

# A PORTABLE OPTICAL PLANIMETER FOR MEASURING LEAF AREA

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The increasing use of the photoelectric cell method for measuring the area of botanical materials is evidenced by the many instruments developed since the pioneering work of Gerdel and Saulter in 1928. Although the value of using this principle was clearly demonstrated, the early designs (Gerdel and Saulter, 1928; Marshall, 1933; Withrow, 1935; Mitchell, 1936) were cumbersome, consequently none of these instruments were adopted extensively by plant scientists.

Had the report of Bergman (1933) been published it might have influenced the design of later instruments as the collimated lens system offered certain advantages not found in other instruments. The following described instrument might appear to be one of Dr. Bergman's suggested modifications, however this instrument had been developed and used two years prior to the receipt of his report.

The need for a rapid, accurate method of area determination was recognized in this laboratory during transpiration studies. The methods usually employed (Miller, 1931; Darrow, 1932) proved to be laborious and prohibitively time consuming. Because few of the previously described instruments met the desired qualifications, the instrument described here was designed to be portable, large enough to accommodate most specimens and/or segments of larger ones, easy to calibrate and operate, capable of rapid recordings, and neither complex nor expensive (\$10.00, less labor and accessory instruments).

Direct current was used by Gerdel and Saulter (1928) and Mitchell (1936) to eliminate power fluctuations. These fluctuations are effectively controlled by the use of a variable resistance (Bergman, 1933; Frear, 1935; Kramer, 1937) allowing the use of alternating current, as was employed with this instrument. A voltmeter is usually incorporated, but was found unnecessary with this instrument because standardizations are made from the more sensitive Weston Master light meter.

## DESCRIPTION OF APPARATUS

The apparatus consists of a vertical metal tube which encloses an adjustable light source, specimen stage and press, adjustable light meter probe stage, and a collimated lens system. The optical system consists of two 5-inch double-convex lenses which have a focal length of 9.89 inches. Heat dissipation is accomplished by perforations in the top of sleeve (B) through grid plate (A) and the sides of the supporting tube.

The light source, a single, inside frosted, 100-watt bulb (C) was used to correspond to the light meter scale desired, to eliminate the need for a fan cooling system and complex center brightness corrections. The adjustable sleeve (B) permits easy access to the light socket so that replacement bulbs of the same or different wattage may be installed. This sleeve is held in place by friction and may be adjusted to the proper focal distance from the fixed collimating lens (D) as is indicated by the maximum light meter reading.

The sunken plate specimen stage (G) is made readily accessible by lifting the leveling plate (E) by means of the sleeve knobs (Q). The plastic leveling plate (F) is recessed flush with the sleeve as curling of the specimen causes significant reduction in foot-candle reading.

The adjustable light meter stage (K) is equipped with spring clips (P) to facilitate removal of the light meter probe when it is desirable to use it elsewhere. The

tension on these clips assures correct alignment with the fixed focusing lens (I). Correct alignment is indicated by obtaining the maximum reading at a selected voltage.

A knurled ring stand rod (N) supports a ring (O) which holds potted plants in any position so that those attached leaves being measured are on the same plane as the specimen stage when light meter readings are being taken. The tube is attached to a cushioned steel base which prevents tipping.

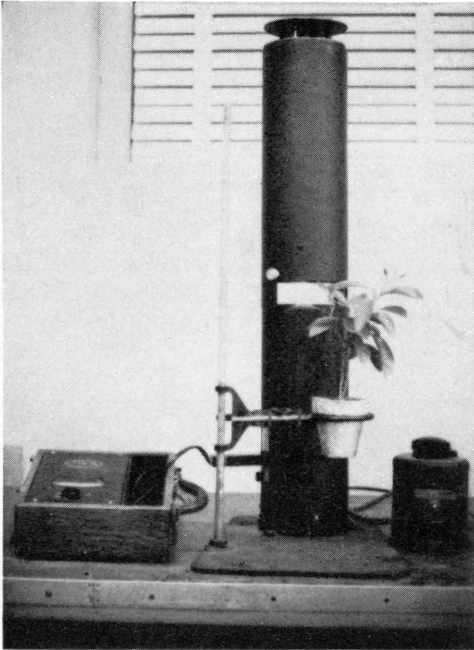


FIGURE 1. Photograph showing plant in position.

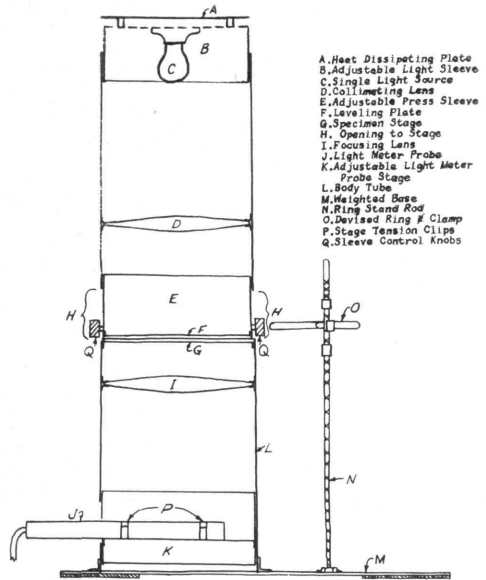


FIGURE 2. Diagrammatic sketch showing internal features.

CALIBRATION

Calibration of the instrument was accomplished by taking light reduction readings of materials with opaque to low light transmission properties, cut simultaneously to insure area exactness. Various sizes and distribution on the stage were employed to check for uniform distribution of light and sensitivity range.

Readings were plotted and shown in figure 3. Differences for those plant materials utilized were determined to be non-significant; therefore, only one reference chart was used to provide area values for the reading observed.

Readings were compared with those obtained from the same specimens by tracing and using a Keuffel and Esser model 4236 planimeter. The readings of smaller leaves were 1.2 per cent less than determined by the planimeter method, while those near the maximum capacity of the instrument indicated an increase of 1.4 per cent above those obtained with the planimeter. Because of the random sizes of leaves in a significant sample, and because of inherent positive errors in the mechanical planimeter method, the slightly lower readings obtained with the use of this device are accurate to within  $\pm 1$  per cent as determined by a comparison of the two methods during transpiration studies (Wallace and Stout, 1962).

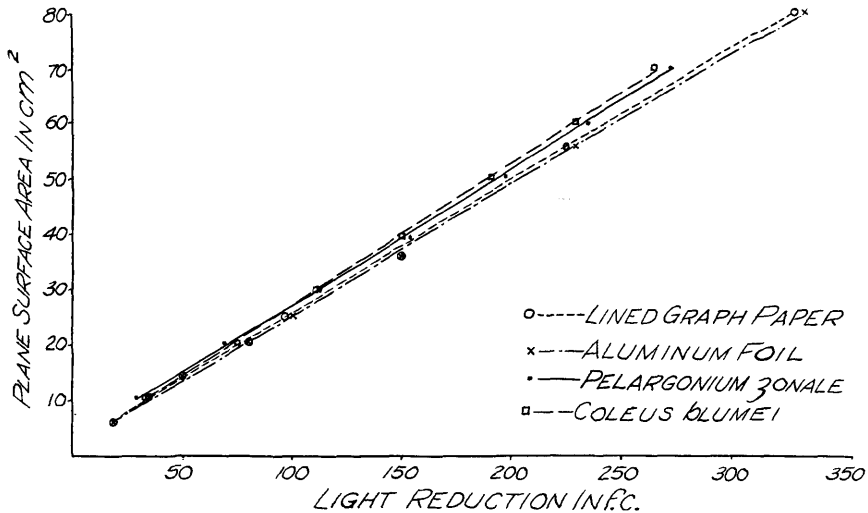


FIGURE 3. Calibration graph showing straight line relationships for four materials measured.

#### SUMMARY

A portable photoelectric device is described, which by modification of designs based upon principles employed by earlier researchers, incorporation of adjustable mechanisms and detachable accessories, provides an accurate, economical, and practical instrument for measuring leaf area.

#### ACKNOWLEDGMENT

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