# How Vainly Men Themselves Amaze*

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It is a matter of some personal regret that the particular product of the palm tree to which this issue is devoted has not, so far, come my way. Nonetheless, on a small island in Fiji some seven years ago, I was able to form two major conclusions about the coconut palm (*Cocos nucifera*). The first has nothing to do with this article but, in view of the society being honoured, it is worth a passing mention. The local rum there is distilled—or so I would judge from its characteristics—from a mixture of sugar cane, old sacking and unwanted battery acid. It rates about 100 octane and, in emergency, can be diluted with an equal volume of paraffin to propel a jeep for several miles. There appear to be no ill effects to the jeep except for some incipient corrosion in the petrol tank. But, bore a hole in a green coconut, fill the interior space with rum and the result is delightful with no ill effects apart from a creeping paralysis of the limbs . . .

The second conclusion is that the coconut palm is a remarkable piece of natural engineering—and that is the subject of this article.

I cannot expect the Palmwine Drinkerds' Club to be fully conversant with all of the subtleties of engineering. So we must rely upon observation. And, since we live in a computerised age, what better way to instruct than by means of a flow chart. The process involves three stages:

*Stage A*

(1) Pour an emblem of palmwine.
(2) Carrying it with you seek a palm tree, part grown, which has a petiole (the trade name for what you call a branch) at a convenient height from the ground.
(3) If you cannot find one, call upon a friend, and go back to (1).
(4) You will find that, if you repeat this process often enough (2) will need a petiole even closer to the ground than you first thought.

*Stage B*

(1) Repeat A1 and proceed from here.
(2) Study Figure 1 as carefully as you are able.
(3) Observe the petiole carefully. Note that it is in the shape of a bent cantilever, and that the leaflets form a flexible blade.
(4) If you can create a small wind note that the petiole twists in order to equalise the wind forces on the two sides of the petiole.
(5) Note also that the action of the wind is to lift the petiole.
(6) If at any stage none of these phenomena are apparent GOTO A1 (that is the correct computer term, by the by).

*Andrew Marvell, "The Garden"

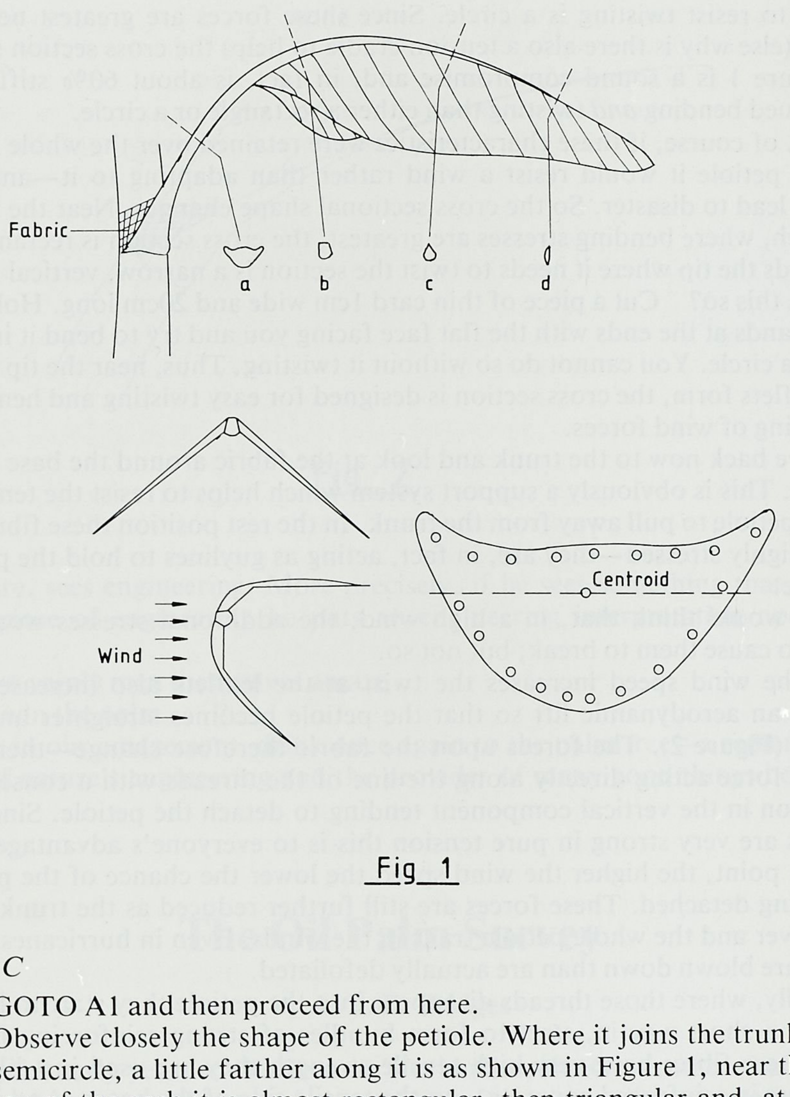


Fig 1

*Stage C*

(1) GOTO A1 and then proceed from here.
(2) Observe closely the shape of the petiole. Where it joins the trunk it is a semicircle, a little farther along it is as shown in Figure 1, near the very top of the arch it is almost rectangular, then triangular and, at the tip where the leaflets form it is a thin vertical blade.
(3) Since that is quite a lot to take in all at once you may, if you so wish, GOTO A1.
(4) Look at the attachment of the petiole to the trunk. It much resembles the old sacking referred to in my first paragraph. You will find that, if you slice this through each string will snap with the sound like a breaking banjo string. When enough are cut the whole petiole will fall on your head producing an effect (and an after effect) not unlike that produced by an excess of palm wine.

Now if you are sitting comfortably we will begin the difficult bit. The petiole must resist bending (due to its own weight) and twisting (due to the wind). The best shape of cross section to resist bending is a rectangle, the best shape to resist twisting is a circle. Since these forces are greatest near the trunk (else why is there also a tension cradle to help) the cross section shown in Figure 1 is a sound compromise and, in fact, is about 60% stiffer for combined bending *and* twisting than either a rectangle or a circle.

But, of course, if these characteristics were retained over the whole length of the petiole it would resist a wind rather than adapting to it—and that would lead to disaster. So the cross sectional shape changes. Near the top of the arch, where bending stresses are greatest, the cross section is rectangular. Towards the tip where it needs to twist the section is a narrow, vertical blade. Why is this so? Cut a piece of thin card 1cm wide and 20cm long. Hold it in both hands at the ends with the flat face facing you and try to bend it into an arc of a circle. You cannot do so without it twisting. Thus, near the tip where the leaflets form, the cross section is designed for easy twisting and hence the balancing of wind forces.

Move back now to the trunk and look at the fabric around the base of the petiole. This is obviously a support system which helps to resist the tendency of the petiole to pull away from the trunk. In the rest position these fibres are quite highly stressed—they are, in fact, acting as guylines to hold the petiole in place.

One would think that, in a high wind, the additional stresses would be likely to cause them to break; but not so.

As the wind speed increases the twist at the leaflets also increases and creates an aerodynamic lift so that the petiole becomes straighter and less arched (Figure 2). The forces upon the fabric therefore change—there is a greater force acting directly along the line of the threads with a consequent reduction in the vertical component tending to detach the petiole. Since the threads are very strong in pure tension this is to everyone's advantage and, up to a point, the higher the wind speed the lower the chance of the petiole becoming detached. These forces are still further reduced as the trunk itself leans over and the whole petiole trails in the winds. Even in hurricanes more palms are blown down than are actually defoliated.

Finally, where those threads disappear into the petiole they start to bunch and, in a short way in, start to form bundles of strong reinforcing fibres. Since these fibres have very high tensile strength they are used just like the steel bars in reinforced concrete—on the tensile side of the beam. And if you look at a section of the petiole at some point such as Figure 1 you will see most of these reinforcing bundles exactly where you would expect to find them—near the top of the semicircle cross section where the tensile forces are greatest. And, for good measure, there will be a particularly noticeable bundle on each of the 'ears' which act as stiffeners to prevent local buckling.

Much of the above is conjecture. We did not, in fact, realise that we were sitting in the middle of beautiful examples of natural engineering until the day before we left our island. And, in the panic to take measurements, cut up petioles, record cross sections and all, we may have missed out much of interest and significance. Thus even the way in which the petioles are arranged around the trunk is not without significance though it would stretch the bounds of credence to suggest what I think the engineering significance is.

But, of course, all of the above could be wrong. For an engineer, looking

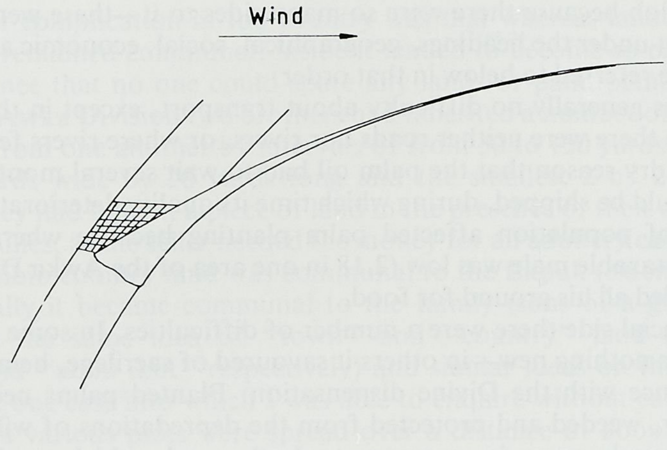


Fig 2

at nature, sees engineering. More precisely, if he sees something that looks like a piece of engineering he puts an engineering interpretation upon it. Thus

"How vainly men themselves amaze
To win the palm . . ."

And, in our amazement, drink once again to the palm tree—a remarkable piece of nature's engineering and the provider of many good things besides.

# The Oil Palm Survey

**by A. F. B. Bridges**

During the early years of the Second World War, the Government had been getting alarmed at the growing menace of the extensive plantations in Sumatra to the Nigerian industry and Agricultural officers had been doing all they could to improve yield and quality. The palm growing areas were entirely dependent on palm products, which had been the only export ever since the suppression of the slave trade around 1800. In some areas palm trees were almost the only vegetation, so thick was the growth, and it would have been practically impossible to develop any other export crop. Hand presses had been introduced to reduce the labour of oil extraction and mechanical nut crackers to reduce the labour of extracting the kernels. New high-yielding strains of palm had been introduced and efforts had been made to encourage the people to plant them. But all these ideas had little success and it was now my job to try to find out why.

During the next five months on this enquiry I travelled nearly 4,000 miles by road and canoe and interviewed nearly 6,000 individuals. It was a very