A SIMPLIFIED PRECISION AUXANOMETER

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In a former paper[1] the writer described a precision auxanometer capable of registering very small increments of growth. The improved auxanometer here described works on the same principle as the previously described instrument. It consists essentially of a device which is carried upwards as the plant grows. When the device has moved a certain distance, it closes an electric circuit, which operates the recording pen of a chronograph. As pointed out in the paper referred to above, this arrangement makes it possible to have the recording mechanism at any desired distance from the plant and also to make simultaneous records of a number of plants or of various parts of the same plant.

The design of the instrument has been changed in order to make it suitable for the class room. The new auxanometer is light, compact, easily and quickly attached to the plant, and, as the force of gravity is not utilized for moving any of its parts, it may be set at any angle with the vertical, so that growth in any direction may be measured and recorded. A slight change in the electrical mechanism has made the instrument more reliable. The experimental model ran the entire summer in the garden exposed to the weather, the brass case being open part of the time so that the internal mechanism was exposed.

A rack and pinion has been substituted for the micrometer screw and nut of the instrument described in 1912. This change has been made in order to lower the cost of manufacture. For special research work, where records of very small variations in the rate of growth are to be made, the micrometer screw model should be used; but it has been found that for class work, and for research work where great precision is unnecessary, the rack and pinion gives satisfactory results. In the instrument with the micrometer screw the escapement wheel is fastened to the top of the micrometer screw and consequently the control of the motion of the micrometer screw is positive. As will be seen presently, the instrument described here does not possess this

[1] Bot. Gaz. **53**: 504–509. 1912.

valuable feature. The difficulty has been met by making the instrument less sensitive. The improved instrument records each 0.1 mm. of growth, and the errors due to the loss of motion of the various parts of the mechanism are within the range of other unavoidable errors. Making the instrument less sensitive has an advantage for classroom work. It has been found that if the instrument is more sensitive the

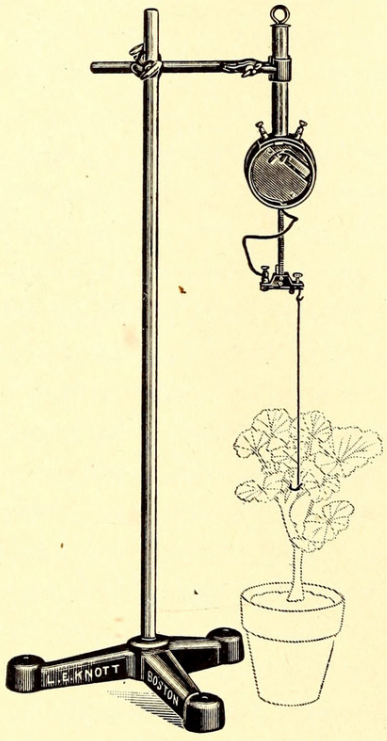

FIG. 1. A simplified precision auxanometer.

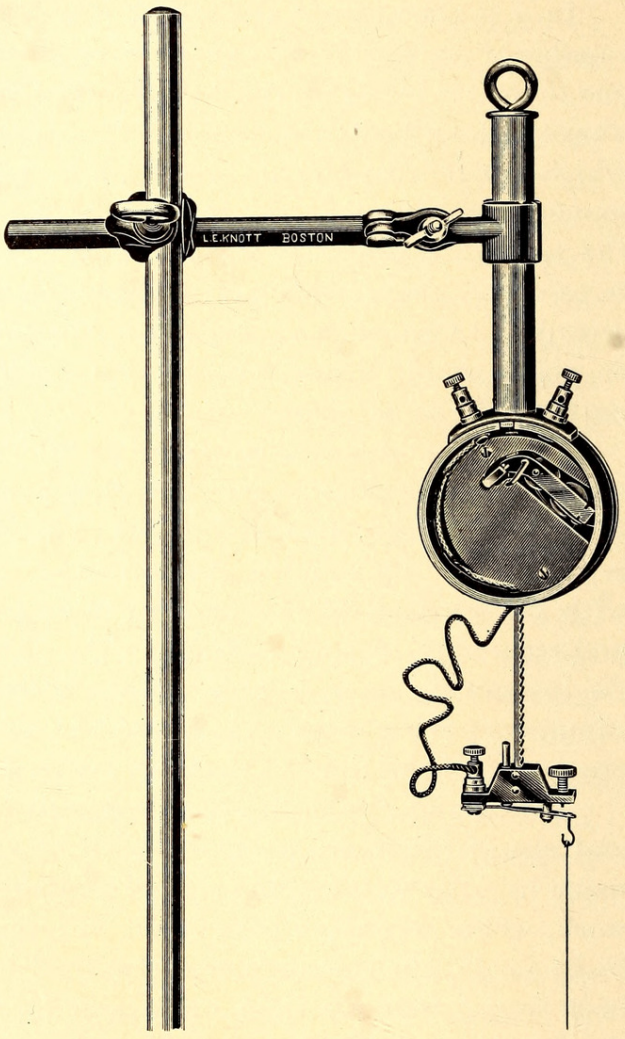

FIG. 2. Precision auxanometer, showing external details.

task of counting the checks on the chronometer record and plotting the curves requires too much of the student's time. The record of the

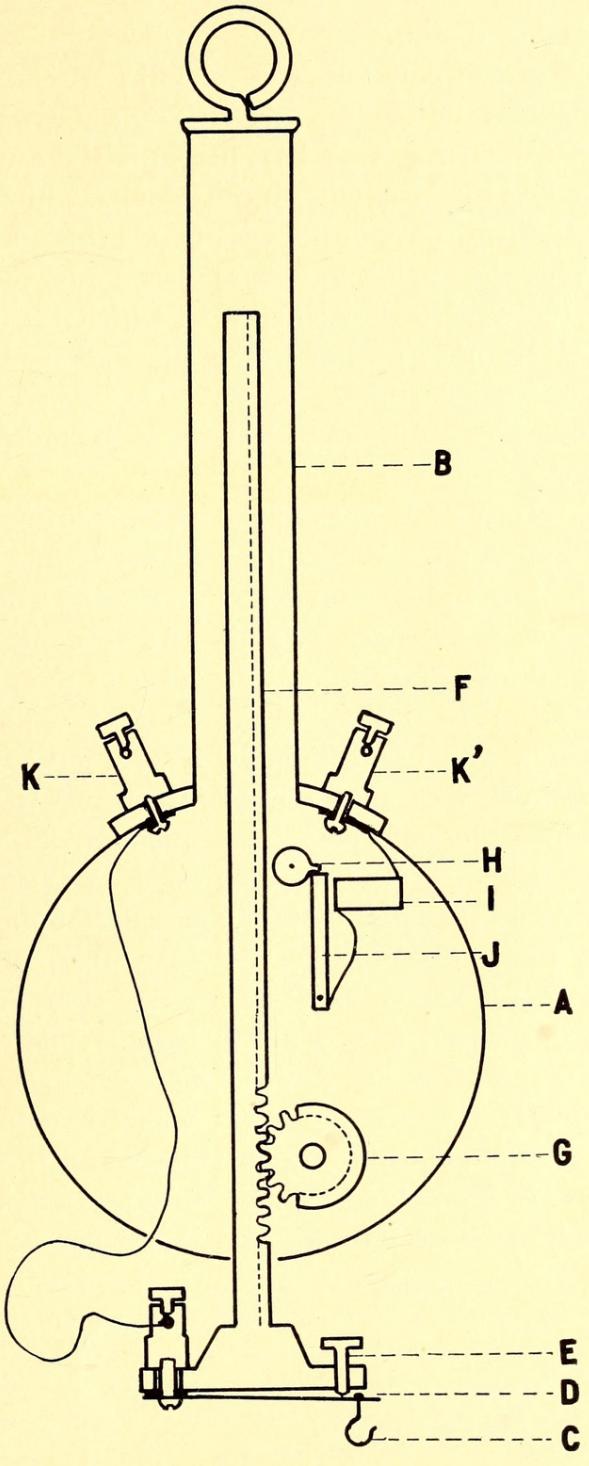

FIG. 3. Precision auxanometer, showing construction (see text for explanation).

improved instrument, because of the smaller number of checks, requires less time for plotting the curves.[2]

The principle of the new instrument will be understood from the accompanying figures. Figures 1 and 2 show the exterior while figure 3 shows the construction. *A* and *B*, fig. 3, is the auxanometer case. The plant is attached by a fine wire to the hook *C*, which is fastened to a flat spring. A slight tension on the wire bends this spring downwards. As the plant grows the spring moves upwards and touches the screw *E*, thus closing the electrical circuit at *D*, which up to this time has been open, since the other end of the spring and its binding post are insulated from the block supporting *E*. The tension on the spring, which is controlled by turning the screw *E*, is so slight as not to affect the rate of growth.

Through the terminals *K* and *K'* the instrument is connected to an battery and chronograph. When the contact is made at *D*, current flows through the instrument and the chronograph and the pen of the chronograph makes a record. The current through the instrument flows from the terminal *K* to the binding post of the flat spring, along the flat spring and on to the screw *E*. From *E* it flows through the rack *F* to the pinion wheel *G*, through a train of gear wheels and their supporting framework (not shown in the diagram) to the escapement wheel *H*, then on to the armature *J* and through the electromagnet *I* to the terminal *K'*. The electromagnet *I* is thus energized, and attracts the armature *J*, which is held against *H* by a spring. When the armature *J* moves over against the electromagnet it releases the pin on the escapement wheel, and at the same time opens the circuit, since the contact between *H* and *J* is broken. The electromagnet is thus deenergized, the armature *J* returning to its position against the escapement wheel *H*. The escapement wheel is connected with the pinion wheel *G* through a train of gear wheels and the pinion wheel is under the tension of a clock spring. Therefore, when the pin on the escapement wheel has been released by the movement of the armature

[2] The L. E. Knott Apparatus Company of Boston have developed a special chronometer which in addition to making the records, automatically draws a curve of the rate of growth. The writer has had no part in the development of this chronometer other than to test the experimental model. The instrument does its work well, but it has the disadvantage that the record of only one auxanometer can be made at one time. With the chronometer which the writer has devised for his own use (a drum rotated by an eight-day clock) the record of six auxanometers can be made at one time.

J, the escapement wheel turns. At the end of one revolution the pin of the escapement wheel is again engaged by *J*. For each revolution of the escapement wheel the pinion wheel *G* turns sufficiently to lift the rack *F* 0.1 mm. This upward movement of the rack causes the contact at *D* to open and the plant must grow 0.1 mm. before it will close again. Thus it will be seen that a record is made for each 0.1 mm. of growth, and from the chronograph records the rate of growth may be determined.

It will be noticed that the circuit is closed at *D* but never broken there. The break is between *H* and *J*. This avoids arcing and the pitting of the terminals at *D*. It prevents sticking and actual falsification of the record due to changes in the length of *E*. Making the break between *H* and *J* has another advantage: in setting up the instrument it is only necessary to attach the plant at *C*, and make the electrical connections. The escapement wheel is released and continues to revolve until the rack *F* has lifted sufficiently to open *D*. The instrument then begins to record growth, no further adjustment being necessary.

As the rack *F* moves up into the case the clock spring which actuates *G* unwinds. It is rewound by grasping the lower end of *F* and pulling it down. As the rack is 15 cm. long, 15 cm. of growth may be recorded at one winding.

The expense of the experimental work on this machine has been borne by the L. E. Knott Apparatus Company of Boston and their mechanician, Mr. Browne, is to be credited with the development of the design so as to minimize the cost of manufacture.

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