

tion of silver nitrate is placed in *A* and then a weighed piece of magnesium (about 0.01 g.). This is stirred about with a glass rod so as to remove the silver from the ribbon as fast as it is deposited. When all the magnesium has disappeared, the stopper is removed. As the solution runs out, the precipitated silver is retained by the glass wool in *B*. After well washing the metal, the funnel is placed in a drying oven or on a sand bath to dry. On weighing the funnel with the silver, the weight of the precipitated metal is found and its equivalent calculated. For example:

Weight of magnesium used ..... = 0.104 g.

Weight of funnel alone ..... = 17.215 g.

Weight of funnel + silver ..... = 18.156 g.

Weight of silver ..... = 0.941 g.

Accordingly, 0.104 g. of magnesium has displaced 0.941 g. of silver, and since the equivalent of magnesium is 12, that of silver is  $0.941 \times 12 \div 0.104 = 108.1$ .

In a similar manner the equivalents of other metals can be determined, it being necessary in some cases to use *hot* solutions in *A* and in the case of an easily oxidized metal (*e. g.*, copper) it is as well to aid the drying by washing it with a little alcohol and ether.

Numerous other experiments can be performed by means of this simple piece of apparatus, which under ordinary circumstances could not be undertaken by *beginners*, owing to the great manipulative skill required, but the results of which are of great educational value when "discovered" by the pupil. Thus, one can set a class of 30 pupils to work to find out the equivalent of chlorine by dissolving a known weight of silver in nitric acid, and precipitating the metallic chloride in the funnel, and on comparing the results it will be found that the equivalent obtained by *each* pupil is the same within less than one per cent of error.

### A SIMPLE AUXANOMETER.

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Many simple auxanometers have been devised for recording the growth of a plant at all hours of the day.\* Perhaps it will be sufficient to state that simplification of apparatus, so as to

\*Ganong's Plant Physiology, 1901, p. 105, refers to a number of these, and choice may be had among them.

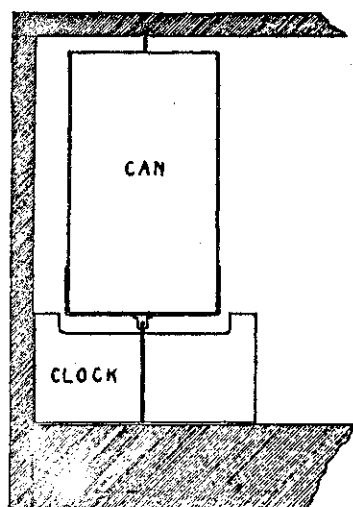
make physiological work possible in more secondary schools, is the chief reason for giving this description of a boy's-made auxanometer. So far as I know, none of those described can be made by boys or an inexperienced teacher.

The boys were given a rough sketch, the materials, and a description of what was wanted. After the apparatus was completed and in use, a first-year student in the Drawing Department made the working drawing here presented. Of course, the wood-work was somewhat rougher than sketched, but this was no serious drawback.

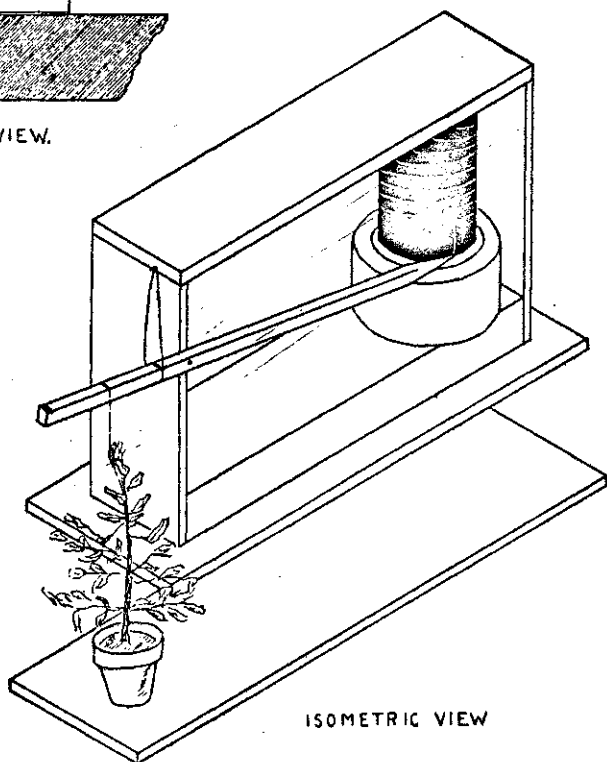
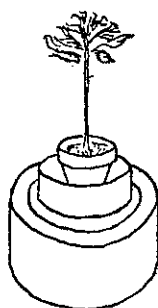
The materials necessary for the device are some pieces of  $\frac{3}{4}$ -inch boards (ours were from a soap box), nails, a cheap nickel day clock, an empty one-pound baking powder can. First, the button on the back of the clock, for turning the hands, was soldered to the middle of the cover of the can. Then a tack or small nail was soldered to the middle of the bottom of the can. This formed the cylinder upon which the blackened paper is carried.

The boards would better be cut or split about as wide as the diameter of the clock. Two pieces are cut fourteen inches long for the top and base. The base may be doubled or nailed to a heavier baseboard for stability. In the former case it will appear  $1\frac{1}{2}$  inches thick as in the sketch. Next two end pieces were cut 9 inches long—enough to make an oblong frame, with the top and base board so that the cylinder on the back of the clock may stand in one end of the frame. When the frame was nailed together this end of it was left open at one joint so as to raise the top for putting the clock (on its face) and cylinder in place (see sectional view). Just where the nail or tack in the top of the cylinder came, a hole was bored through the top-board for the insertion of the nail; this keeps the cylinder upright while the clock rotates it. A pointed marker twelve inches long and  $\frac{1}{4}$  inch in diameter was cut from thinner boards and pivoted to about the middle of the end of the frame opposite the end in which the clock and cylinder stand. The hole in the marker for the pivot should be  $\frac{1}{4}$  the length so that the record is magnified three times.

The marker must be put on that side of the frame that will insure the cylinder being turned away from it by the clock, other-



SECTIONAL VIEW.



ISOMETRIC VIEW

wise the point of the marker will catch on the blackened paper of the cylinder and stop the record. With several notches cut on the end of the marker it is adapted for plants differing in their rate of growth. The elastic band outside the pivot of the marker is to take up the slack caused by the growth of the plant and thus to move the marker down the cylinder as fast as the plant grows. (See figure.)

When the clock is wound and in place some paper is pasted on the tin cylinder. This may be easily smoked from the flame of a piece of candle wicking that has been dipped in coal oil; if one application is not enough a second dip will insure a more uniform coat. A twirling motion of the cylinder, while holding the end pivots between thumb and fingers, will bring about the best result in the least time. After the cylinder is carefully placed in position the time of starting should be marked by a short vertical line and the plant immediately attached. Where it is possible the temperature should also be noted as often as possible and recorded on the line just outside the point of the marker.

When the record is complete it may be fixed while on the cylinder with shellac fixative and may then be preserved for future reference. Any writing to be done on the record must, of course, be done before the fixing.

The clock with the cover of the baking-powder can may be also used as a sort of clinostat as shown in the upper figure. A small pot of seedling morning glories, placed in the cover and one placed by the side for control will show the phenomenon of heliotropism nicely. Then if some germinating peas are pinned to a cork or to a piece of circular, soft-wood board, and some wet sphagnum or sawdust placed over them and the whole fitted into the tin cover, the effect of rotating the seedlings in a vertical direction may be observed. A few experiments may be necessary to find seeds or temperature such that the root's rate of growth and the rate of movement of the clock are about the same. Very satisfactory results have been obtained in this way without changing the rate of the clock. A very simple, though not as satisfactory way, is to remove the glass in the front of the clock and tie a small vial filled loosely with soaked morning glory seeds and sawdust, to the minute hand, lengthwise, but as near the pivot as possible.