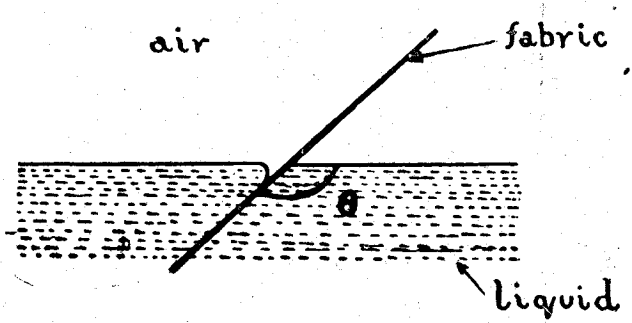

Fig. 1

In Adam's (1941) inclined plate method of determining the angle of contact, the angle measured was either the advancing or the receding angle of contact, depending upon the sense of rotation of the plate. To obviate this difficulty, Wenzel (1936) and Sumner (1937) had adjusted the axis of rotation of the plate to lie on the surface of the liquid so that the line of contact between the liquid and the plate remained fixed, but their apparatus was complicated and could not be easily adopted for fabrics. Wakeham and Skau (1945) have employed the Du Nouy tensiometer for this purpose but could not measure angles of contact greater than 120°. The apparatus described in this note is simple in construction, easily manipulated and can be satisfactorily used for measuring contact angles of very high values with fabrics.

The apparatus, illustrated in Fig. 2, consists of a crank shaped piece C to which a frame FF is rigidly fixed. The crank can be rotated about a horizontal axis and has a graduated head H, fixed at one end, to indicate the angle of tilt. The fabric is held by two clamps C_1 and C_2 which can slide along the two bars F and F of the frame. The clamp C_1 can be raised up and down by a screw S, while the lower clamp C_2 is kept free.

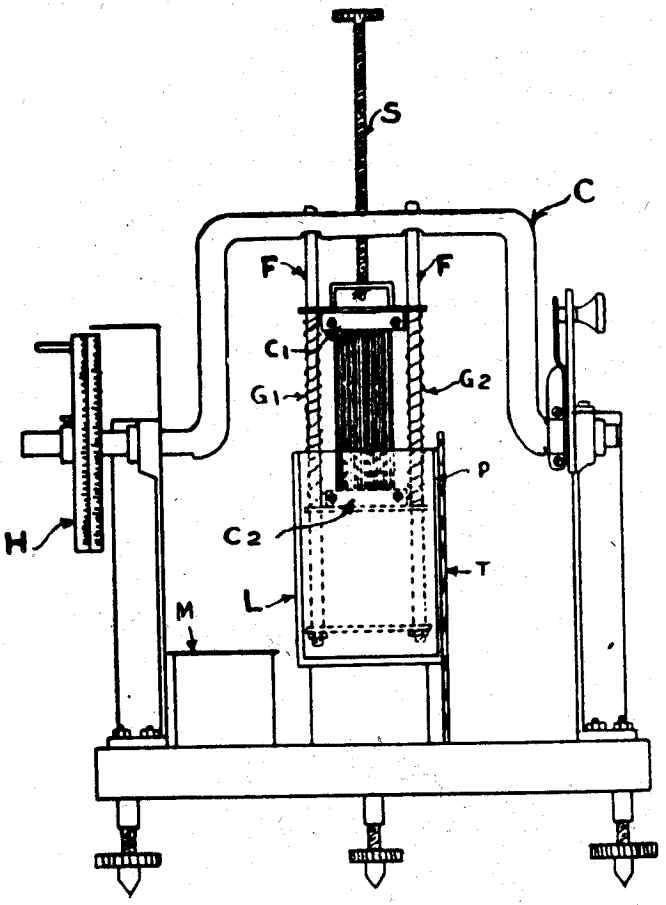

Fig. 2

A fabric sample about $4'' \times 1''$ is clamped to C_1 and C_2 and is kept stretched by the springs G_1 and G_2, sliding along the bars FF. A glass cell L is placed below the frame on a block of wood, so that its rim coincides with the axis of rotation of the crank. At the commencement, the screw S is rotated to draw the fabric sample vertically upwards, and water is filled in the cell till it overflows. The fabric sample is lowered into the cell by screwing in S. The surface of the water near its line of contact with the fabric will appear curved and distorted in the beginning. The frame FF is gradually tilted, and as its inclination to the water surface approaches the angle of contact, the distortion of the surface will tend to disappear.

An optical device, shown in Fig. 3 was set up to find the position when the surface of water was least distorted. A graph paper P, mounted on a glass plate T and illuminated by a lamp, is placed against the cell L from outside. When the sample is held at an angle far from the angle of contact, the curved surface of the water near the fabric will act as a cylindrical mirror which will form a distorted image of the graph paper. This image is viewed through a suitably placed plane mirror M. The distortion of the image of graph lines will decrease as the inclination of the fabric approaches the contact angle. It will not vanish completely due to the variation of the contact angle at different

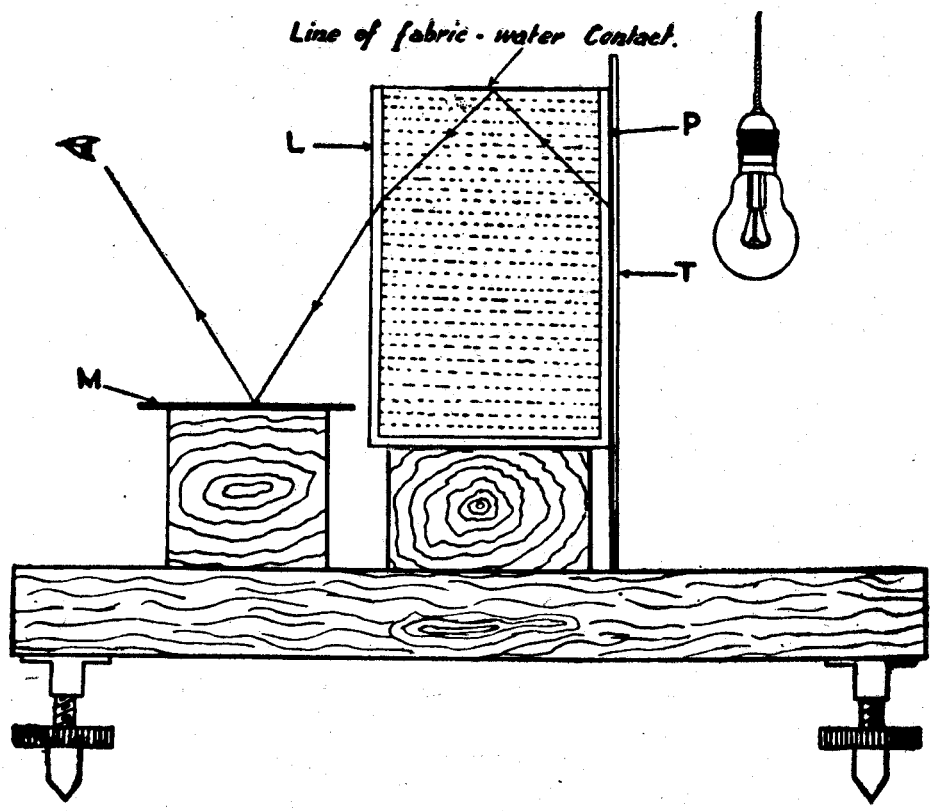

Fig. 3

parts of the fabric. The position of minimum distortion signifies that the water surface, in contact with the fabric is no longer curved, and at that position as indicated in Fig. 1 the inclination of the fabric to water represents the contact angle which can be read on the graduated head. By operating the screw S downwards, repeated observations can be taken on fresh unwetted parts of the fabric.

Paper strips coated with paraffin wax were used to find the contact angle of the wax by this apparatus and the results are very close to those reported by other workers, *e.g.*, the value of the contact angle for a paper surface coated with paraffin wax as obtained with this apparatus was 104° while the accepted value for this material is 105° (Adam, 1941). The apparatus was subsequently used with success to find the advancing contact angle of fabrics which had previously been given various water repellent treatments and some typical results are given in the following table:—

Serial No.	Description	Advancing contact angle with water
1	Mineral Khaki treated with aluminium soap	170° to 174°
2	Drill treated with soap and chrome alum	166° to 167°
3	Mineral Khaki washed with yellow soap	169° to 173°

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