a part in wing development and coloration appears not to occur to Vignon, such matters obviously being enveloped in an impenetrable cloud of mystery. He calls attention, however, to the important fact that, in many insects, mimetic structure and the instinct for making use of it develop inseparably. This proves the utility of the mimicry, but can the selectionist show that its possessors have thereby an advantage in the rate of reproduction? This question, likewise, does not interest Vignon, who prefers to think that mimicry "serves to show that Life knows how to introduce something personal and new into nature."

In the final chapter, examples are given of mutations and "orthogenetic series" offered as proofs of evolution. Here are described an example of mutation in *Drosophila,* changes which the wing muscles of Dragon-flies have undergone since the Carboniferous, the strange metamorphosis of the parasitic cirriped *Sacculina,* the change of the reptile's jaw into the bird's toothless beak, of the reptile's scale into the feather, eventually into the gorgeous plume of the bird of Paradise, and finally the evolution of the pine cone into the various types of inflorescence of the higher plants.

Whether looking at the world through mechanistic, organistic, or vitalistic glasses, one can not but admire the vigorous, vivid style, the adequate descriptions and excellent figures of this unique book. Although the experimentalist will find its method deductive and descriptive, rather than that which in America we call experimental, he will find here plenty of problems which seem to require experimental treatment, or he may prefer to turn his imagination into other channels and think of them awhile, as would the poet or artist, simply as ideas.

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SCIENTIFIC APPARATUS AND LABORATORY METHODS

AN AUTOMATIC BALANCE

DURING the course of studies of the relation of soil moisture to plant growth extending over more than a decade it has been necessary to weigh many thousands of soil samples. We have designed and constructed, with the tools usually available in most laboratories, a simple and inexpensive balance which we believe has unique features and which we have found to increase very materially the speed with which weighing may be made.

The balance, which operates on the displacement principle, is shown in Fig. 1. This balance, which has a capacity of 3 kilograms with a sensitivity of 20 milligrams at full load, is of German make and is on sale by most dealers in laboratory equipment in this country. We are also using our device on an analytical balance. Probably many standard makes of beam balances would serve as well as the one illustrated. It will be apparent from the following description that there are, however, several features which are desirable in the balance to be used as a base for our device. The balance is arranged to weigh an article in the left-hand pan by placing weights in the right-hand pan until the difference in weight is 10 grams or less, which is recorded on the scale *a*. The inequality in weights on the two pans is compensated for by the depression of the plunger *b* in the displacement cup *c,* the plunger being depressed until a quantity of liquid is displaced which is exactly equal in weight to the difference in the loads on the weighing pans. A circular disc *d* of slightly less diameter than that of the displacement cup is attached to the plunger *b*. The disc *d* is to dampen the movement of the plunger, and the plunger assembly with the cup and liquid acts as a dashpot.

The plunger assembly is hung from a yoke *e* which

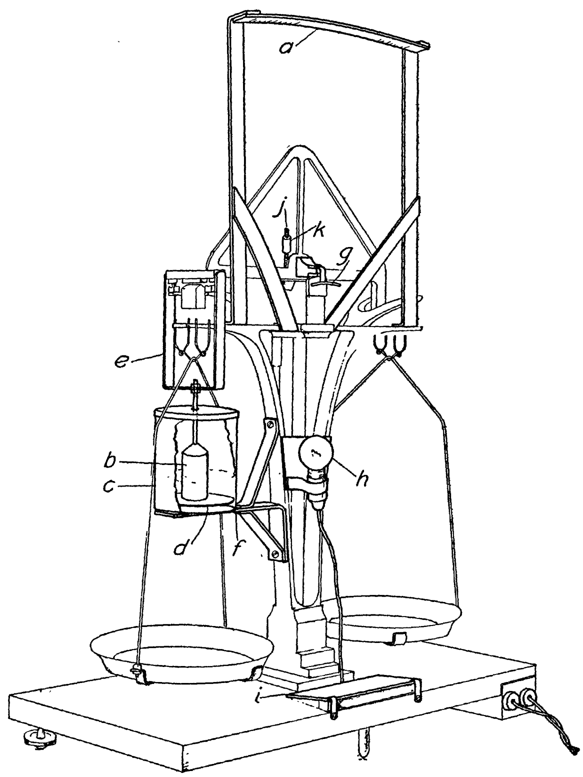

FIG. 1. View from the rear of balance with displacement cup cut away to show plunger assembly. The attachments placed on the stock balance are shown by heavy lines.

is attached to the cross-bar carrying the agate plane for the stirrup and pan hanger. The yoke is pivoted in the cross-bar at points in line with the face of the agate plane by two cylindrical pins so that it can swing freely and its motion be independent of that of the weighing pan. One of the desirable features of the balance is that the stirrup be returned to a fixed position when the knife edges are removed from the agate planes. The beam of the balance must be supported so that it is restrained from horizontal movement and must return to its former position when lowered after being raised. The clearance between the periphery of the disc *d* and the sides of the cup *c* is small, and any considerable movement out of line of the plunger will cause it to stick. The displacement cup *c* is attached to its support *f* by means of lugs which pass through slotted holes so that its position may be changed slightly to center the cup in relation to the plunger assembly.

A spherical concave mirror *g* is attached to the back of the beam of the balance so that its reflecting surface is tangent to a line projected from the central knife-edge. A 3-volt single filament lamp *h* is attached to the back of the balance on an adjustable plate. A small transformer reduces the line voltage from 110 to 3 volts. The lamp is adjusted until the image of the filament is focused on the scale *a* when the beam of the balance is raised. The image of the lamp filament is reflected from the concave mirror *g* down to the plane mirror *i* and thence up to the scale *a* which is attached to a metal piece shaped to the proper arc. The movement of the beam of the balance, then, is greatly amplified. In effect we have a weightless pointer of great length. Furthermore, the angular movement of the beam of light reflected from the concave mirror is twice that of the beam of the balance. The position of the scale *a* may be varied. Raising it increases the length of the scale for a unit weight.

There has long been a prejudice against displacement balances and one reference book, which deals, in part, with weighing machines, states that they are not practical nor accurate. We have met with similar discouragement during the several years we have been attempting to perfect our balance. The failure of the many arrangements we tested was due to the displacement liquid used. Mercury, which, at first thought, would appear to be well suited for this purpose, due to the fact that it will not wet the metal of the plunger or cup, has a low vapor pressure at room temperature and low coefficient of expansion. Mercury, however, has a high surface tension which precludes its use. Pure water, also, has a high surface tension and can not be used. Organic liquids with low surface tensions have high coefficients of cubical expansion which causes some inaccuracies in the balance since the movement of the plunger, and in turn that of the light beam on the scale, depends upon the density of the liquid which changes with the temperature. The properties that an ideal displacement liquid should have are: Low surface tension, low vapor pressure, low viscosity, and low thermal coefficient of expansion.

Water has low viscosity and low coefficient of expansion but it has high surface tension and vapor pressure. However, for some time we used water for the displacement liquid by adding a thin layer of high boiling-point kerosene to reduce the interfacial tension between the water and the metal of the plunger and cup. The evaporation of the water which necessitates frequent additions to the supply in the cup is objectionable. We finally selected a pure organic liquid as the best one available for use in the displacement cup. It has low viscosity, vapor pressure, and surface tension, but, in common with other organic liquids, has a higher coefficient of thermal expansion than water. The variations in the movement of the image of the lamp filament on the scale caused by the change in density of the displacement liquid has been overcome by installing a threaded rod *j* on the arm which carries the pointer and by placing a movable threaded weight *k* on the rod. The deflection of the beam of any balance for a given difference in the loads on the pans varies directly with the distance between the central knife-edge and the end knife-edge and inversely with the weight of the beam and the distance of the center of gravity of the beam below the central knife-edge. Therefore, raising the center of gravity of the beam system increases the deflection. Thus the scale may be lengthened or shortened by moving the weight *k*. The rapidity with which a balance returns to its position of equilibrium after being displaced is influenced by the position of the center of gravity of the beam. In an ordinary balance the center of gravity of the beam must be below the knife-edge, but in our balance it may be above or below because the stability is controlled by the plunger assembly. The weight *k* may be adjusted readily but this need be done only when there is considerable variation in temperature. The change in density of the displacement liquid with temperature variations will cause changes in the rest point of the balance which may be compensated for by means of the adjusting screws. Adjustments due to this cause may have to be made more frequently than the adjustment of the length of the scale. With the present arrangement, the smallest amount of liquid which can be used and still allow the plunger to operate should be placed in the displacement cup.

We are using the balance to weigh accurately to

0.05 gram. The scale and plunger are of such dimensions that 10 grams is indicated on the scale. The loads on the pans have to be balanced to within 10 grams and then the excess in weight is indicated on the scale. However, the scale and plunger can be changed to increase or decrease the portion of the weight which is automatically indicated on the scale. It is rather simple to calculate the diameter of the plunger necessary to give an even multiple or an aliquot part of the scale, and the plungers may be interchanged readily. Since the length of the scale can be changed by adjusting the weight k, the calculation of the diameter of the plunger does not have to be exact. We have replaced and used the plunger shown in the sketch with a smaller one so that the entire length of the scale indicates 2 grams only, instead of 10 grams.

The scale divisions are equally spaced throughout the entire length of the scale. The total movement of the beam of the balance is through a relatively small angle, about 5° 55′, and for such an angle the error introduced by equally spacing the scale division is negligible. The scale a may be made flat instead of being shaped in the form of an arc, but it is necessary to arc the scale in the balance shown to keep the image of the lamp filament sharply focused throughout the entire range of the scale. On the analytical balance mentioned below we use a flat scale. Another change in the construction of this balance is in the adjustment for the change in rest point due to the contraction or expansion of the displacement liquid which is made by shifting the scale.

Our device has been installed also on an analytical balance of 200-gram capacity. A difference in loads on the weighing pans of 1,000 milligrams or less is indicated on the scale, and the scale can be read easily to 5 milligrams, but it is possible to make the balance more sensitive than this.

The balance has been proven to be simple to construct and operate. It is accurate, and since the movement of the indicating beam of light may be altered at will and the plunger may be interchanged to give different values to the scale divisions, it is extremely flexible and may be employed for a wide variety of weighings. We have found the balance to be very useful in preparing samples of definite weight, since the amount of material to add after the approximate quantity has been placed in the weighing cup is indicated on the scale. The fatigue of weighing is reduced with our balance, and the speed of weighing is greatly increased.

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SECTIONING ORBITOID FORAMINIFERA[1]

THIS fall, wanting to make some careful studies of several different Orbitoids, of which there was only one specimen each available, it was necessary to develop a new technique in order to get both equatorial and vertical sections from the same specimen, the ordinary technique requiring more than one individual.

The technique developed is applicable to all Orbitoids ranging in size above 3 mm in equatorial diameter. The method is as follows:

The specimens were first freed of matrix. Then a common cork about 25 mm in diameter (Fig. 2) was

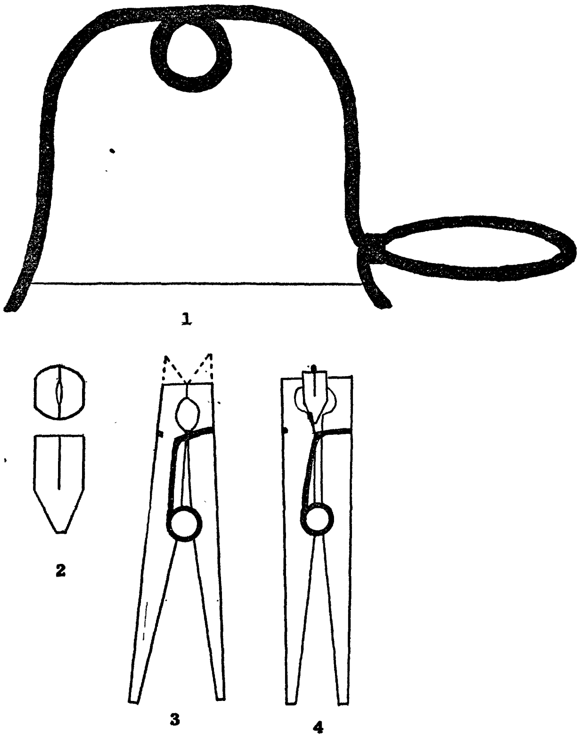

FIG. 1. Fret saw strung with wire. 2, Cork cut to hold specimen. 3, Spring clothes pin with ends cut off as shown by dotted line. 4, Clothes pin, cork with specimen in place to cut.

slit with a sharp blade about two thirds of the way down the center and the sides cut off parallel to the center cut. The lower part was then beveled off to allow it to be grasped in a common spring clothes pin. It is necessary to select a good cork and to cut it parallel with the grain.

The specimen was placed in the cut in the cork for about one half its diameter, the rest sticking out. Then an ordinary spring clothes pin with the ends cut off, as in Fig. 3, was used to hold the cork plus the specimen. I found it best to force a slight depression in the sides of the cork against the specimen so

[1] Method developed during some work done under a grant from the National Research Council.