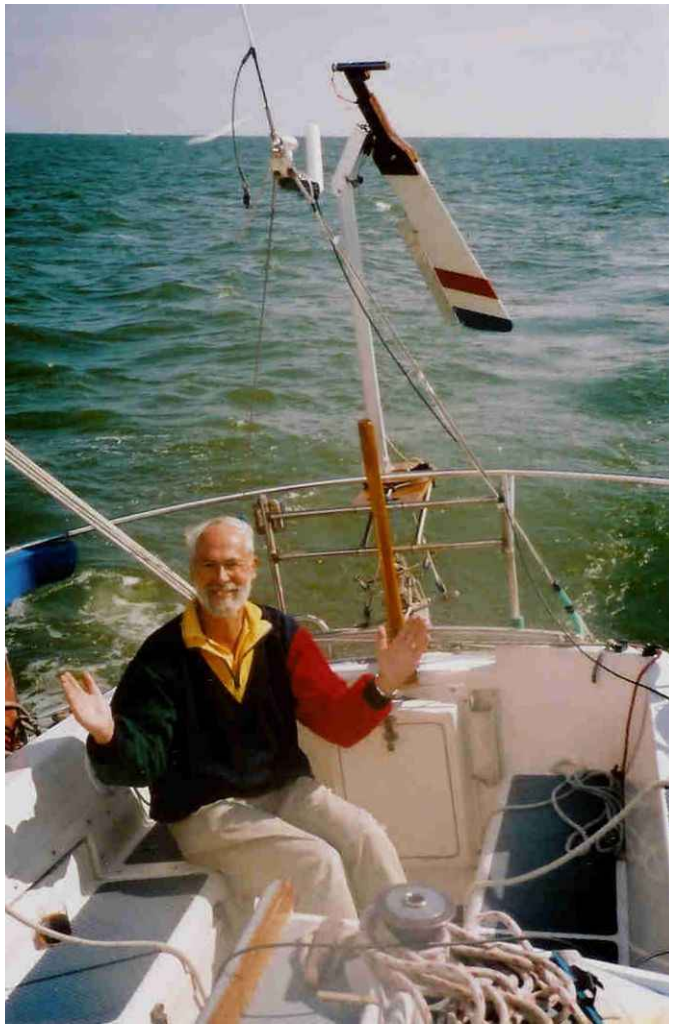
An innovative windvane system.



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Preface
This article deals with a new type of windvane. It is invented by the author, tried and tested and in use for years now.

Existing windvanes.

Windvane systems exist already for some 50 years. There has been a lot of development during the years, but the last 20 years the development seems only to be cosmetic. The present systems, mostly pendulum systems, are nicely shaped and also much lighter in weight than the older types, but its working principle remained the same.

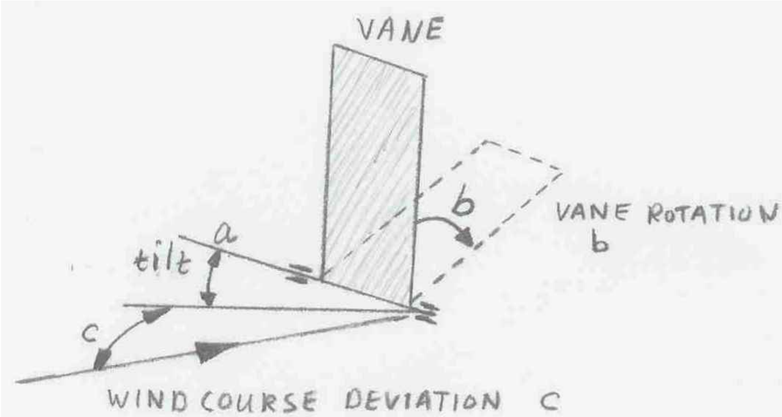

FIG. 1

The windvane can have a vertical (V-vane) rotation axis or a nearly horizontal rotation axis (H-vane). Windvanes with a nearly horizontal rotation axis are mostly used on present systems.

The windvane rotation can be calculated with the (simplified) formula :

$$\tan(b) = \tan(c) / \sin(a)$$ see figure 1.

where b = vane rotation angle
c = wind course error
a = vane axis tilt angle

The relation between course error and vane rotation appears to be highly depending on the vane axis tilt angle.

The H-vane is magnifying the wind error signal, depending on the tilt angle of the axis. Therefore the H-vane is more powerful and can have smaller dimensions than the V-vane. Most systems now use a tilt angle of 20 degrees.

<u>Influence of heel.</u>
During sailing the yacht is normally heeled, depending on the wind strength and course angle to the wind. The heeling angle of the yacht has an remarkable influence on the effective tilt angle of the vane axis to the wind direction.
The maximum effect is when the apparent wind direction is just perpendicular to the yacht. In that situation the heel angle and the tilt angle have to be added before using the formula. See figure 2.

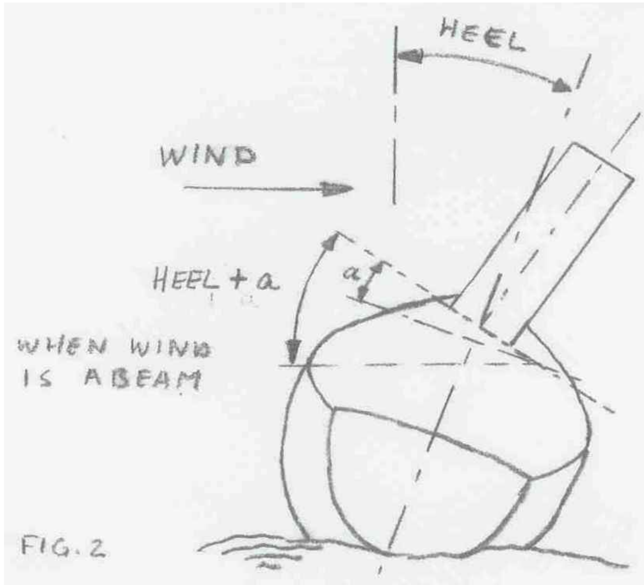

FIG. 2

When the heel is taken into account then the formula has to be extended to :

tan(b) = tan(c) / (sin(a + heel * sin(course))

where heel = the heeling angle of the yacht
course = the adjusted course angle between vane and yacht

We now can calculate the vane rotation depending on the heel angle.
Suppose a tilt angle a = 20 degr.
Sailing before the wind the heel = 0 and the course = 180 degr.
Then the relation between vane rotation and wind course error is:
tan(b) = tan(c) / sin(20) so tan(b) = 2.9 * tan(c)

When the yacht is heeled 20 degrees and the vane is adjusted to the apparent wind at 90 degrees with the boat axis, then tan(b) = 1.55 * tan(c)
In that situation the vane action is reduced to approx. 50% compared with the unheeled sitatuation. As the vane is connected with the rudder via the pendulum also the rudder action is reduced due to heel.

We now analyse what is necessary for steering the yacht.
It is known that downwind sailing is a difficult course for most windvane systems, because most yachts are less balanced on that course and are prone to yawing. When the vane action is too high then the system induces oversteering and the yacht starts yawing.
Reduced rudder corrections are necessary, but the windvane action is unfortunately at its maximum then. The vane action on the rudder can be influenced by varying the positions of the steering lines on the tiller. On most

yachts this correction method is very limited and not always successful for reducing yawing on running courses.

On windward courses most yachts built up some weather helm when heeled. To remain on course more rudder action is needed. But according to the formula the action of the H-vane is reduced due to heel, just when more action is needed to stay on course. The result is a substancial course deviation, before the rudder angle is sufficient to counteract the weather helm.
When the wind force is varying also heel and amount of weatherhelm is varying. Due to the reduced vane action there will be an oscillating course with the risc of rounding into the wind.
Note that V-vanes are hardly influenced by heel. In fact the vane action is slightly increased by heeling.

The conclusion for the mostly used type of windvane, is that, when the vane action is maximum, we don't need it and when it is needed, the vane will not give it.

<u>The adjustable vane axis tilt angle.</u>
A solution to the unwanted behavior of the H-vane is to have the possiblity to adjust the tilt angle of the vane. When heeled the vane axis is simply adjusted in opposite direction to compensate for heel. F.i. for a 20 degrees of heel and the apparent wind abeam, just compensate with -20 degrees . Now the effective tilt angle remains 20 degrees and there is no loss of steering action due to heel.
For the running courses just increase the tilt angle of the vane axis to 30 degrees to reduce the vane action. This will dampen the yawing course.
I have sailed with a windvane with adjustable axis since 1976 . I reduced the tilt angle for windward courses to get action and accuracy and I increased the tilt angle for the running courses for reduced action, to prevent yawing. It worked very well.

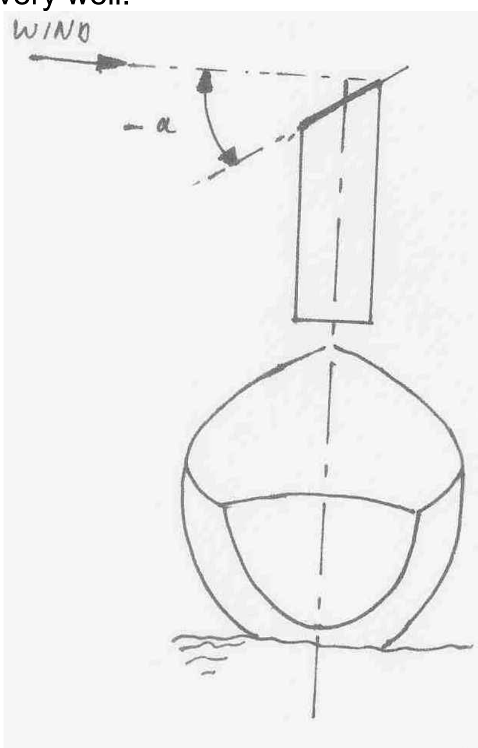

FIG. 3

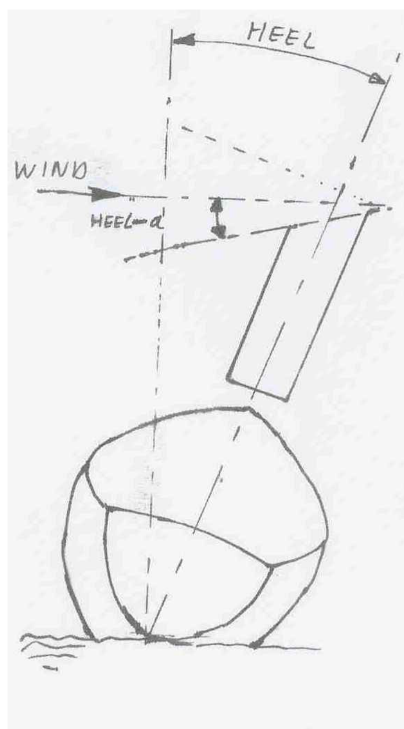

FIG. 4

<u>The upside down vane.</u>

An automatic compensation for the vane axis tilt angle is theoretical possible when the vane is positioned **upside down,** with a vane axis tilt angle of say - 30 degrees. (In the formula a = - 30)

See figure 3 and 4 and a picture of the real vane in figure 5.

figure 5. The upside down (USD) vane

The unheeled vane action is less compared with the known systems as a bigger effective tilt angle is applied. On courses with heel, the effective tilt angle of the vane axis is decreased and consequently the windvane action is increased. This is desirable to cope with weather helm and to keep the course more accurate.

Theory

To show the differences between the normal vane and the upside down vane I calculated the rudder rotation as a result of a windcourse error of 5 degrees. I assume that via the linkage, pendulum and steering lines the rudder rotation is half of the vane rotation. For this comparison the normal vane has an axis tilt angle of 30 degrees (existing systems use 20 degrees on average) and the upside vane - 30 degrees.

	normal vane	upside down vane
down wind no heel	5 degr.	5 degr.
wind 90 degr. 10 degr. heel	3.9	7.3
wind 50 degr. 20 degr. heel	3.5	10

These calculations show indeed that the vane and consequently the rudder action are increasing with heel, which seems to be more in line with the actual need on various courses.

Practise

I built a prototype of the upside down vane to my existing pendulum system to find out how it should work in practise. The first test were in nov. 1998 and I compared the output of the upside down windvane with the normal (but adjustable) windvane.
It worked as expected and the observation was that the boat was steered more precisely on close hauled and close reaching courses, without yawing on running courses. The behavior in variable windstrength was also good. In a puff the boat heels a little more and the vane builts up more action and steers more accurate.

After the prototype I built the mark two version of the upside down windvane, (shortly named USD vane) and I am still sailing with it. See picture 6
An important point is that the upside down windvane gives a good yaw damping in downwind and broad reaching courses on a modern, lively boat. Note the straight track on figure 7 during a running course in force 5. On windward courses the system works also very well.

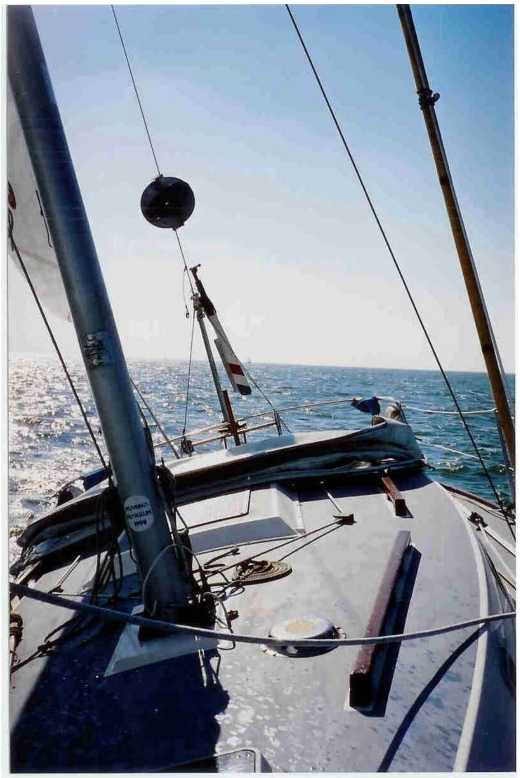

figure 7. Accurate sailing close to the wind

Conclusion.
The upside down vane coupled to a pendulum system works very well and steers the boat in a more natural way as it adjust itself to the sailing circumstances.

This new windvane principle can be used on all kinds of windvane pendulum or trim tab systems.

The upside down or USD windvane has also been described in the article " Which windvanes work best " (Practical Boat Owner nr. 414 , June 2001) .