cutting angles (angle between knife and the horizontal plane). An increase in the cutting angle from 10°–20° resulted in a significant (5 per cent) increase in the number of slip planes induced.

In all these sections there was a tendency for more slip planes to develop on one side of the double wall than on the other side (Fig. 2). This confirms previous observations by Kisser and Steininger[5], who consider this diagnostic of microtome induced slip planes.

In the examination of a brash sample of spruce timber containing microscopic compression lines, a reduction in the draw angle of the knife to 1·5° prevented the formation of slip planes, but the microscopic compression creases, originally present, remained (Fig. 3). It will be noted that these horizontally aligned series of slip planes tend to be equally developed on each side of the middle lamella, unlike those induced by sectioning. As previously recorded[9] it is possible to have microscopic compression lines develop in wood without first having slip planes, though, as already noted, if slip planes are present, they will generally develop into compression lines.

Slip planes are normally associated with brittleheart timber[9,13]. A preliminary investigation of slip plane development in this type of timber was made using sections (draw angle 2°) of utile (*Entandrophragma utile*), idigbo (*Terminalia ivoresis*), ramin (*Gonystylus bancanus*), agba (*Gossweilerodendron balsamiferum*), danta (*Nesogordonia papaverifera*), and three species of *Shorea*. Each timber displayed a considerable number of microscopic compression lines, but isolated slip planes were generally absent or else, as in one of the *Shorea* species and also utile, a few were present in isolated areas. Further work is required to establish if these slip planes are induced or are of natural occurrence.

In conclusion, it is possible to produce slip planes during section cutting, a view which is contrary to some previous results[2,9]. The present results confirm the conclusions of Robinson[7] and Kisser *et al.*[5,10] and will necessitate the re-examination of many previous results on slip planes. Their presence in many timbers appears to have been an artefact. To eliminate the possibility of inducing slip planes, sections should be as thin as possible (less than 10μ), cut with a draw angle less than 5° and at as low a cutting angle as possible.

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Resistance to Water Transport in Plants—a Misconception

IN 1948, van den Honert[1] directed attention to Gradmann's idea of applying an analogue of Ohm's law to water movement in plants, and others have made the same suggestion (see Ray[2] and Monteith[3]). Using this analogy, Gradmann concluded that the major resistance to water flow in the plant is in the gaseous phase above the transpiring surface, since almost all the potential drop occurs there. Van den Honert reconsidered this idea and concluded that the "permeability" of a free water surface appears to be 20 to 500 times smaller than protoplasmic permeability. He also concluded that regulators of water transport can be in the gaseous phase only, and if, for example, resistance to the passage of water in the roots is increased, it will have little effect on the overall rate of water transport.

These conclusions were contrary to accepted concepts, and Gradmann's view received little attention in the literature. "If correct," van den Honert says, "his conception and some of its corollaries may be considered of importance in all cases where water transport as a whole is concerned."

Recently, many[4] have accepted the concept of major resistance to flow in the gaseous phase above the transpiring surface, although Ray[2] has objected to the equation on theoretical grounds, and Monteith's[3] calculations conclude that the aerodynamic resistance to diffusion of water vapour is not large compared with the internal resistance of the plant. Gradmann's application of Ohm's law to water flow in plants has even been referred to (orally) as "van den Honert's law". It is essential to examine the conclusions quantitatively. On the basis of the analogy, van den Honert expresses the rate of flow of water through a plant as

$$\frac{dm}{dt} = \frac{P_1-P_0}{Rr} = \frac{P_2-P_1}{Rx} = \frac{P_3-P_2}{Rl} = \frac{P_4-P_3}{Rg}$$

where dm/dt is the rate of water transport in the steady state (stomata open); P is the potential (atms.); Rr is the resistance across the root; Rx is the resistance across the xylem; Rl is the resistance across the leaf; and Rg is the resistance across the gaseous phase.

Since the largest osmotic potentials of leaf cells are normally below 50 atms., he concludes that the potential drop from the soil to the top of the plant cannot exceed 50 atms. From the evaporating surface of the leaf to the outside air the drop may be 1,000 atms. (for example, at a relative humidity of 50 per cent) based on a conversion of relative humidity to osmotic potential units. Therefore, P_4-P_3 is about $20 \times P_3-P_0$, and from Ohm's law analogue, the resistance to flow at the evaporating surface must also be 20 times that of the whole plant.

The error in this argument is in assuming that the same kind of pressure is responsible for the flux of water in both the liquid and gaseous phases. The liquid is moving by bulk flow as a result of a gradient in hydrostatic pressure, whereas the gas is moving by diffusion, as a result of a gradient in vapour pressure. Consequently, when van den Honert states that the potential drop from the liquid water surface to the external atmosphere is 1,000 atms., he means that the vapour pressure drop from the evaporating surface to the gaseous phase in air (at a relative humidity of 50 per cent) is the same as the vapour pressure drop from a solution with an osmotic potential of 50 atms. to one with an osmotic potential of 1,000 atms. At 30° C, this vapour pressure drop is about 15 mm mercury or about 0·02 atm. This is only 1/2,500 of the drop in hydrostatic pressure that van den Honert concedes for the whole plant. Obviously, then, the major resistance to flow through the plant is in the liquid and not in the gaseous phase.

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