MEASUREMENT OF RAPIDLY VARYING SURFACE TENSION

THE determination of surface tension has acquired great importance in biological work and references to suitable methods have appeared on several occasions in SCIENCE. For the measurement of quickly changing surface tension, in addition to the ring method so ably championed by Dr. du Noüy, I have found very useful a simple form of the "pressure in bubble" method.[1] The "pressure in bubbles" method enables one to take readings within one fifth of a second or less after the formation of the surface and is of value especially when one deals with liquids giving elastic films, when the ring method can not be used.

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SCIENTIFIC APPARATUS AND LABORATORY METHODS

A WEIGHT-DRIVEN KYMOGRAPH

WHEN such phenomena as the speed of a nerve impulse or reaction time are to be recorded, a very fast kymograph drum is an absolute necessity. A weight-driven machine seems to serve the purpose more satisfactorily than one propelled by a spring.

Most instructors, who have tried to explain to the student in the laboratory of experimental physiology how to arrange the writing-points of the signal-magnet and of the muscle-lever in the same vertical line, open the switch, pluck the tuning fork and spin the drum a single revolution only, have been struck by the look of dismay upon the student's face. Such procedure requires good technic and plenty of patience. When the situation is complicated by a limited amount of time and a meager knowledge of technic, it is obvious that either simpler methods must be developed or these experiments must be omitted. Due to the great values being placed upon reaction times, it becomes advisable to devise simpler methods.

Therefore a stand was constructed for supporting the drum and the necessary devices for starting and stopping the drum, as well as a mechanism for producing break shocks. The stand consists of a triangular base of cast iron (Fig. 1), supported by three legs, as shown in Fig. 2. From one corner of the base arises a vertical pillar near whose point of origin is a slot to allow the placing of a pulley, such as a sash-pulley, over which the cord of the propelling weight passes. A horizontal limb arising from the vertical pillar is fitted with a 10/24 knurled head screw, 1-a, provided with a check nut. The end of this screw is sharply pointed to fit into the cupped end of the drum spindle, 1-d. This spindle is one-half inch in diameter to fit a Harvard drum, has cups at both ends and is of the proper length, about eleven and three quarter inches, to rest upon a steel point, 1-b, fitted into the base and to engage the screw, 1-a. Of course the base must be level and the spindle exactly in the vertical position.

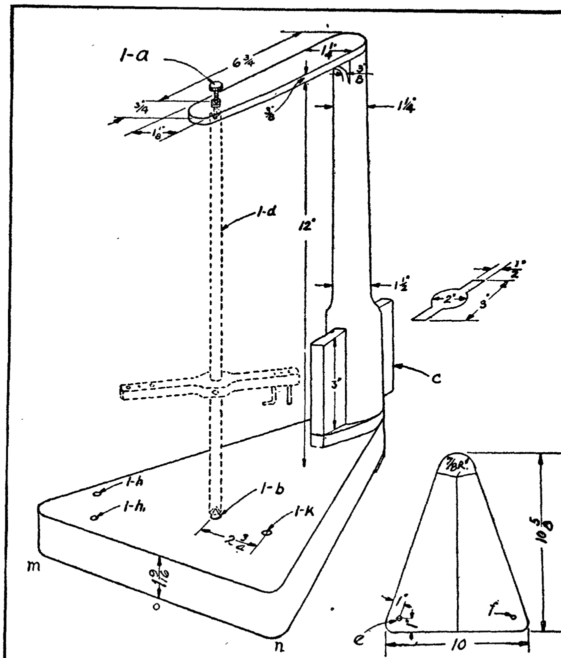


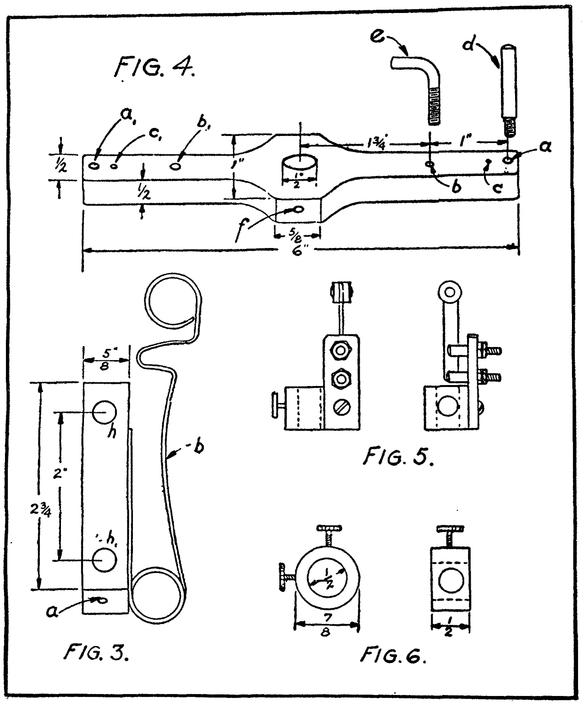
FIG 1. FIG. 2.

When in use the stand is so placed that the vertical pillar rises almost directly from the edge of the table and allows the weight to fall therefrom. Near the margin of the right side of the base, as viewed by the operator, are drilled two holes, 1-h and 1-h_1, in which are placed three-eighth inch round iron rods six inches long for supporting the starting and stopping device. The latter is shown in Fig. 3 and consists of a bar of the dimensions shown in the figure, to the mesal surface of which is soldered a spring "latch" b, of the shape figured and made from number 26 piano-wire. Piano-wire is quite difficult to handle unless one end is firmly held in a vise. In construction the bar is first laid out and drilled, after which it is used as a guide for drilling the holes, 1-h and 1-h_1, in the base of the stand.

A vertical brass rod, Fig. 4-d, projecting downward from the brass bar attached to the lower end of the drum, engages the U-shaped bend in the "latch" and serves as a means of holding the drum at rest and checking it at the proper time when in motion. This brass bar, whose dimensions are shown in Fig. 4, is

[1] *Chemical Reviews,* Vol. 4, p. 31.

bolted to the cross arm of a Harvard drum by means of two 4/36 round-head machine screws and is provided with the holes, a and a_1, for placing of the rod, d, holes b and b_1 for receiving an L-shaped "dog," e, which actuates the break-shock device, with holes c and c_1 for attaching the bar to the drum and finally with a one-half inch hole for the spindle. These holes are all drilled symmetrically so that the bars are interchangeable upon all drums used. An Allen set screw, f, serves to retain the bar on the spindle in the desired position. Much convenience results from the ability of changing the position of the "dogs," as it has been found best to place the lap of the drum paper opposite the "dogs," and the recording levers parallel with the side of the base opposite the pillar. The "dogs" d and e are made from round brass rod three-sixteenth inch in diameter. The brass bar, after removal of the dogs, may be allowed to remain upon the drum, thus facilitating a rapid shift from the weight-driven to spring-driven machines and *vice versa*. In Fig. 1 this brass bar is shown in proper position upon the spindle but without the drum.



The device for breaking the current is shown in Fig. 5. It consists of a single-pole double-throw radio-switch obtainable from five-and-ten-cent stores or from mail-order houses. One of the poles of the switch was removed, and a 4/36 round-head machine screw passed through the hole to attach the base of the switch to a brass block, which in turn is provided with a one-quarter inch hole for fitting it to the upright rod, 1-k, a round iron rod four inches long. If a Guthrie switch were used here it is probable that superimposed records of muscular contraction as well as records of simple contraction could be secured.

The braided or twisted cord about fifteen inches long extending from the propelling weight and over the pulley is attached to the spindle by means of a collar made from a short section of a seven-eighth inch round brass rod, Fig. 6, which has a hole of sufficient size to slip over the spindle. The collar is set upon the spindle by means of two knurled head 6–32 machine screws. The propelling weight used consists of a six inch-length of one and one-quarter inch steel-shafting which has become unsatisfactory for other purposes. Any other ten-pound weight would serve as well.

Construction of the stand: As the pattern differs but slightly from the finished stand and in details essential for construction only, the pattern has been shown in Fig. 1. The stand is cast on edge in order to make possible the placing of the foot beneath the pillar and the core, c, for the pulley-wheel slot. The dimensions of the base and of the pillar are given in Figs. 1 and 2. The thickness of the base should be as given at 0 in Fig. 1. In order to allow ready removal from the moulding sand, the edges M and N should be at least one-sixteenth inch less in thickness than at 0. This is accomplished by the removal of a few shavings from the bottom of the base with a plane.

The general process of manufacture consists in the cleaning of the casting after delivery from the foundry, drilling and tapping the holes for the two added feet made from one-half inch round iron rod, leveling the base and drilling the hole in the horizontal limb of the vertical pillar for the screw, 1-a, according to the dimensions given in Fig. 1. The stand is then placed upon a level bench and the point for the hole, 1-b, located by means of a plumb bob and a three-eighth inch hole drilled for the point to receive the lower end of the drum spindle. The hole, 1-k, is at a radius of two and one-quarter inches from the hole 1-b.

In operation, timed break-shocks may be delivered by wiring the primary of the inductorium in series with one or two dry-cells, the switch and the signal magnet.

SUMMARY

(1) Herein has been described a stand for supporting the drum, a device for starting and stopping the drum and a circuit-breaker for a weight-driven kymograph.

(2) This device has proved satisfactory for recording simple muscular contractions, for securing data for the determination of the speed of the nerve-impulse and for determining reaction times.

(3) With but a little training in technic, college freshmen have secured very good graphs with this apparatus.
(4) This machine, exclusive of the drum, has been constructed at less than one third the cost of a spring-driven kymograph, and the drum of the latter may readily be used for either, since but a few minutes are required to make the shift.

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SPECIAL ARTICLES

A NEW ARRANGEMENT FOR SHOWING THE DIURNAL VARIATION IN THE INTENSITY OF THE EARTH'S-SURFACE CHARGE AT A GIVEN PLACE

DURING the past seven years I have been recording a diurnal variation in the deflection of a quadrant electrometer inside a grounded-wire cage with one pair of quadrants grounded to the cage and to the city water-system of Palo Alto, the other pair insulated and the needle charged. Set up in this way the electrometer has shown both a solar and a lunar diurnal variation in deflection which varies with the seasons, being much greater at the equinoxes than at the solstices, which is not due to temperature, illumination or atmospheric pressure and which is sometimes greatly disturbed by solar activity and by auroras.

I have attributed this variation to the inductive effect of the electric charges of the sun and moon upon the earth's charge; but this explanation has not met with general approval, partly, at least, because it is quite commonly held that it is impossible that the sun as a whole can be highly electrified, though the tremendous charges in sun-spot regions are quite generally accepted.

One of the most plausible explanations of the phenomenon which have been offered, and the one which is most often proposed, is that it is due in some way to a diurnal variation in the electrical conductivity of the air. This has seemed the more plausible because a number of observers have recorded similar electrometer deflections which they have attributed to changes in atmospheric conductivity, due to penetrating radiations or other causes.

I have several times offered what seem to me to be conclusive objections to this interpretation of my observations, and I wish now to give a definite experimental proof that the phenomenon is not due to variations in atmospheric conductivity.

If a quadrant electrometer have one pair of quadrants and the needle grounded to the inside of a hollow conductor which is also grounded and have the other pair of quadrants connected to one pole of a constant battery, the other pole of which is also grounded to the inside of the hollow conductor, we have an arrangement in which the electrometer will not be disturbed by any changes in the conductivity of the air. The needle and one pair of quadrants must necessarily remain at the same electrical potential as the earth, and the charged quadrants must remain at a constant potential difference from the needle and the grounded pair.

An electrometer set up in this way shows the same diurnal variation in deflection as does the one which I have been using for the past seven years. Fig. 1

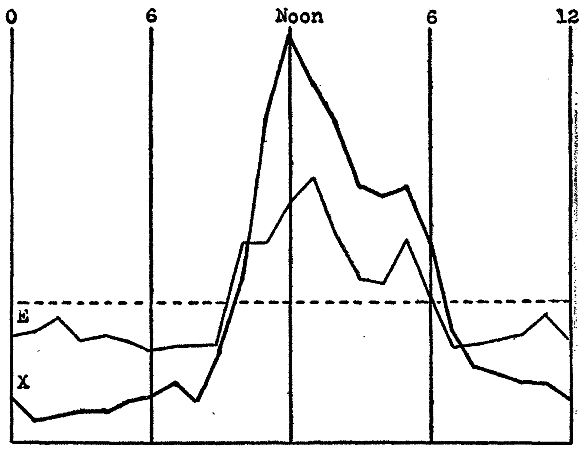

FIG. 1

shows the simultaneous mean diurnal variation for eight days of two electrometers standing upon the same pier and giving photographic records upon the same sheet. The two were charged from different batteries. Curve E was given by the electrometer with a charged needle, one pair of quadrants grounded and the other pair connected to an insulated conductor inside the cage, and Curve X was given by an electrometer with one pair of quadrants and the needle grounded and the other pair grounded through a constant battery. It will be seen that the deflection given by electrometer X was twice as great as that given by electrometer E.

The fact that the electrometer deflections have both a solar and a lunar diurnal period as well as a seasonal period shows that they are dependent upon the sun and moon, and their electrostatic nature will hardly be questioned. Also, the fact that the solar variation is several times as great as the lunar shows that they are not due to gravitational tides.

Since most of my previous statements in regard to this phenomenon have been declared impossible by *a priori* physicists, I have no doubt that this one will