The chapter on "Electro-Motors and their Uses" is good considering how much may be said on this subject and how short a space is 14 pages to say it in. By what means, however, Messrs. Immisch have succeeded in making the dogcart for the Sultan of Turkey go "ten miles an hour for about five hours" by means of "twenty-four small accumulators which weigh about seven hundredweight" we are at a loss to conceive, since the weight of accumulators, according to our calculation, must be much greater than this in order that they may have anything like a reasonably long life.

Chapter XVII., on "Electro-Metallurgy," is interesting although very brief, but the descriptions of the electrical circuit-closers for torpedoes in the next chapter, on "Electricity in Warfare," we find too short to be intelligible. A chapter of 5 pages then follows on "Medical Electricity," and another chapter of the same length on "Miscellaneous Applications of Electricity," in which a very interesting account is given of the electrical method employed in America for protecting furnished dwelling-houses that have been left locked up during the absence of the tenants.

On closing this book one certainly cannot deny that one has had one's money's worth, even if the entertainment has been of the "variety order" so characteristic of the amusements of the present day. If a member of the general public will read the book right through, as we have done, he may perhaps feel with exultation that he has mastered the whole subject of electrical engineering; indeed, even a well-trained electrician can learn from it many things that he did not know before, concerning those branches of the subject to which he has not given special attention. But we fear that, if even a general reader were to turn up any particular subject to study in detail, he would probably wish he had been told a good deal more about what was most important, and not so much about everything electrical whether important or not. The best features of "Electricity in Modern Life" are the many interesting scientific narratives, in the writing of which Mr. de Tunzelmann appears to excel; the worst are the mistakes in the science, which more knowledge, or more care, ought to have eliminated.

ON THE TENSION OF RECENTLY FORMED LIQUID SURFACES.[1]

IT has long been a mystery why a few liquids, such as solutions of soap and saponine, should stand so far in advance of others in regard to their capability of extension into large and tolerably durable laminæ. The subject was specially considered by Plateau in his valuable researches, but with results which cannot be regarded as wholly satisfactory. In his view the question is one of the ratio between capillary tension and superficial viscosity. Some of the facts adduced certainly favour a connection between the phenomena attributed to the latter property and capability of extension; but the "superficial viscosity" is not clearly defined, and itself stands in need of explanation.

It appears to me that there is much to be said in favour of the suggestion of Marangoni ("Nuovo Cimento," vols. v.–vi., 1871, p. 239), to the effect that both capability of extension and so-called superficial viscosity are due to the presence upon the body of the liquid of a coating or pellicle composed of matter whose inherent capillary force is less than that of the mass. By means of variations in this coating, Marangoni explains the indisputable fact that in vertical soap films the effective tension is different at various levels. Were the tension rigorously constant, as it is sometimes inadvertently stated to be, gravity would inevitably assert itself, and the central parts would fall 16 feet in the first second of time. By a self-acting adjustment the coating will everywhere assume such thickness as to afford the necessary tension, and thus any part of the film, considered without distinction of its various layers, is in equilibrium. There is nothing, however, to prevent the interior layers of a moderately thick film from draining down. But this motion, taking place as it were between two fixed walls, is comparatively slow, being much impeded by ordinary fluid viscosity.

In the case of soap, the formation of the pellicle is attributed by Marangoni to the action of atmospheric carbonic acid, liberating the fatty acid from its combination with alkali. On the other hand, Sondhauss (*Poggendorff's Annalen*, Ergänzungsband viii., 1878, p. 266) found that the properties of the liquid, and the films themselves, are better conserved when the atmosphere is excluded by hydrogen; and I have myself observed a rapid deterioration of very dilute solutions of oleate of soda when exposed to the air. In this case a remedy may be found in the addition of caustic potash. It is to be observed, moreover, that, as has long been known, the capillary forces are themselves quite capable of overcoming weak chemical affinities, and will operate in the direction required.

A strong argument in favour of Marangoni's theory is afforded by his observation,[1] that within very wide limits the superficial tension of soap solutions, as determined by capillary tubes, is almost independent of the strength. My purpose in this note is to put forward some new facts tending strongly to the same conclusion.

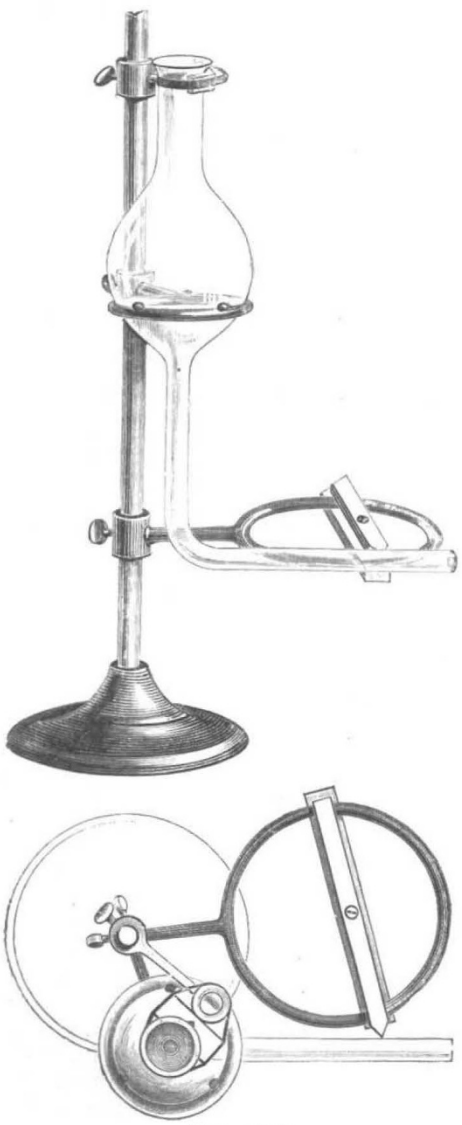
It occurred to me that, if the low tension of soap solutions as compared with pure water was due to a coating, the formation of this coating would be a matter of time, and that a test might be found in the examination of the properties of the liquid surface immediately after its formation. The experimental problem here suggested may seem difficult or impossible; but it was, in fact, solved some years ago in the course of researches upon the capillary phenomena of jets (Roy. Soc. Proc., May 15, 1879). A jet of liquid issuing under moderate pressure from an elongated, *e.g.* elliptical, aperture perforated in a thin plate, assumes a chain-like appearance, the complete period, λ, corresponding to two links of the chain, being the distance travelled over by a given part of the liquid in the time occupied by a complete transverse vibration of the column about its cylindrical configuration of equilibrium. Since the phase of vibration depends upon the time elapsed, it is always the same at the same point in space, and thus the motion is *steady* in the hydrodynamical sense, and the boundary of the jet is a fixed surface. Measurements of λ under a given head, or velocity, determine the time of vibration, and from this, when the density of the liquid and the diameter of the column are known, follows in its turn the value of the capillary tension (T) to which the vibrations are due. *Cæteris paribus*, $T \propto \lambda^{-2}$; and this relation, which is very easily proved, is all that is needed for our purpose. If we wish to see whether a moderate addition of soap alters the capillary tension of water, we have only to compare the wave-lengths λ in the two cases, using the same aperture and head. By this method the liquid surface may be tested before it is $\frac{1}{100}$ second old.

Since it was necessary to be able to work with moderate quantities of liquid, the elliptical aperture had to be rather fine, about 2 mm. by 1 mm. The reservoir was an ordinary flask, 8 cm. in diameter, to which was sealed below as a prolongation a (1 cm.) tube bent at right angles (Figs. 1, 2). The aperture was perforated in thin sheet brass, attached to the tube by cement. It was about 15 cm. below the mark, near the middle of the flask, which defined the position of the free surface at the time of observation.

[1] A Paper read by Lord Rayleigh, Sec.R.S., before the Royal Society, on March 6.

[1] *Poggendorff's Annalen*, vol. cxliii., 1871, p. 342. The original pamphlet dates from 1865.

The arrangement for bringing the apparatus to a fixed position, designed upon the principles laid down by Sir W. Thomson, was simple and effective. The body of the flask rested ont hree protuberances from the ring of a retort stand, while the neck was held by an india-rubber band into a V-groove attached to an upper ring. This provided five contacts. The necessary sixth contact was effected by rotating the apparatus about its vertical axis until the delivery tube bore against a stop situated near its free end. The flask could thus be



FIGS. 1 and 2.

removed for cleaning without interfering with the comparability of various experiments.

The measurements, which usually embrace two complete periods, could be taken pretty accurately by a pair of compasses with the assistance of a magnifying glass. But the double period was somewhat small (16 mm.), and the little latitude admissible in respect to the time of observation was rather embarrassing. It was thus a great improvement to take magnified photographs of the jet, upon which measurements could afterwards be made at leisure. In some preliminary experiments the image upon the ground glass of the camera was utilized without actual photography. Even thus a decided advantage was realized in comparison with the direct measurements.

Sufficient illumination was afforded by a candle flame situated a few inches behind the jet. This was diffused by the interposition of a piece of ground glass. The lens was a rapid portrait lens of large aperture, and the ten seconds needed to produce a suitable impression upon the gelatine plate was not so long as to entail any important change in the condition of the jet. Otherwise, it would have been easy to reduce the exposure by the introduction of a condenser. In all cases the sharpness of the resulting photographs is evidence that the sixth contact was properly made, and thus that the scale of magnification was strictly preserved. Fig. 3 is a reproduction on the original scale of a photograph of a water-jet taken upon November 9. The distance recorded as 2λ is between the points marked A and B, and was of course measured upon the original negative. On each occasion when various liquids were under investigation, the photography of the water-jet was repeated, and the results agreed well.

After these explanations it will suffice to summarise the actual measurements upon oleate of soda in tabular form. The standard solution contained 1 part of oleate in 40 parts of water, and was diluted as occasion required.[1] All lengths are given in millimetres.

	Water.	Oleate 1/40.	Oleate 1/80.	Oleate 1/400.	Oleate 1/4000.
2λ... ...	40·0	45·5	44·0	39·0	39·0
h... ...	31·5	11·0	11·0	11·0	23·0

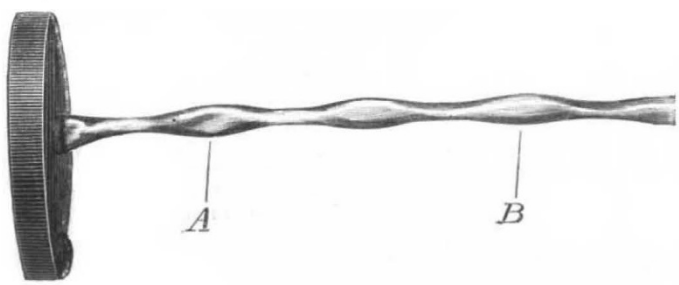


FIG. 3.

In the second row h is the rise of the liquid in a capillary tube, carefully cleaned before each trial with strong sulphuric acid and copious washing. In the last case, relating to oleate solution $\frac{1}{4000}$, the motion was sluggish and the capillary height but ill-defined. It will be seen that even when the capillary height is not much more than one-third of that of water, the wave-lengths differ but little, indicating that, at any rate, the greater part of the lowering of tension due to oleate requires time for its development. According to the law given above, the ratio of tensions of the newly-formed surfaces for water and oleate ($\frac{1}{80}$) would be merely as 6 : 5.[2]

Whether the slight differences still apparent in the case of the stronger solutions are due to the formation of a sensible coating in less than $\frac{1}{100}$ second, cannot be absolutely decided; but the probability appears to lie in the negative. No distinct differences could be detected between the first and second wave-lengths; but this observation is, perhaps, not accurate enough to settle the question. It is possible that a coating may be formed on the surface of the glass and metal, and that this is afterwards carried forward.

[1] Although I can find no note of the fact, I think I am right in saying that large bubbles could be blown with the weakest of the solutions experimented upon.

[2] Curiously enough, I find it already recorded in my note-book of 1879, that λ is not influenced by the addition to water of soap sufficient to render impossible the rebound of colliding jets.

As a check upon the method, I thought it desirable to apply it to the comparison of pure water and dilute alcohol, choosing for the latter a mixture of 10 parts by volume of strong (not methylated) alcohol with 90 parts water. The results were as follows :—

$$2\lambda \text{ (water)} = 38{\cdot}5, \qquad 2\lambda \text{ (alcohol)} = 46{\cdot}5,$$
$$h \text{ (water)} = 30{\cdot}0, \qquad h \text{ (alcohol)} = 22{\cdot}0\,;$$

but it may be observed that they are not quite comparable with the preceding for various reasons, such as displacements of apparatus and changes of temperature. It is scarcely worth while to attempt an elaborate reduction of these numbers, taking into account the differences of specific gravity in the two cases ; for, as was shown in the former paper, the observed values of λ are complicated by the departure of the vibrations from isochronism, when, as in the present experiments, the deviation from the circular section is moderately great. We have—

$$(46{\cdot}5/38{\cdot}5)^2 = 1{\cdot}46, \qquad 30/22 = 1{\cdot}36\,;$$

and these numbers prove, at any rate, that the method of wave-lengths is fully competent to show a change in tension, provided that the change really occurs at the first moment of the formation of the free surface.

In view of the great extensibility of saponine films it seemed important to make experiments upon this material also. The liquid employed was an infusion of horse chestnuts of specific gravity 1·02, and, doubtless, contained other ingredients as well as saponine. It was capable of giving large bubbles, even when considerably diluted (6 times) with water. Photographs taken on November 23 gave the following results :—

$$2\lambda \text{ (water)} = 39{\cdot}2, \qquad 2\lambda \text{ (saponine)} = 39{\cdot}5,$$
$$h \text{ (water)} = 30{\cdot}5, \qquad h \text{ (saponine)} = 20{\cdot}7.$$

Thus, although the capillary heights differ considerably, the tensions at the first moment are almost equal. In this case then, as in that of soap, there is strong evidence that the lowered tension is the result of the formation of a pellicle.

Though not immediately connected with the principal subject of this communication, it may be well here to record that I find saponine to have no effect inimical to the rebound after mutual collision of jets containing it. The same may be said of gelatine, whose solutions froth strongly. On the other hand, a very little soap or oleate usually renders such rebound impossible, but this effect appears to depend upon *undissolved* greasy matter. At least the drops from a nearly vertical fountain of *clear* solution of soap were found not to scatter (Roy. Soc. Proc., June 15, 1882). The rebound of *jets* is, however, a far more delicate test than that of *drops*. A fountain of strong saponine differs in appearance from one of water ; but this effect is due rather to the superficial viscosity, which retards, or altogether prevents, the resolution into drops.

The failure of rebound when jets or drops containing milk or undissolved soap come into collision has not been fully explained ; but it is probably connected with the disturbance which must arise when a particle of grease from the interior reaches the surface of one of the liquid masses.

P.S.—I have lately found that the high tension of recently formed surfaces of soapy water was deduced by A. Dupré ("Théorie Mécanique de la Chaleur," Paris, 1869), as long ago as 1869, from some experiments upon the vertical rise of fine jets. Although this method is less direct than that of the present paper, M. Dupré must be considered, I think, to have made out his case. It is remarkable that so interesting an observation should not have attracted more attention.

NOTES.

It is stated that the committee to be appointed to inquire into colour-blindness in seamen, railway guards, and others, will not be exclusively confined to members of the Royal Society. Some gentlemen who, like Dr. Farquharson, M.P., and Mr. Bickerton, of Liverpool, have taken special interest in the question will, it is said, be asked to join the committee. A further question on the subject will, in the course of a few days, be put to the President of the Board of Trade.

We regret to have to record the death of Sir John Henry Lefroy, F.R.S. He died on Friday evening last at his residence, Lewarne, a few miles from Liskeard. He was seventy-three years of age. He entered the Royal Artillery in 1834, and was Director of the Magnetical and Meteorological Observatory at St. Helena from 1840 to 1841, whence he moved to a similar position at Toronto in 1842. During the next year he made a magnetic survey of the interior of North America from Montreal to the Arctic Circle. From 1854 to 1855 he was scientific adviser to the Duke of Newcastle at the War Office on subjects of artillery and inventions, and in 1855 he was sent, as lieutenant-colonel, on a special mission to the seat of war. Afterwards he held several high military appointments. In 1882 he was made a general, and retired. He had been elected a Fellow of the Royal Society in 1848.

Mr. Thomas Johnson, Demonstrator in Botany at the Normal School of Science and Royal School of Mines, has been appointed to succeed the late Prof. McNab, as Professor of Botany at the Royal College of Science, Dublin. Prof. Johnson begins lecturing this term.

An International Medical Congress was opened at Vienna on Tuesday, and will continue its sittings until to-morrow (Friday). Many physicians from the principal Europe an countries are taking part in the proceedings.

At the next meeting of the Anthropological Institute, on Tuesday, April 22, M. Jacques Bertillon will give a lecture, with demonstrations, on the method now practised in France of identifying criminals by comparing their measures with those of convicted persons in the prison registers. The registers contain the measures of many tens of thousands of persons, with their photographs ; yet M. Bertillon's method enables the reference to be rapidly effected. It is thought, therefore, that the authorities in England who are concerned with the police, or with the identification of deserters from the army or the navy, may be glad of the opportunity of hearing M. Bertillon's exposition.

The Meteorological Office has adopted a new way of spreading information as to the condition of the weather on our coasts. On Monday it began to exhibit, at 63 Victoria Street, Westminster, outside the building, a series of boards, showing the state of the wind, weather, and sea at Yarmouth, Dover, the Needles, Scilly, Valentia (Ireland), and Holyhead. The information given is for 8 o'clock in the morning and 2 o'clock in the afternoon, and the notices are posted up at about 9.30 a.m. and 3 p.m. respectively. The words are printed in clear type, and can be read by those having ordinarily good sight from the pavement or roadway.

At the meeting of the Institution of Civil Engineers on Tuesday evening, Sir Frederick Bramwell read a paper on the application of electricity to welding, stamping, and other cognate purposes.

There has been some talk lately about a scheme for the construction of a bridge across the Bosphorus. The Turkish newspaper *Hakikat* gives some particulars of the project *à propos* of