priately selected cork-borers. In order to prevent cracking of the disc it is necessary that the cork-borer be hot. I have found that immersion of the instrument in hot water does this best. So heated, a little well-like curbing is formed around the hole which serves nicely to keep the seedling raised from the flat upper surface of the disc.

It will be at once evident that this device is capable of any modification necessary to suit the individual need. It also allows of easy adjustment of depth of culture solution and degree to which the roots are immersed therein. Its convenience will be apparent to those who have wrestled as I have with the unplastic cork.

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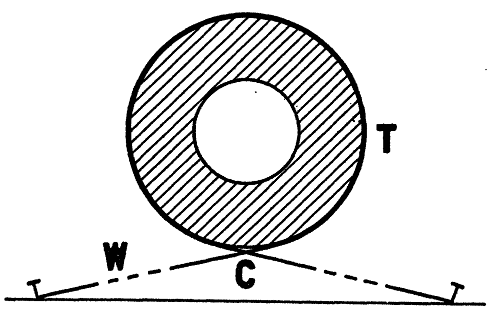
A METHOD FOR CUTTING GLASS TUBING

THE accompanying figure illustrates a method which has been found to be successful for cutting heavy glass tubing. A piece of bare, soft-drawn copper wire "W" is wrapped once around the tube "T" and fastened to the work bench. A mixture of carborundum powder and glycerine makes a convenient grinding compound. A to and fro motion of the glass in a direction parallel to the plane of the figure produces relative motion between the wire and glass and the carborundum is thus carried around. The glass should occasionally be turned so as to make a cut of uniform depth. In case it is



necessary to locate the cut exactly some kind of clamp or guide should be used until a groove is started. If a deep cut is made the point "C" where the wire crosses causes binding. When this stage is reached it is well to mount the tube in a lathe and hold the wire in the groove using only one half of a turn. (Be sure to protect the lathe from the compound.) New wire should replace the old frequently to avoid binding when the new is used.

The author's first use of the method was in cutting a Pyrex tube having an outside diameter of 4.4 centimeters and 1.2 centimeter walls. Number 80 carborundum powder was used, first with Number 18 wire and then with Number 20. The cutting time was about three hours. Finer wire and powder would be better for smaller or more delicate pieces.

The method has the advantages of simplicity, small breakage risk and freedom from strains introduced by methods using heat. It is particularly useful in cutting short lengths of tubing.

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SPECIAL ARTICLES

REFLECTION OF LIGHT FROM THE SURFACES OF LEAVES

THE classical studies of Brown and Escombe[1] on the interchange of energy between the leaf and its environment form our only important sources of information as to the quantitative income and outgo of energy during the processes of photosynthesis, transpiration and thermal emissivity. They measured the solar radiation with much care, determined the coefficient of absorption of energy by the leaf, measured the amount of energy expended in the various forms of internal work, and the gain and loss of energy during positive or negative thermal emissivity at the leaf surface. From these various determinations they attempted to construct a balance sheet of the energy income and outgo of the leaf.

Careful consideration of their work makes it obvious that their figures, which account for 100 per cent. of the energy inflow in terms of work and transmission, can not be as accurate as they appear to be at first glance. The most patent error is one to which they referred, but neglected because they thought it was a small error. This is the reflection of light from the leaf surface, which, they say, with perpendicular incidence "must be very small in amount." The reflected light was allowed to enter, as an error, into the calculation of the coefficient of absorption, which is therefore too large.

During the last two years many measurements of the reflection of light from leaf surfaces have been made by means of the Keuffel and Esser direct reading spectrophotometer. This instrument is designed to measure the percentage of reflection at an angle of 90° to the surface of the leaf when the incident light falls upon the leaf from almost every possible angle. By means of a wheel, carrying a wave-length

[1] Brown, Horace T., and Escombe, F. "Researches on some of the Physiological Processes of Green Leaves with Special Reference to the Interchange of Energy between the Leaf and its Surroundings." *Proc. Royal Soc.* London B. 76: 29–111. 1905.

TABLE I

PERCENTAGE OF 90° REFLECTION OF BRIGHT DIFFUSED LIGHT FROM THE SURFACES OF LEAVES

Species	Wave Lengths in mμ														
	430	440	460	480	500	520	540	560	580	600	620	640	660	680	700
Syringa vulgaris															
Upper surface	3.0	3.5	4.5	4.5	4.5	5.0	6.0	6.5	6.0	5.5	5.0	5.0	4.0	3.5	3.0
Lower surface	8.5	8.0	8.5	9.0	10.0	12.0	16.0	16.0	14.0	13.0	12.0	11.0	8.0	8.0	8.0
Morus rubra															
Upper surface	4.0	4.5	5.5	5.5	5.5	6.5	8.5	8.5	7.0	5.5	5.0	5.0	5.0	5.0	4.0
Lower surface	7.5	8.0	8.0	9.0	10.0	12.5	14.0	15.0	13.0	11.0	10.0	10.0	9.0	7.5	10.0
Populus alba															
Upper surface	6.5	7.5	9.0	10.0	12.0	14.0	19.0	20.0	16.5	13.0	12.0	12.0	10.5	10.0	8.5
Lower surface	50.0	50.0	50.0	50.0	50.0	51.0	50.0	52.0	53.0	51.0	52.0	51.0	50.0	51.0	50.0
Psedera quinquefolia, autumn crimson															
Upper surface	5.0	4.5	4.5	5.0	5.5	6.0	7.0	6.5	7.0	9.0	12.0	13.0	12.0	8.0	17.0
Lower surface	9.0	11.0	13.0	14.0	14.0	17.0	19.5	21.5	22.5	24.0	26.0	28.0	22.0	18.0	28.0
Betula alba, autumn yellow															
Upper surface	5.0	6.0	6.0	7.0	8.0	16.0	24.0	30.0	33.0	35.0	37.0	39.0	42.0	38.0	32.0
Lower surface	11.0	12.0	12.0	13.0	15.0	23.0	26.0	30.0	32.0	33.0	33.0	34.0	39.0	36.0	35.0

scale, the constant deviation prism of the spectrometer may be adjusted to throw light of any desired wave-length into the comparison telescope. It is possible, therefore, to measure the percentage of reflection in each portion of the spectrum from 430 mμ to 700 mμ. The measurements were made at about 20 mμ intervals across the spectrum, for many different kinds of leaves, chosen for variation in color, texture, and quality of surface. The accompanying Table I presents a few of the measurements.

From the measurements presented, it is seen that the greatest reflection in green leaves usually falls at about 540 to 560 mμ, and in the darkest green leaves like those of *Syringa vulgaris,* the reflection is a little over 6 per cent. in this region of the spectrum. In lighter green leaves, as in *Populus alba,* the reflection is much greater, 20 per cent. at 560 mμ. The under surface of the leaf of *P. alba* is very hairy and white. The reflection from this surface was about the same across the entire spectrum as would be expected in a gray color, and accounted for fully 50 per cent. of the incident light.

In autumn colored leaves, such as the crimson leaves of *Psedera quinquefolia* and the brilliant yellow leaves of the white birch, *Betula alba,* the greatest reflection naturally occurs in the brighter regions of the spectrum, at 640 and 660 mμ. The upper surface reflection of *Psedera* leaves is low in comparison with the reflection from *Betula* leaves. The latter in autumn brilliancy reflect over 40 per cent. of the incident light, the former about 13 per cent. Many other measurements have been made with similar results. These will be published in detail elsewhere.

The results indicate that we are not justified in omitting reflection as a factor when we attempt to develop a balance sheet for energy "revenue and expenditure" of leaves. If the correction of the coefficient of absorption of energy could be made in some simple manner for the reflection factor, the omission would not be so serious. But if we correct this item in the energy relations, the other figures have to be changed also, and no simple correction can be applied to these. They can only be remeasured, and the entire work done over, with reflection taken into account.

As Brown and Escombe did their work chiefly with the leaves of one species, *Catalpa bignonioides,* it is certain that many leaves differ from this species in mass per square centimeter of surface. This difference will also disturb the calculated balance of energy with special reference to thermal emissivity. The energy relations of leaves are therefore in need of reinvestigation, and the balance sheet of energy should be constructed on the basis of a more critical study of all the energy factors involved, and on the basis of a study of a number of leaf types.

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