The great number of measurements of surface tension with the du Noüy tensiometer performed in this laboratory during the past 4 years has progressively revealed most of the causes of error and disturbing factors which at first prevented the reproducibility and the perfect checking of the measurements. These causes are of two kinds: mechanical and chemical. They are both a consequence of the fundamental fact, pointed out in the preceding papers, that, when colloidal substances are dealt with from the standpoint of surface tension, the time factor has to be considered, since adsorption takes place in the surface layer, thus changing the value of the surface tension continually. Hence, at least two values of the surface tension were always measured: the initial value, and the value after an empirically determined time, say 2 hours. After 2 hours the surface tension is practically constant, an equilibrium having been established between the surface layer and the bulk of the solution. It has been shown that part of all the substances present in the solution were adsorbed, with the colloids, in the surface layer, and also that the slightest jarring or shaking changed the value of the surface tension by tearing the delicate film formed in the superficial layer. Very pure water and sodium chloride, and freshly cleaned glass were used. The solutions were handled in such a way that the film was not torn. This was very important, since only one measurement of every solution can be made,
after it has stood for 2 hours; indeed, the tearing off of the ring breaks up the film and a second measurement gives a totally different value. In order to secure immobility of the solutions in the watch-glasses,

![Diagram of device used for making a series of measurements of surface tension without disturbing the solutions.]

The tensiometer, S, runs on the carriage supported by the rollers, J, on the rails, J. A brake, K, released by the button, O, blocks the carriage rigidly at any given point.

A, bronze cylinder on which the watch-glass is placed. It is leveled by means of three screws, B, so as to be strictly parallel to the raising table, H. This cylinder slides in a hole made in the table, F. C, watch-glass containing the solution; D, platinum ring; E, hood protecting the solutions against dust and air currents; F, steel table supporting the cylinder, A; G, screw for raising table, H, and cylinder, A; J, rollers on which the carriage moves; J, rails; K, brake; L, support of table, F, and hood, E; M, metallic base supporting rails, J; O, button releasing brake, K.

and a rise of the surface so that its plane remains strictly parallel to the original plane, a metallic bench was made, and screwed on to a very substantial table. On this bench, twenty-four holes were bored,
the diameter of which was 40 mm. (Fig. 1 and Plate 1). Three leveling screws \((B)\) were placed at 120° from each other around the circumference of every hole. Twenty-four hollow bronze cylinders \((A)\), bearing a collar designed to rest on the leveling screws \((B)\), were placed in the holes. They could thus be leveled perfectly and raised by the moving table \((H)\) of the tensiometer.

The tensiometer is placed on a small carriage rolling on two steel rails \((J)\). A brake \((K)\) is provided so as to block the whole moving system in a perfectly fixed position. The watch-glasses are placed on the bronze cylinders \((A)\) and protected against dust and air currents by the metallic hood \((E)\).
The cylinders are leveled in the following way. The watch-glass being in position, a powerful Mazda lamp is placed in such a way as to produce, by reflection on the concave face of the watch-glass, a brilliant caustic on the white wall of the hood (Fig. 2). The tensiometer is brought in front of it and the table (H) raised by means of the screw (G). When the watch-glass is raised so that the plane of the solution remains parallel to its original plane, no jerky motion of the caustic is to be seen. On the contrary, if one side of the watch-glass is raised before the other, in other words, if the base of the bronze cylinder is not perfectly parallel to the table (H), a shift is observed in the caustic, and the parallelism can be reestablished by means of the screws.

When measurements are made, the same time should elapse between the moment the platinum ring touches the surface of the liquid, and the moment it breaks off. Our experience was that approximately 15 seconds were satisfactory.

Under such conditions, the surface tension of pure colloidal solutions may be measured with as much accuracy as can be expected. Of course, when the initial values are taken, it is advisable to make the measurements as rapidly as possible, in order to obtain the value of the tension before the colloidal molecules have had time to wander from the bulk of the solution to the surface. In this case, 5 seconds or less are sufficient, and the results will check within 0.1 dyne. The tensiometer has been improved recently, and has now a direct reading scale. A vernier and a larger scale allow the readings to be made to 0.1 dyne with great ease.

EXPLANATION OF PLATE 1.

View of apparatus, described in this paper, set up for measurements.

¹ Since the reflecting surface is the watch-glass (which is a segment of a sphere) the reflected beam appears on the intercepting surface as a caustic and not as an image.