of the third German edition. All the illustrations of the latter are reproduced. In fact, the identical cuts which were used for the German printing were employed in the American presses, thanks to the cooperation of the German editors and publishers.

Professor Southall and those who have assisted him in the translation of this stupendous work deserve the utmost praise. We must also laud the Optical Society of America and the generous benefactor who has insured the financing of a very expensive publication. Money could not and did not buy the affectionate effort which has produced this faithful interpretation of the original German; money will never repay those who have put this work into accessible form. But both the translator and the publishers receive their recompense in the knowledge that they have accomplished something tremendously worth while, which has been dreamed of for years by English-speaking scholars, but regarded by them as a practical impossibility.

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SCIENTIFIC APPARATUS AND LABORATORY METHODS

SURFACE TENSION MEASUREMENT BY THE RING METHOD

F. H. MACDOUGALL'S article on surface tension, published in SCIENCE[1] some months ago, makes an inference which if misunderstood will convey a wrong impression to the scientific worker whose investigations make necessary a measurement of surface tension. The article in question might be understood as meaning that the ring method because of supposed inherent inaccuracies is not a practicable tool in investigations that require reliable information about surface tension phenomena. Because of the fact that such an inference is far from fact, a brief discussion of MacDougall's criticism seems in order.

There will be no misunderstanding if the distinction between two kinds of accuracy is clearly made. Some investigators who are interested in the phenomenon of surface tension purely from its physical aspects will naturally think of accuracy as that attribute of the measurement by which the *n*th place in the surface tension constant becomes significant. On the other hand, to the investigator who is concerned not at all with the surface tension constant of pure liquids, but to whom surface tension values of a liquid medium tell a story of the changes that are taking place in the medium, the term accuracy as applied to his surface tension measurements will have an entirely different meaning. The former investigator will spare no pains nor time in eliminating and reducing to the utmost those factors which he recognizes as sources of error in his measurements. He may, for example, devote months to the selection of a capillary tube which is exactly right for his purpose. The latter is interested in obtaining data as rapidly as possible in terms of which he may interpret the phenomena in which he is primarily interested. Both are doing necessary and valuable work; but it is essential that their respective ideas of accuracy be not confused.

In his discussion MacDougall says, "I do not think that the simple theory of the experiment even with the procedure advocated by Klopsteg can lead to accurate values of the surface tension." The procedure to which he refers is that described in my communication to SCIENCE, XL, 319, 1924. His criticism indicates that he thinks of accuracy in terms of the *n*th significant figure in a surface tension constant. My suggestions were directed at obtaining accuracy sufficient for the purpose of the investigator who may find the ring method to be more time saving and easy to apply than any other.

Bearing in mind what has been said about the "practical" accuracy which is desired by the investigator who uses surface tension measurements as means to an end, I think it possible to show that the ring method with the procedure described in my earlier communication measures up to the requirements of such investigations. My demonstration is based on such an authority as Professor H. Freundlich, who in his "Kapillarchemie," published in 1923, gives the following table:

SURFACE TENSION OF WATER AT 18°

Method		Observer
Oscillating jets	73.0	Rayleigh
Oscillating jets	73.8	Pederson
Oscillating jets	72.4	Bohr
Oscillating jets	73.0	Lenard
Capillary waves	74.0	Rayleigh
Capillary waves	73.3	Dorsey
Capillary waves	73.8	Kalähne
Surface curvature	73.5	Lohnstein
Large air bubbles	73.0	Quincke (Reported by Worthington)
Capillary rise	73.0	Volkmann
Copper ring	76.8	Weinberg
Adhesion plate	73.1	Hall
Drop weight	73.8	Ollivier (Reported by Lohnstein)
Pressure in bubbles	75.2	Cantor
Pressure in bubbles	73.7	Magini
Pressure in bubbles	72.7	F. M. Jäger
Tensiometer, duNoüy	73.7	Klopsteg

[1] "Surface Tension determined by the Ring Method," SCIENCE, XLII, 290, 1925.

To these should be added several values which have not appeared in the tables of physical constants hitherto published.

Capillary rise	73.1	Harkins and Brown
Capillary rise	73.1	Richards and Carver

We may take for granted that the values mentioned in the table were obtained under carefully controlled conditions of observation and that the observers were competent to analyze their problems from the standpoint of eliminating gross errors. The unweighted average of their results should therefore give a value whose probable error may be assumed as not greater than a few tenths of a dyne. This average (omitting the values of Weinberg and of the writer, since theirs are results obtained by the method which is being compared with the others) is 73.4. The value of 73.7 obtained by the duNoüy tensiometer differs by only .3 dyne from this average, an agreement which is closer than that of most of the individual values given in the table. In the case of pure water, therefore, the ring method comes as near qualifying as an "accurate" method as most of the methods cited in Freundlich's table.

At another point in his discussion MacDougall states that my procedure "is undoubtedly correct," with the exception of the method for correcting for the droplets adhering to the ring. Speaking of the correction for the droplets, he states, "I hope to show that the magnitude of the pull on the ring is independent of whether the droplets are formed on the ring or not." So far as I can discover, there is no demonstration of this point, unless the statement, "if there is in fact a maximum pull, it is evident that its magnitude will be independent of such phenomena as the actual breaking of the film and the adherence of droplets to the ring," can be so considered.[2] Beyond stating that the conclusion is by no means obvious, I refrain from arguing this question, because, according to the standard of "practical" accuracy, the correction for the droplets may be ignored without affecting the value of the data.

The ring method of measuring surface tension has its practical limitations, of course; but this statement is generally valid for all methods of physical measurement. From the standpoint of greatest accuracy in determining the physical constant of surface tension for pure liquids it is probably not so well suited as some others because of the complicated mathematical relationships[3] between the pull on the ring and the actual surface tension value. The fact remains, however, that for practical purposes these complicated relationships are of small importance in most cases, since the correction involved is small from the standpoint of practical accuracy. The ease with which the ring method can be used, the speed of measurement attainable, and the agreement with values obtainable by methods that involve most exacting refinements render the ring method one of the best, if not the best, for the study of the phenomena which are associated with changes in surface tension. This has been amply demonstrated in the work of duNoüy as reported at the Third National Colloid Symposium.

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[2] The phenomenon of maximum pull, whether the ring or a straight edge is used, was observed by investigators thirty or more years ago. See, for example, Arthur L. Foley, *Physical Review*, III O. S., 381, 1896.

[3] "Zur Theorie der Abreissmethode," J. J. Tichanowsky, *Phys. Zschr.*, 26, 1925, 522. Tichanowsky in this article gives a mathematical analysis of the ring method employing rings having different kinds of cross sectional shapes. In this paper he investigates a "ring" having infinite radius but leaves the ring with finite radius for a future paper.

SPECIAL ARTICLES

THE EFFECT OF ADRENALIN ON THE LUMINESCENCE OF FIREFLIES

IN a recent paper by C. W. and H. H. Green[1] the effect of adrenalin on the luminous organs of *Porichthys notatus*, a California shore fish, was discussed. The authors found that an injection of adrenalin caused a brilliant glow of the luminous organs which persisted for several hours after the injection. From this and other experiments they came to the conclusion that the luminous organs of *Porichthys notatus* are hormone controlled rather than under nervous coordination.

It is interesting to note that an identical result is produced when adrenalin is injected into the body of a firefly (*Photuris pennsylvanica*). Although it is true that scattered masses of tissue of a similar staining reaction to that of the medulla of the suprarenal glands are known to occur in invertebrates, it is unlikely that the normal flashing of the firefly is controlled by hormones. The glow which is produced by the injection of adrenalin appears to be due to an abnormal condition resulting from the action of the drug on the myo-neural junction of the muscle

[1] "Phosphorescence of *Porichthys notatus*, the California Singing Fish," *Amer. Jour. of Phys.*, Vol. 70, 1924. Additional references given in these notes can be found, except when otherwise noted, in the bibliography of E. N. Harvey's monograph, "The Nature of Animal Light," or in that of his more recent paper, "Recent Advances in Bioluminescence," *Physiol. Rev.*, Vol. IV, No. 4, Oct., 1924.