starch of suitable fineness, to test the powers of the different parts of the conducting systems of vascular plants, determining by the presence of starch the course of the streams, the cells actually used, whether some or all the constituents of a vascular bundle are employed, etc. In this way we may also be able to throw the light of facts upon the disputed subject of the energetics of sap ascent.

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RING METHODS FOR SURFACE TENSION MEASUREMENTS

IN recent years there have appeared a number of papers treating of the ring methods employed for the measurement of surface tension. Most of those that have appeared in this country have been concerned more particularly with the Du Noüy tensiometer, and have ignored the fact that that instrument might conceivably be used for either of two distinct methods.

As a ring is slowly raised from an extended surface of a liquid that wets it, the resultant downward pull of the liquid passes through a distinct maximum, and, if the ring is not too small,[1] it then reaches a lower and constant value before rupture occurs. These changes have been described and explained by Sondhauss,[2] Hall,[3] Lenard,[4] Fahrenwald,[5] and others. Reducing the thickness of the ring reduces the difference between the constant and the maximum pull.

The surface tension may be derived from either of these values of the pull, but the procedures differ. As the maximum pull is the least that will suffice to detach the ring from the liquid, the method based on it may be called the ring detachment method. The lower and constant pull, observed when the ring is raised sufficiently higher than the position of maximum pull, corresponds to the existence of a true double film between the liquid and the ring, and the method based on it may be called the ring film method. In the detachment method, a portion of the pull arises from the suction exerted by the column of liquid, in bulk, pendent from the ring and extending from it to the main body of the liquid. In the film method, a portion of this column has been replaced by the film, and only the weight of the small portion lying above the top of the film contributes to the pull, the rest of the pull being due to the film itself.

In practice, the ring is suspended from the arm of a torsion, or other, balance by which the pull exerted by the liquid is measured. If the balance is pliant, so that the force exerted by it varies very little with the elevation of the ring, and if the motion of the ring is not suitably restricted, then rupture will occur when the maximum pull is reached. But if the balance is stiff, then the rise that occurs as the ring passes the position of maximum pull may relax the balance sufficiently to restore equilibrium, and then a further adjustment is required in order to produce rupture; this adjustment draws out the true film, and the pull registered at rupture will be that corresponding to the film method. By suitable care and control of the motion of the ring, either method can be realized with either type of balance, but without such care and control each balance favors one method rather than the other.

Before data obtained by such an instrument can be satisfactorily discussed and interpreted, it is necessary to know by which of these methods they were obtained. Each experimenter should determine and clearly indicate the method employed. The absence of such indication detracts greatly from the value of the work, and compels the reader to infer the method from a consideration of the manner in which the instrument has been most frequently used by others. Unfortunately, it seems impossible to determine with certainty from the published papers whether the Du Noüy tensiometer usually functions as a detachment or as a film instrument. In the paper[6] describing his first instrument, Du Noüy regards the method as a mere refinement of that of Weinberg,[7] which was a detachment method. But in a later account[8] of the origin of the instrument, he groups the method with that of Sondhauss (film) as well as with that of Timberg and of Weinberg (detachment). In his study of the instrument, Harkins[9] speaks definitely of measuring the maximum pull, thus showing that he used it as a detachment instrument. Klopsteg[10] classes the method with that of Weinberg (detachment), but a little further along he says that at a certain stage before rupture occurs "the liquid adher-

[1] Its internal diameter must be no less than that of the tube in which the liquid will rise to a height equal to the elevation of the ring when the pull is a maximum.

[2] C. Sondhauss. Pogg. Ann., Erg. Bd. 8: 268–298; 1878.

[3] T. P. Hall. *Phil. Mag.* (5), 36: 385–413; 1893.

[4] Lenard, v. Dallwitz-Wegener, and Zachmann; *Ann. d. Physik,* 74: 381–404; 1924.

[5] A. W. Fahrenwald. *J. Opt. Soc. Am. and R. S. I.,* 6: 722–733; 1922.

[6] P. L. Du Noüy. *J. Gen. Physiol.,* 1: 521–524; 1919.

[7] B. Weinberg. *Zeits. f. physik. Chem.,* 10: 34–50; 1892.

[8] P. L. Du Noüy. "Surface Equilibria of Colloids," p. 23, Chemical Catalog Co., New York, 1926.

[9] Harkins, Young and Cheng, SCIENCE, 64: 333–336; 1926.

[10] P. E. Klopsteg. SCIENCE, 60: 319–320; 1924.

ing to the ring is suddenly drawn out into a thin annular film, several millimeters long, yet retaining stability." This strongly suggests that the film method was the one actually realized.

Although I have not used the Du Noüy instrument, I am inclined to believe that the film method is the one most frequently realized. But, until the confusion just indicated has been removed by the publication of the results of a careful, detailed study of the behavior of the instrument, it is not possible to speak with certainty regarding it. That study should include a description of the essential features of what occurs during the process of tearing the ring from the liquid, as well as adequate numerical data.

The factors that must be considered in the reduction of observations obtained by means of the detachment method have been discussed by Weinberg, Cantor,[11] Lenard, Tichanowsky,[12] and others. They involve the inclinations of the liquid surfaces where they meet the ring, and the suction of the pendent column. No satisfactory, theoretical formula for computing any of these quantities has yet been derived, but Harkins has published empirical curves from which the surface tension can be deduced from the observed maximum pull on wire rings of certain sizes. Owing to the absence of such formulae, Weinberg had to make a number of assumptions in the reduction of his observations, and additional complications were introduced by the crossed diametral strips with which he braced his ring. The abnormally high value that he deduced for the surface tension of water is to be sought in errors in these assumptions. It certainly is not due, as has been suggested,[10] to an omission of the very elementary and well-known correction for the inclination of the balance beam at the instant of rupture, for he not only described in some detail the mirror system by which he determined the position of the beam, but also discussed this correction, which, in his case, was small.

In the film method, it is necessary to consider the effective radius of the tubular film, and the weight of the liquid lying between the ring and the top of the film. These have been discussed by Sondhauss, Lenard, and others, and Sondhauss has called attention to the fact that the form of the film suggests a portion of an inverted cone. Again satisfactory formulae are lacking, and empirical curves similar to those determined by Harkins for the detachment method would be of value.

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[11] M. Cantor. *Wied. Ann.*, 47: 399–423; 1892.

[12] I. I. Tichanowsky. *Physik. Zeits.*, 25: 299–302; 1924; 26: 522–525; 1925.

POSSIBLE WATER SUPPLY FOR THE CREATION OF CHANNELED SCAB LANDS

THE creation of the channeled scab lands in eastern Washington has been the subject of much discussion. Dr. J Harlen Bretz, of the University of Chicago, describes the formation of the channels, and the sweeping away of the loess that once occupied the surface, as being done in a short period of time with a huge volume of water, all channels being at high flood at one time with sufficient water flowing across country to cause the Columbia River to rise nine hundred feet at Wallula Gap, where the channel is about a mile wide between basalt bluffs.

A means of providing this volume of water, approximately fifty cubic miles per day, has puzzled Dr. Bretz and other geologists interested in the phenomenon. Dr. Bretz gives two possible explanations of such a flood: first, that the glacier was melted excessively in a short period of time by extreme heat and warm rains; or second, that the Spokane flood was a gigantic Jokulloup, such as has occurred in Iceland where volcanic activity has broken out beneath an ice-cap.

I am more inclined to believe that the flood was caused in a more natural and regular way, by the ponding of waters in natural reservoirs by ice obstructions.

The essential factors necessary to supply a sufficient amount of water to cause the channeled scab lands are as follows: first, a secure ice dam in the Columbia River below the Nespelem River to divert the water across the eastern Washington table-land; second, a reservoir large enough to hold a sufficient amount of water; third, a temporary dam sufficiently high to impound the water; fourth, water to fill the reservoir.

When the glacier was farthest advanced, probably its southern boundary was about as follows: commencing near Wenatchee, Washington, the extreme southwest corner of the Okanagan Lobe; thence, extending across the Columbia River, following the basalt bluffs along the west side of Badger Mountain; thence, along the north slope of the Big Bend plateau to near the upper end of Grand Coulee; thence, across the Columbia River near the mouth of the Nespelem River; thence, in an easterly direction, again crossing the river in the vicinity of Inchelium; thence, in a southeasterly direction, crossing the Spokane River and extending possibly to Spangle, the southern terminus, forming the Spokane Lobe; thence, in a northeasterly direction along the north and west slope of the Coeur D'Alene Mountains to Clark's Fork; thence, southeasterly, following Clark's Fork through the Bitter Root Mountains, completely damming the Clark's Fork Canyon through these mountains; thence, in a northeasterly direction to