In the meantime Cunegonde wrote letter after letter to Candide

but her words were so inflamed that her missives burnt up before they reached the ground.

Wow !

A balloon? No, that won't work. It's almost certain I'd miss the tower.

There doesn't seem to be any solution.

Señor

My name is Juan de la Cierva, could you indicate some toilets that I may use?

Good heavens ! Whatever is that machine?

THE AUTOGIRO

You fly in this ... sort of insect ! Where are the wings? I can't see any.

There are four, isn't that enough?

What do you call this machine?

An autogiro, do you want to try it?

You mean that I have to ensure our lift by hand?

No ...

Could you make the rotor turn a bit?

The... Ah... how?

Goodness! The rotor is turning on its own now! Why?

Autorotacciòn

And now we're flying, but by what miracle?

To the castle, quickly please !

My dearest Cunegonde, who must be down there, below !

Can you land on that terrace?

The autogiro can land very short, but the terrace is really too small !

Ah master Pangloss, I flew over the castle and the tower where Cunegonde is held prisoner. On Mr de la Cierva's fantastic flying machine.

It's that him taking off in the distance, over there?

Oh misfortune ! He's taking all his secrets with him. What is the mysterious force that turns the rotor ?

The explanation is really quite simple: a rotor is made to turn. It is therefore possessed of a rotative virtue, so it turns. There is no effect without a cause.

Your reasoning is most sound master, but I would like to know more...

What's Candide doing?

I think he's going to recreate the air blower that led Mr de la Cierva to discover the reason for this astonishing phenomenon.

+2°

I've rebuilt the rotor of Mr de la Cierva, with blades inclined MORE than two degrees.

The blade is angled POSITIVELY in relation to the air flow!

2°

V

Plus a vertical air-blower, a calming grid and a smoke emitter.

I send an ascending air flow

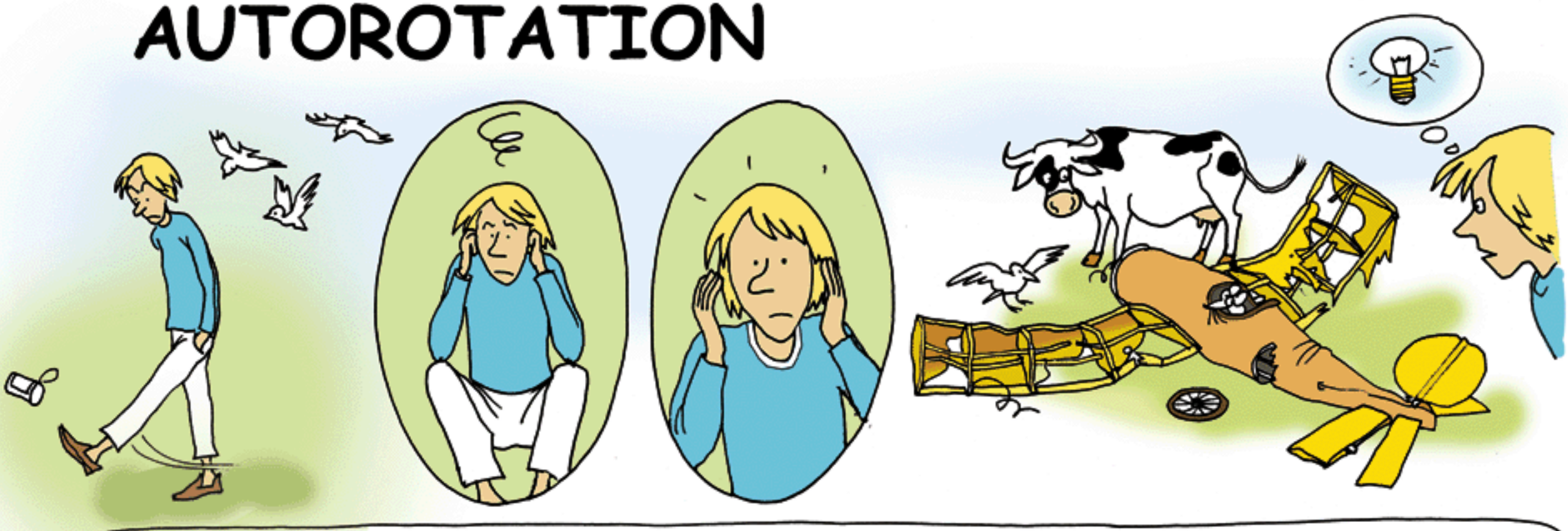
The rotor isn't turning. It's just creating strong turbulence in its wake.

Now I'll set the rotor turning

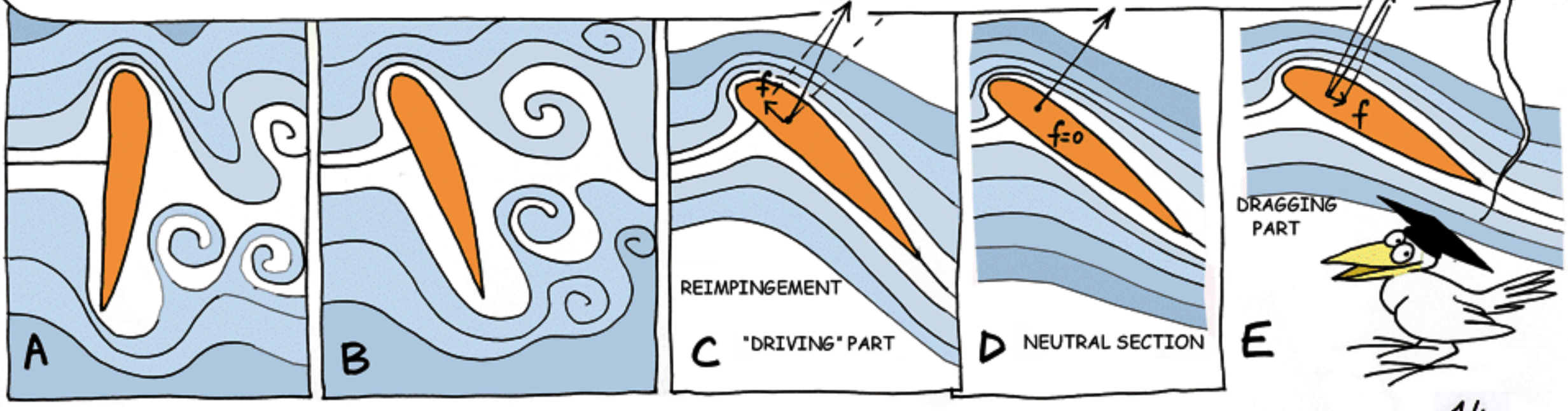
And now it's turning all on its own! I don't get it.

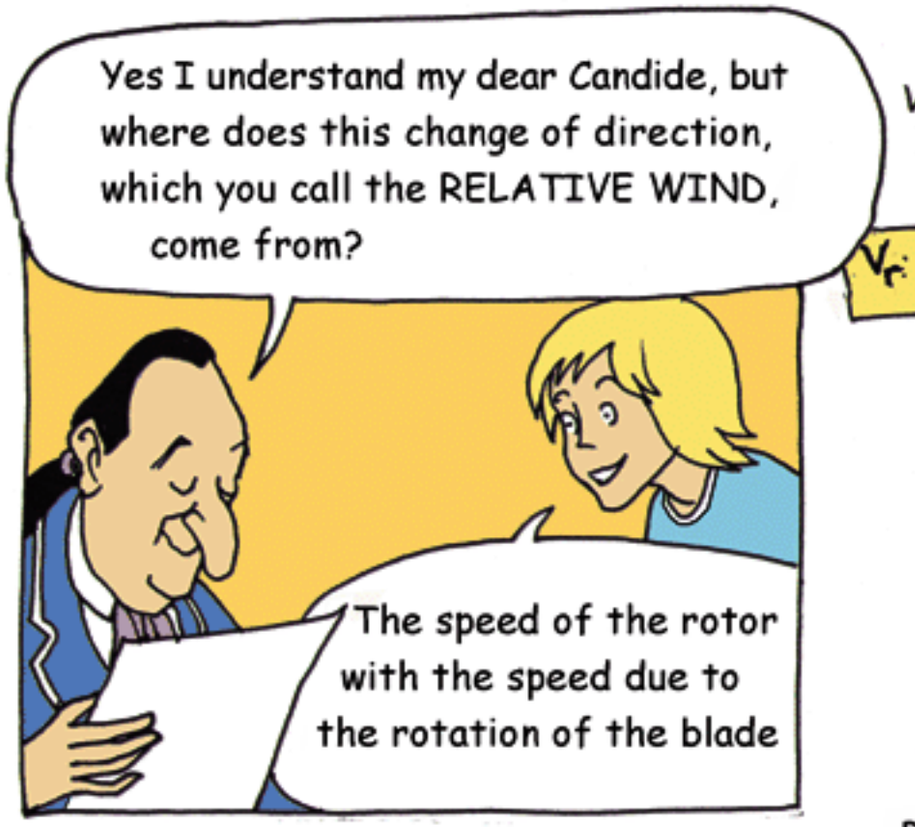
It's ... magic !?

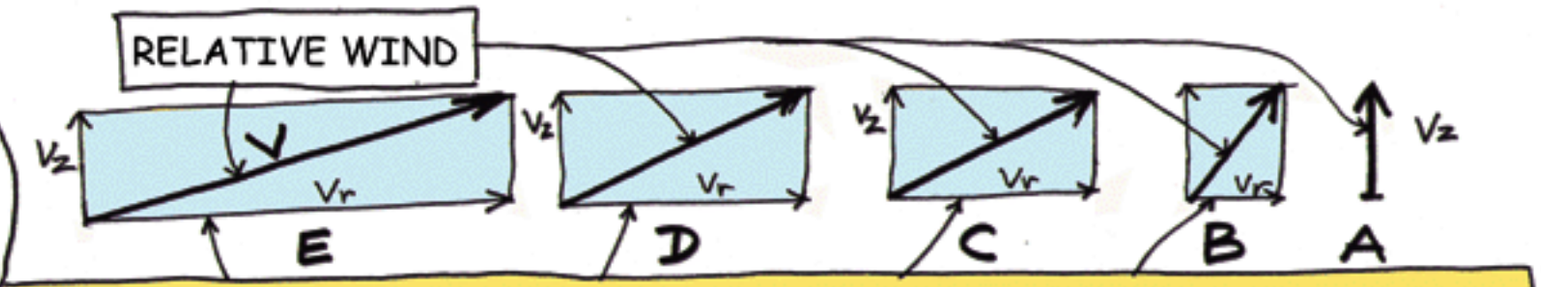
AUTOROTATION



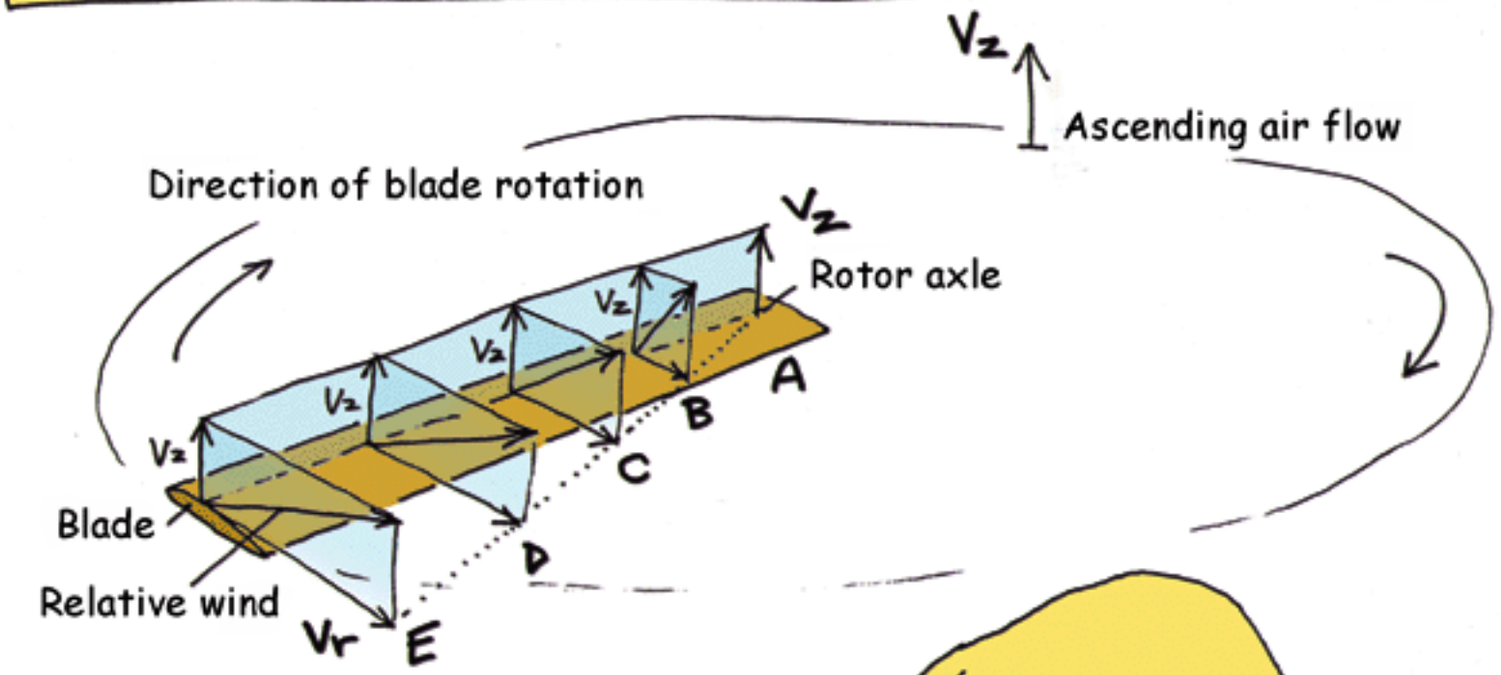
When the incidence of the blade is reduced in relation to RELATIVE WIND direction, the flow reimpinges (figure C). The aerodynamic force (component f) tends to drag the blade. In D this force is cancelled out and then inverted in E. The F component then brakes the blade's movement.



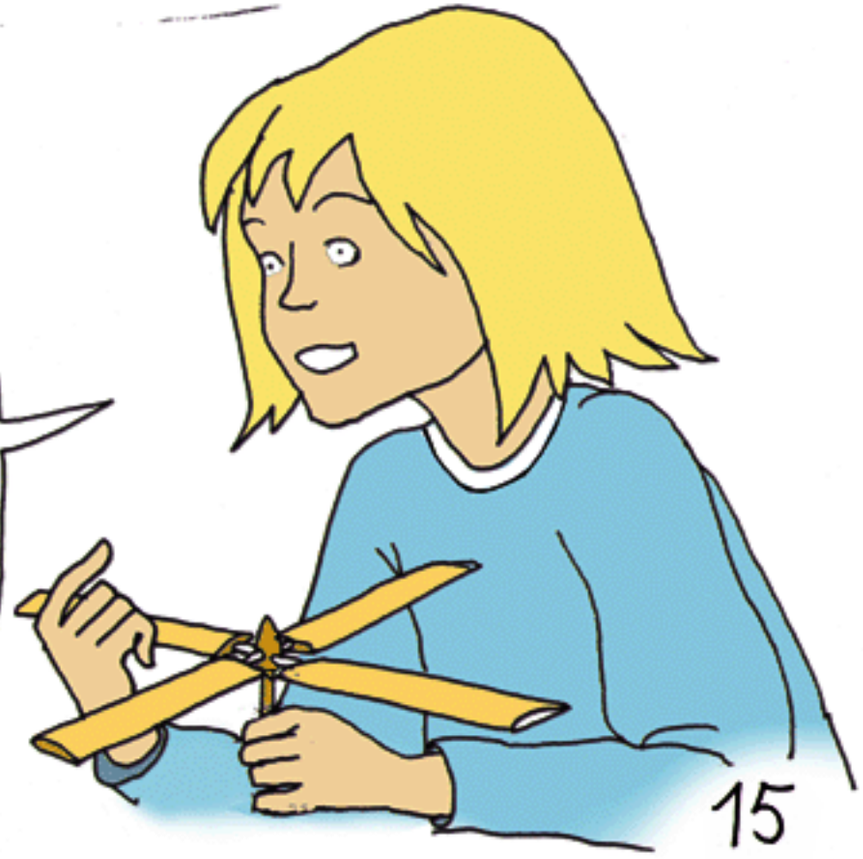




Vr: horizontal component of V relative due to the rotation of the blade.

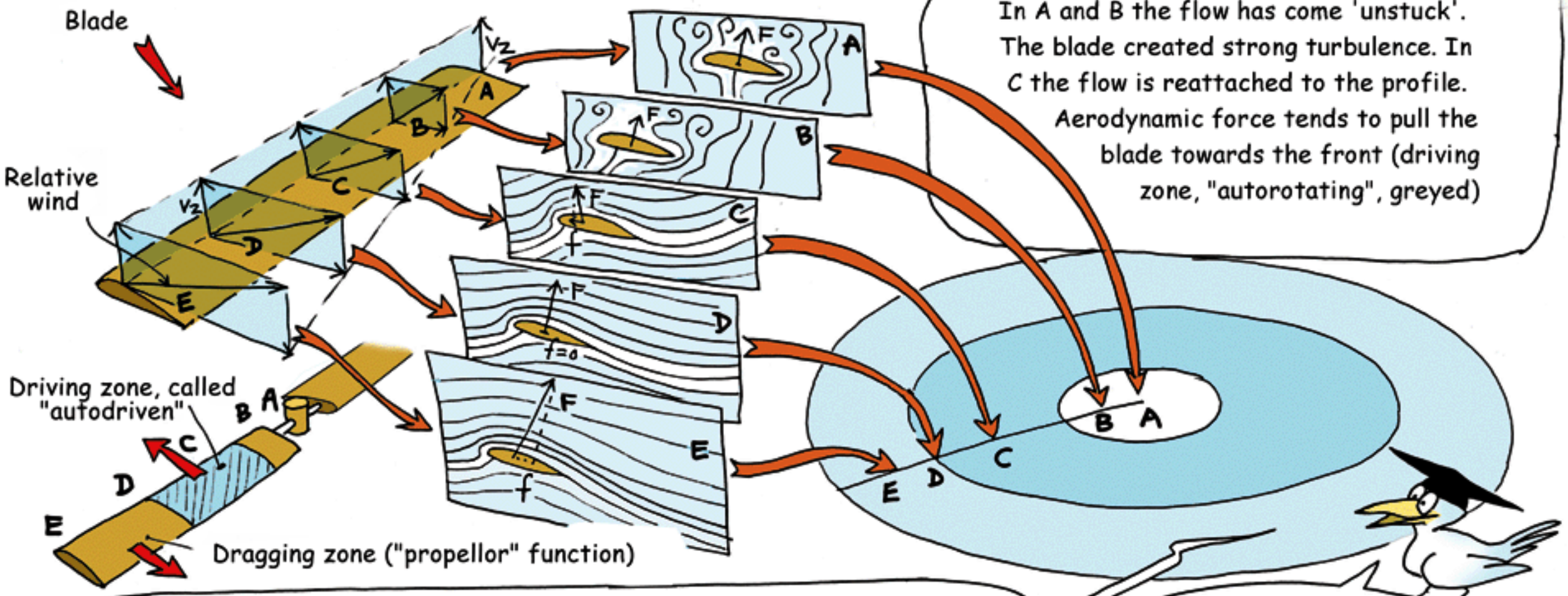


The rotor is immersed in an ascending airflow which corresponds to a speed **Vz**. This combines with the speed induced by the rotating movement of the blade **Vr**, a speed proportional to the distance from the axle. The result gives the **RELATIVE WIND**, which lays more and more on the blade the further it is from the axle. At the same time, the modulo of this speed increases, from the axle to the periphery.



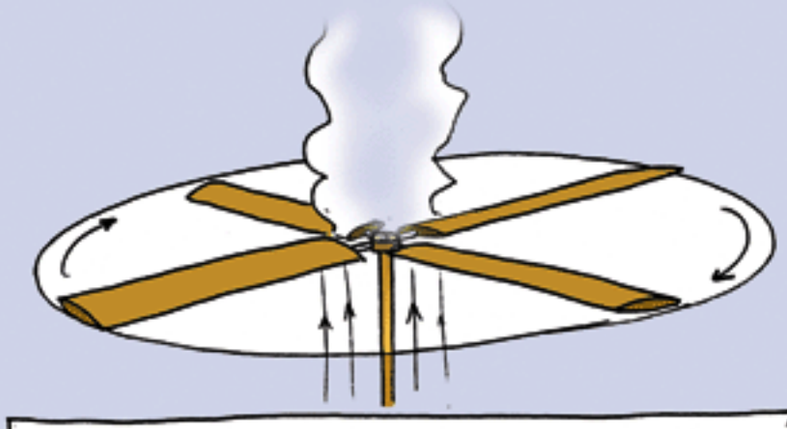
The flows varu greatly according to the way the **RELATIVE WIND** attacks the blade. To visualise it I fixed a thin tube onto the blade that sent out smoke as it turned. These are the results I obtained.

In A and B the flow has come 'unstuck'. The blade created strong turbulence. In C the flow is reattached to the profile. Aerodynamic force tends to pull the blade towards the front (driving zone, "autorotating", greyed)

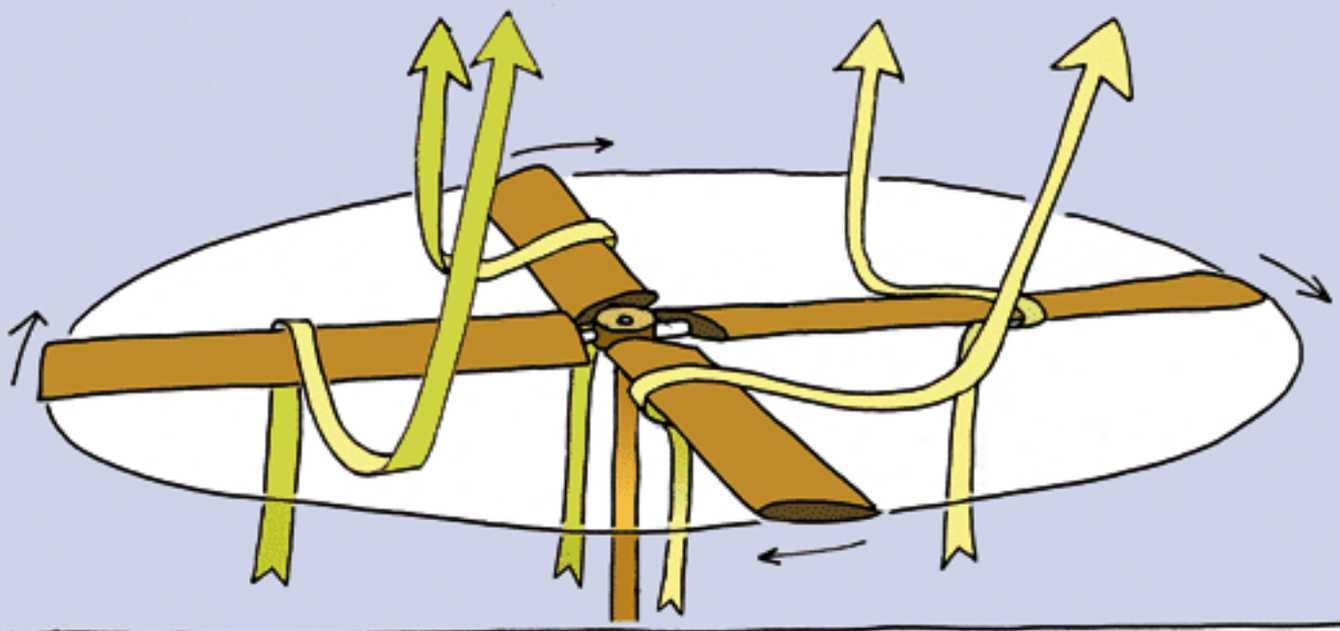


In E the aerodynamic force, always directed upwards, tends to hold back the blade's movement. Figure D shows the limit-situation (f = 0). In this regime of AUTOROTATION the shaded part of the blade is driving while the end of the blade "drags behind". An AUTOSTABLE regime is established.

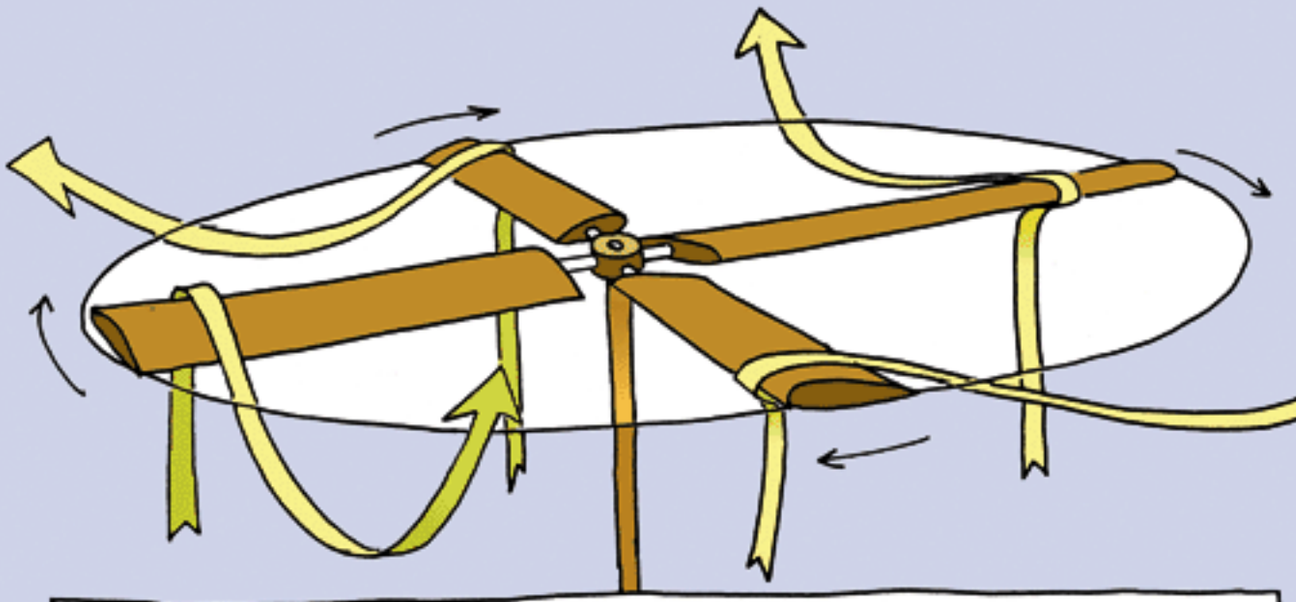
All that was experimented in a wind-tunnel by Juan de la Cierva



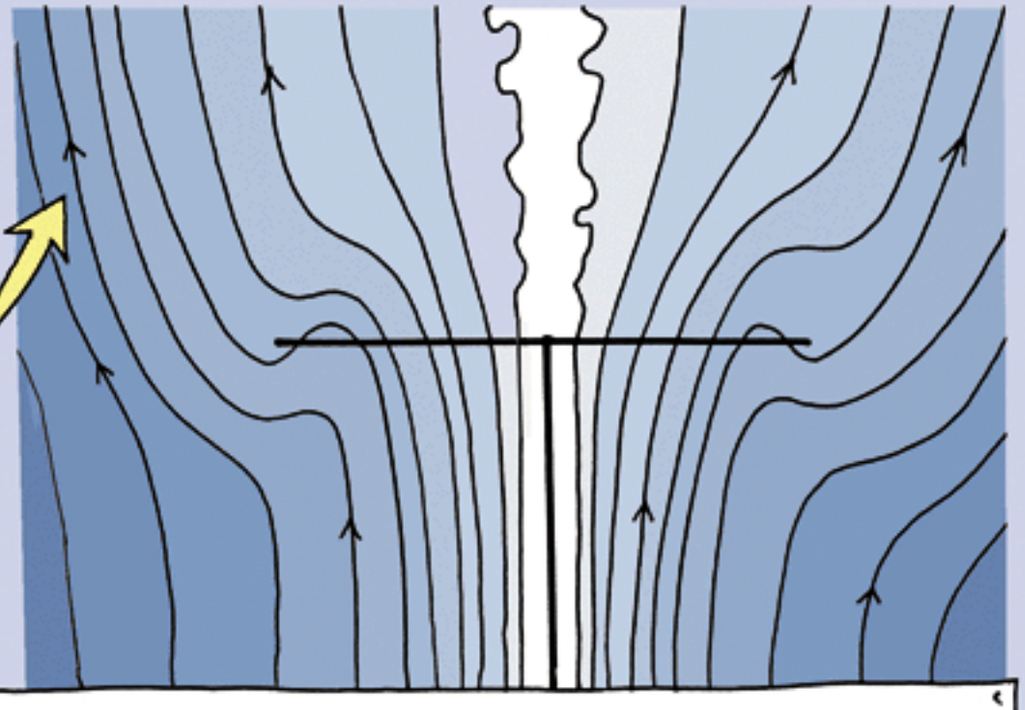
Above the central part ("detached" flow), there is a strong turbulent wake



Here the flow is reattached to the blade's edge



On the periphery, the impulse communicated to the air mass, directed downwards (**INDUCED SPEED**) is sufficient to push the air out beyond the disc area formed by the sweep of the blades.



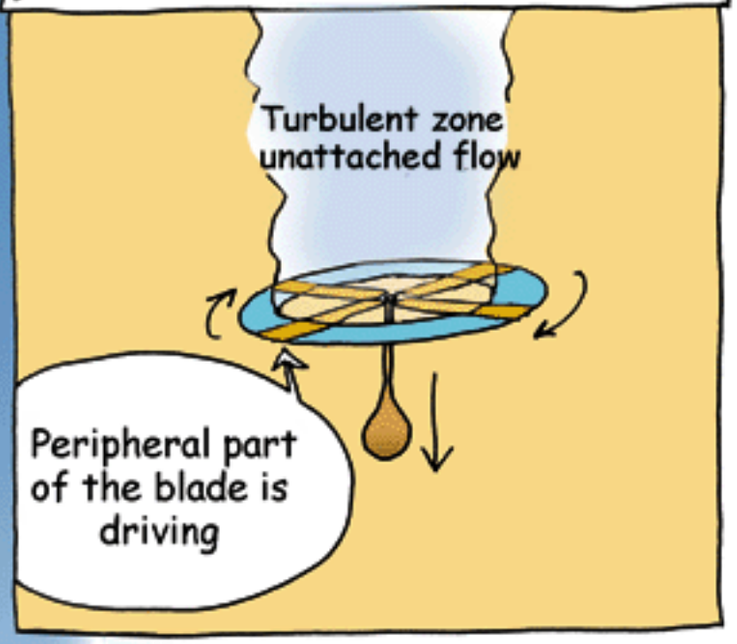
This gives the rather strange airflow shown above.

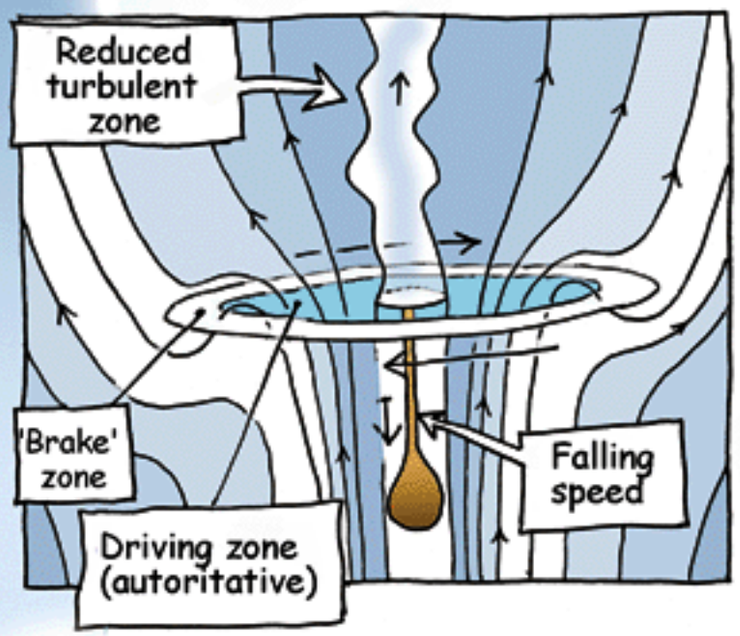
Look master Pangloss, I let go of this little model from the window after having given it a minimal impulsen

Weight

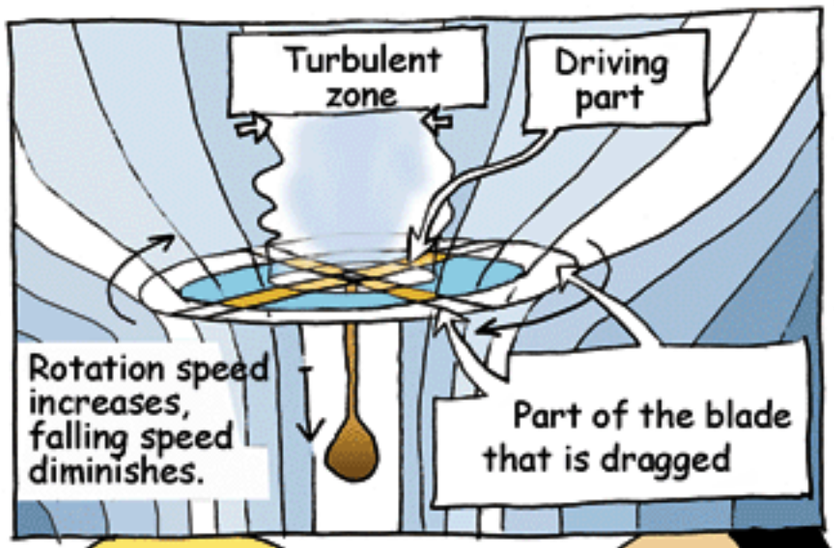
Minimal...in relation to what

Enough to make the peripheral part of the blade turn at a speed which will cause the airflow to "reattach". Then it becomes "driving" and the rotation speed increases.





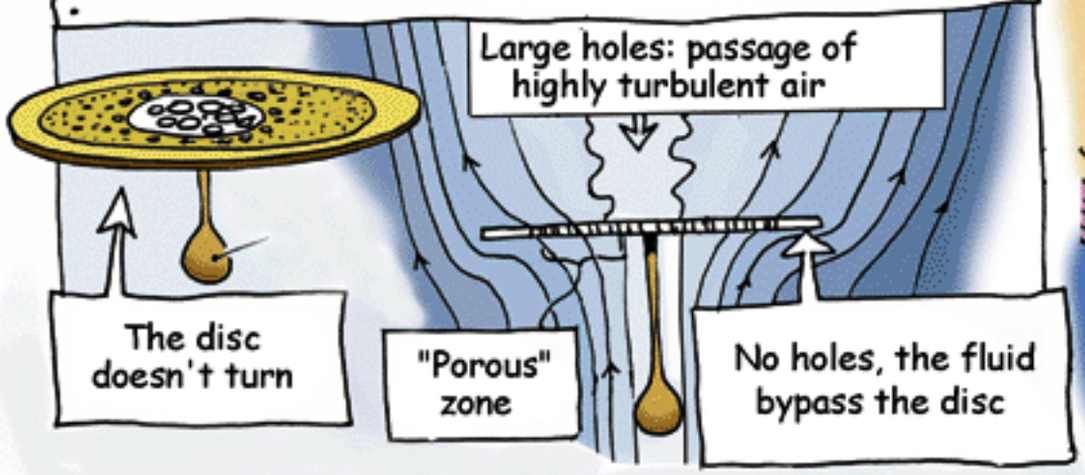
The turbulent part of the flow ("dragging") diminishes with the increase in rotation speed. A "dragging" part then appears towards the end of the blade.

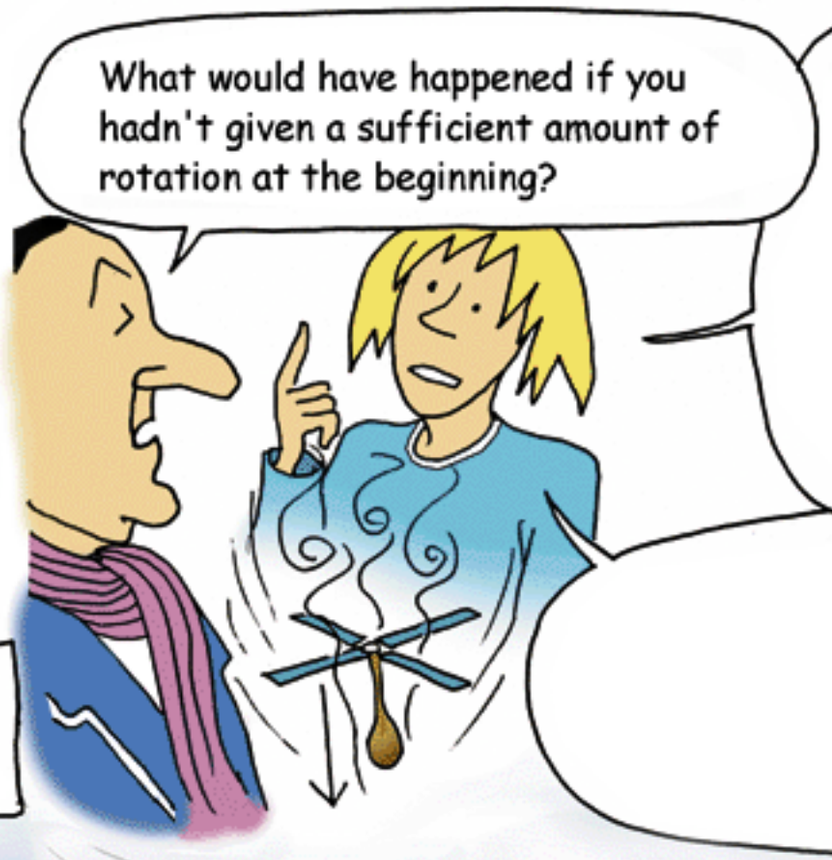


The rotation speed stabilises when the two couples balance each other. Then the autorotation regime is completely established and the speed of descent is minimal.

A similar flow would be obtained if we dropped a non-turning disk perforated with holes of diminishing size from the centre outwards, which would create different zones of porosity

The Management

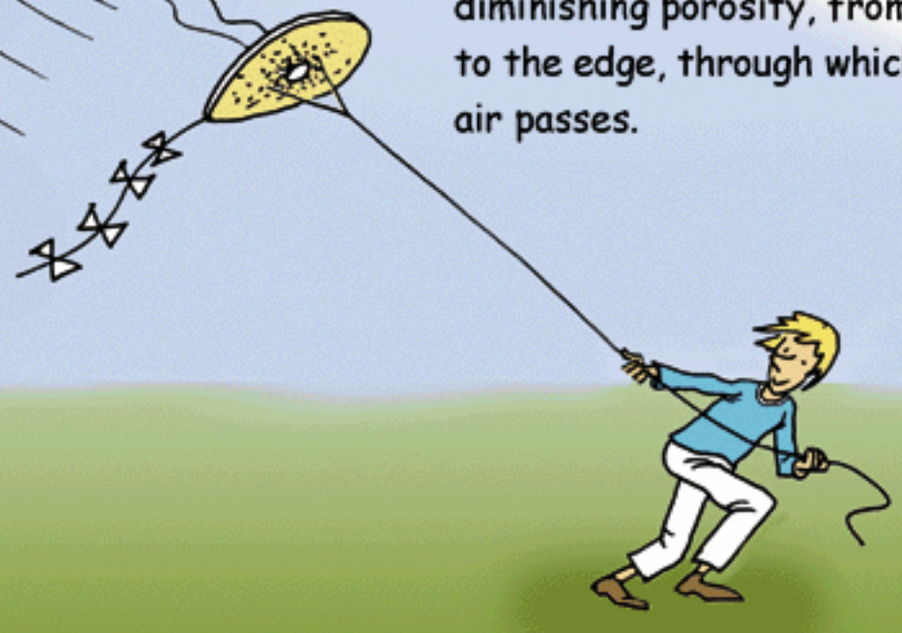




The speed at the end of the blades would not have been enough for the flow to reimpinge on the profile. So no driving force. No creation of an autorotation regime:the model would drop like a stone.

Now that I've understood the mystery of the rotor's autorotation we just need to add a pinch of obliqueness. Then the rotor will behave like a disc whose porosity diminishes from the centre to the periphery.

In short, the autogiro is a distant cousin of the kite with a canvas of diminishing porosity, from the centre to the edge, through which the turbulent air passes.



(*) e pur si muove (Galileo)

150m

15m

Now let's see: an aeroplane needs 150 metres to land. The autogiro can manage with 15 metres. But the tower terrace is too short to land there, it would really need a vertical descent. What flying machine can do such a thing?

?

If there is a solution, it isn't that one.