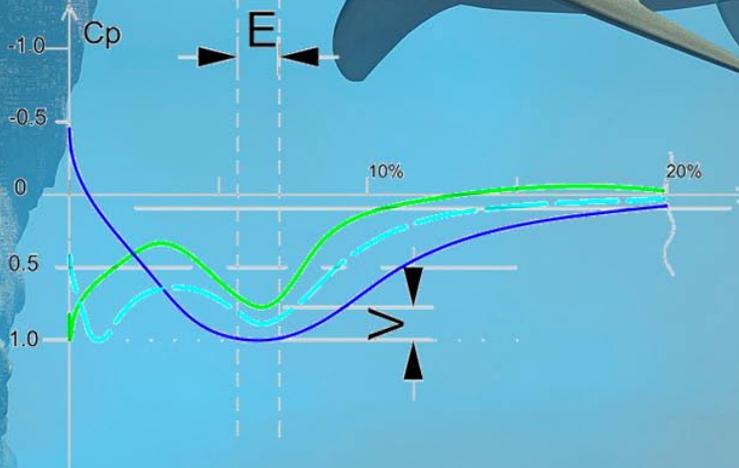




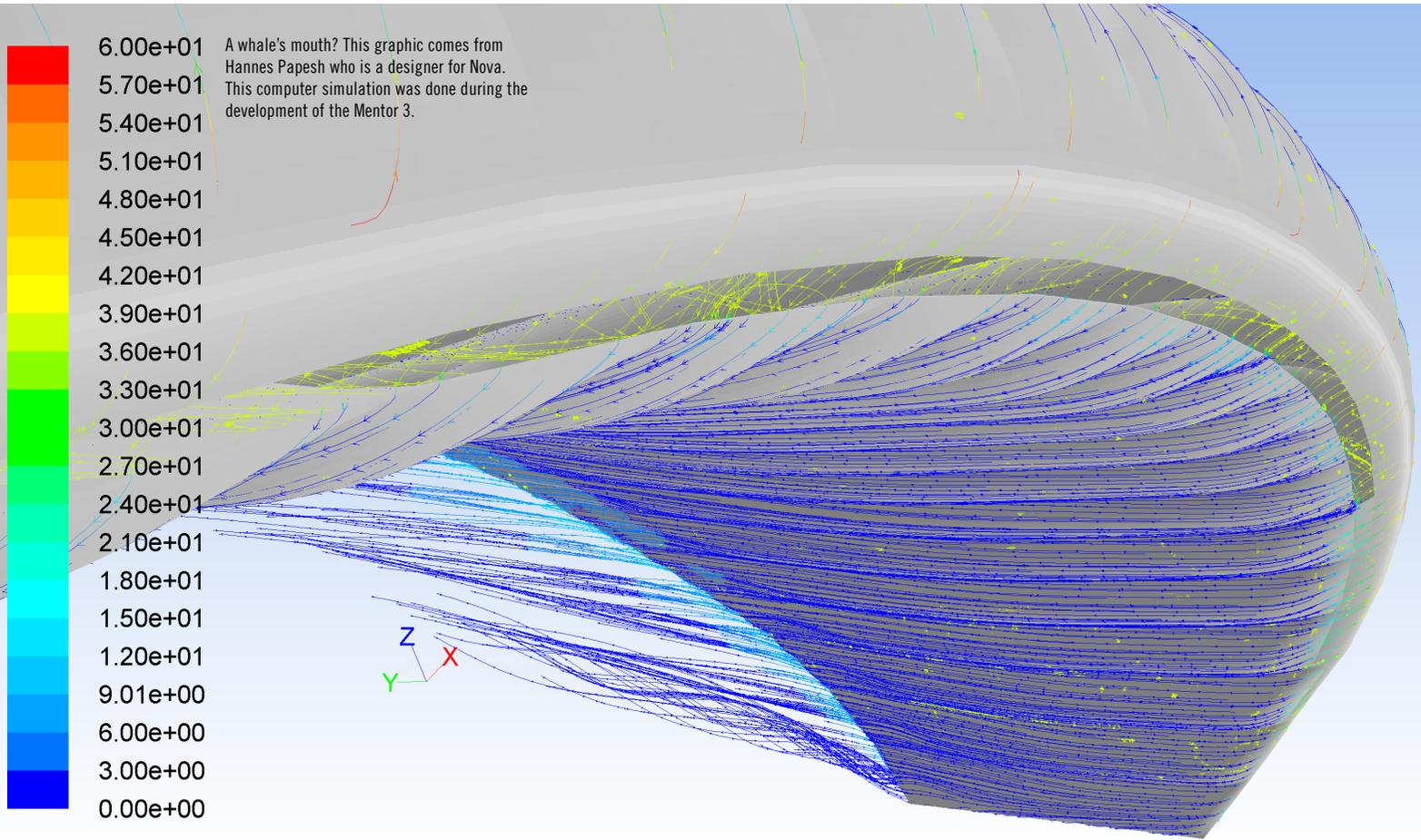
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THE SHARKNOSE



AN AERODYNAMIC REVOLUTION?



SHARK'S MOUTH OR SHARKNOSE ?

By Sascha Burkhardt
Translation Ruth Jessop

A new technology has made its appearance in the air intakes of our wings. The openings are set back and placed in a break in the lower surface. Are these Sharknoses an aerodynamic revolution?

BUNDESREPUBLIK DEUTSCHLAND
Offenlegungsschrift DE 3729934 A1
 Aktenzeichen: P 37 29 934.4
 Anmeldetag: 7. 9. 87
 Offenlegungstag: 23. 3. 89

Ammelder:
 Leibe, Gernot, 8630 Coburg, DE

Erfinder:
 gleich Anmelder

Paraglider mit verbesserten Details
 Gleitschirm mit geschlossener Profillinie sind mit Zusatzöffnungen auf der Profillinie (Haifischmaul) oder mit vertikalen Stützen im Bereich der Profillinie (Kloppenventil).
 Gleitschirm mit V-förmigen Verstärkungen aus Schur- oder Bandgewebe an den Seitenfestigungspunkten der Tragseile, Rippen, oder mit bogenförmigen Verstärkungen zwischen den Seitenfestigungspunkten (Seilack- oder Hängeleitschirm) mit klappbaren Verbindungsgliedern zwischen Leinwandbägen (Kattenstich, ...).

DE 3729934 A1

3729934

Nummer:
 Int. Cl. 4:
 Anmeldetag:
 Offenlegungstag:

Fig.: L 51: L 11
 37 29 934
 B 64 D 17/00
 7. September 1987
 23. März 1989

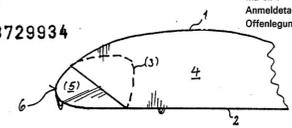


Fig 1

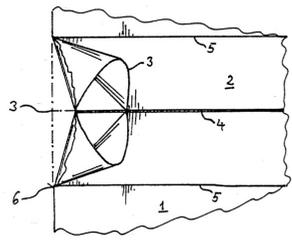
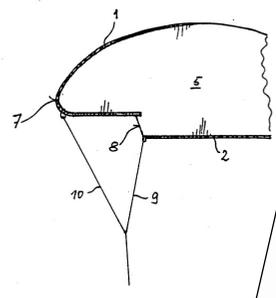


Fig 2



RÉPUBLIQUE FRANÇAISE
 INSTITUT NATIONAL DE LA PROPRIÉTÉ INDUSTRIELLE
 PARIS

N° de publication:
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2 972 4

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DEMANDE DE BREVET D'INVENTION

Date de dépôt: 11.03.11.
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Date de mise à la disposition du public de la demande: 14.09.12 Bulletin 12/37.

Liste des documents cités dans le rapport de recherche préliminaire: Se reporter à la fin du présent fascicule

Références à d'autres documents nationaux apparus:

Demandeur(s): OZONE PARAPENTE — FR.

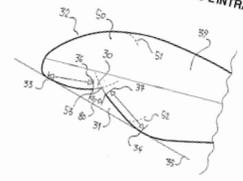
Inventeur(s): PIERI FREDERIC, ARMANT LUC et DAGAULT DAVID.

Titulaire(s): OZONE PARAPENTE.

Mandataire(s): OZONE PARAPENTE.

VOILURE CREUSE AVEC OUVERTURE DISPOSEE AU SEIN D'UN RENFORCEMENT DANS L'INTRADOS.

Une voilure creuse dont au moins un caisson (39) dispose son intrados (32) qui présente un renforcement (31) dans son intrados et une ouverture (30) formant une prise de pression qui permet de garder une surpression interne. L'ouverture se situe au sein du renforcement qui s'étend en avant et en arrière de l'ouverture, de manière à accompagner l'écoulement sans décollement et à s'accompagner à la voilure selon l'invention avant et après l'ouverture de conserver des coefficients de pression interne élevés sur toute la plage d'angle d'incidence de vol tout en générant relativement peu de traînées parasites.



FR 2 972 422 - A1



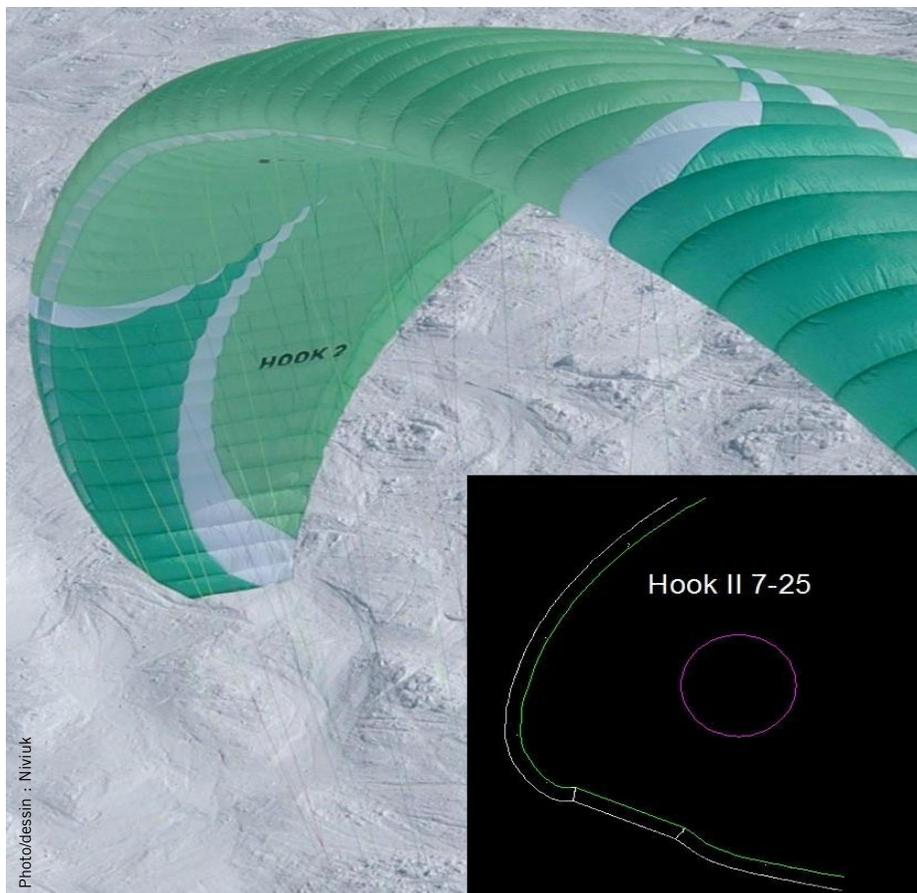
The first time that most pilots heard the expression 'Sharknose', was whilst watching the first prototypes of the R11 during the winter of 2010/2011. The Ozone competition wing had a break in the profile of the lower surface. The main goal was to guarantee better internal pressure at all angles of attack. A wing which maintains a good internal pressure at a high angle of attack offers, among other things, longer brake travel and increased stall resistance at lower speeds. To put it simply, the profile of a classic wing, lacking internal pressure becomes limp and inefficient, losing its performance, whilst a fully inflated profile resists better and assures an even air flow for longer. Another obvious advantage is seen at the top of the speed range during accelerated flight, where high internal pressure inhibits collapses.

INTERNAL PRESSURE

The internal pressure in a paraglider is of a different order of magnitude to the pressure in an inflatable dingy for example (0.2 bars minimum or 200 hPa). This pressure in relation to atmospheric pressure is relatively weak.

Fred Pieri calculated it for us: Pressure would vary, in a normal wing, between 78 pascals at 40 km/h and 180 pascals at 60 km/h, values which correspond to 0.78 hPa – 1.8 hPa. This is very small in relation to atmospheric pressure which varies between 950 and 1050 hPa QNH. Nevertheless this pressure is responsible, in part, for the wing keeping its shape. Again, according to Fred Pieri, 0.8 hPa (or 0.0008 bar) creates a tension in the chord axes of 240N or 24 kg, which is not insignificant...

Two noses, two patents. The first two pages are from a document produced in 1989. The German Gernot Leibe registered the invention of the Haifischmaul (Shark's mouth). On the page on the right, you can see the recent patent for Ozone's Sharknose. At a rough glance there are notable differences...



In 2010, in going from the Hook 1 to the Hook 2, Niviuk modified the profile's nose. It is possible to recognise the first sketch of a Sharknose... However, the reason for this wasn't the same. The designer Olivier Nef didn't want to increase the internal pressure, but instead get rid of a vibration problem.

Not the first profile of a shark...

The Sharknose was developed to guarantee that internal pressure would be kept as high as possible across the whole range of speeds. Designing a paraglider which evokes a shark's nose isn't new. Already back in 1989, the German designer Gernot Leibe registered patent DE 3729934 A1 on behalf of the company Aviamecanic Gleitschirme. In it you can actually see a profile called 'Shark's Mouth', which resembles at first glance, at least, Ozone's Sharknose.

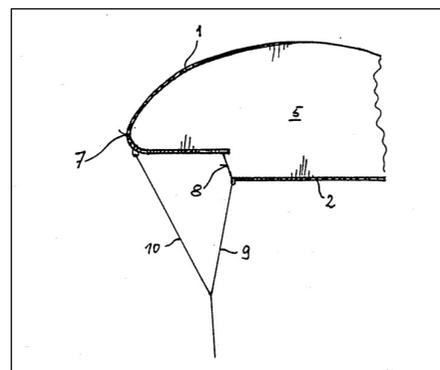
But Leibe's idea wasn't the same. He wanted, above all, to diminish the enormous drag produced by the gaping mouths in the paragliders of his era. For that, he needed to close the nose of the profile with cloth whilst, at the same time, letting air into the wing through air intakes further back on the lower surface.

On the other hand, this new intake didn't give any more tolerance of changes in the angle of attack. This was the big difference between a simple break in the profile and the Sharknose system. Leibe wasn't the only one who described

and used a more or less distinct step on the lower surface. For a long time, Nova's Hannes Papesh had integrated similar shapes in the simulation of profiles in his CAD software. And Niviuk for example, when they moved on from the Hook 1 to the Hook 2, also added a break in the profile at the same level as the air intake – that was in 2010.

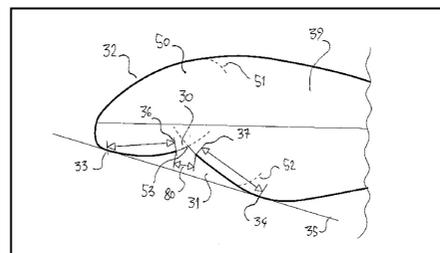
The reasons which push manufacturers to integrate various Sharknoses into their paragliders aren't always the same. For some, putting the air intakes further back allows them to smooth the profile of the leading edge. For others it allows them to rectify vibration problems.

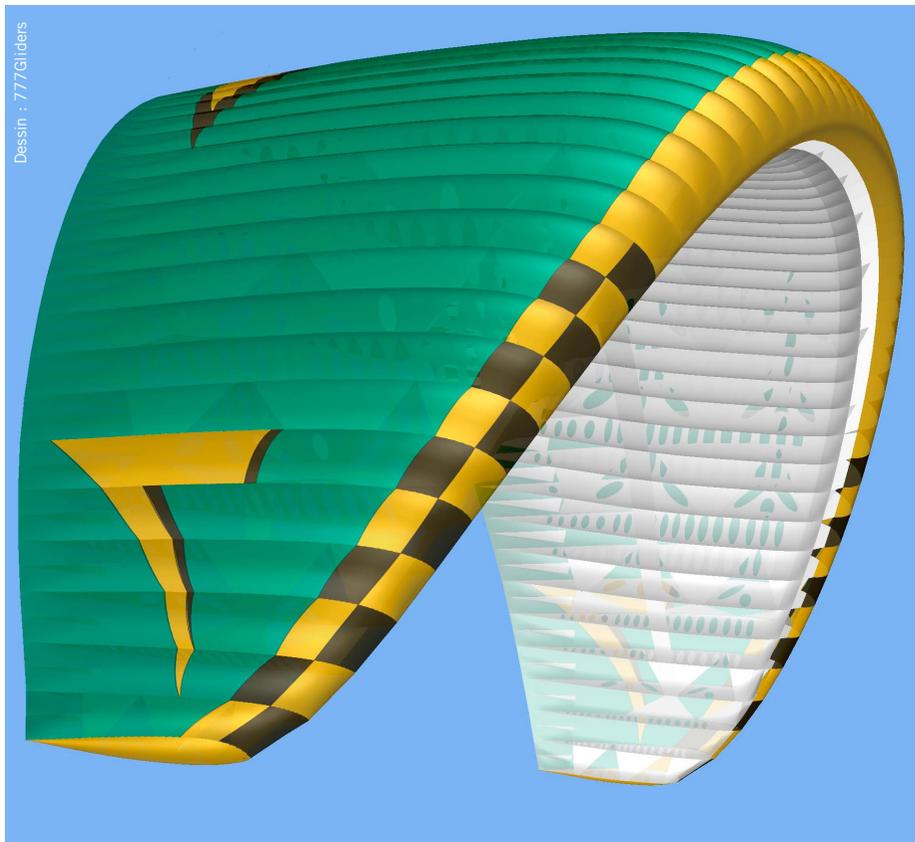
For the developers at Ozone, these other techniques are not identical to the concave form of the Sharknose as it appeared in the R11. They therefore registered it with the INPI (Institut National De La Propriété Industrielle) on the 11th of March 2011. Their patent was for a "reinforcement of the lower surface" which is supposed to "keep the internal pressure coefficients as high as possible throughout the whole range of angles of attack".



"Sharknose", 1989

"Sharknose", 2011





The Rook, an intermediate canopy from Triple Seven, with the Sharknose clearly visible.

In addition it should generate very little parasitic drag, another notable difference compared to the patent registered by Gernot Leibe in 1989, which is specifically referred to in the one registered by Ozone.

In the meantime, other designers have worked to put the intakes on leading edges further and further back and/or with a more pronounced break in the profile. On Niviuk's Icepeak 6, it's clearly visible.

Another manufacturer, Triple Seven, calls his technique BPI 'Back Positioned Intake' and uses it in all the range. Gin is modifying the nose of the Boom 9 and the Atlas. Most of the recent models have something approaching a real Sharknose. Numerous designers recognise the usefulness of a concave mouth. It will be interesting to see to what degree this technology will be adopted in intermediate gliders and, indeed, in beginner gliders. The manufacturers who want to integrate this technology, can do so without paying royalties* because, at the time of the official publication of the patent for the Sharknose in September 2012, Ozone announced that they didn't want to keep the exclusive right to this technology. Luc Armant explained: "Our job being simply to design and build wings, we've decided to allow free use of our patent, but we ask that everyone respects our authorship. Our motivation with the patent is to share the technology."

To help us completely understand the way the development team at Ozone see the advantages of the concave form of the Sharknose as it was patented, Fred Pieri explains the details for us in the following pages... ■

* Ozone only asks that wings which use their technology display a Sharknose logo, attesting to their authorship of the invention. The enthusiasm for this by other manufacturers will no doubt be the same as it was for the logo 'Rigifolis by Gin', which you will hardly find on any model from other manufacturers.

The manufacturer Ozone produced an example of a wing which flies without any internal pressure. The XXlite doesn't have a lower surface. As a consequence it is a very light wing. In addition, when you inflate it (which you don't), this wing goes up like no other. On the other hand, this type of wing only tolerates a much reduced range of angles of attack. As a direct consequence the range of speeds is very narrow, about 27-36 km/h, according to the measurements from Certika who certify the performance and security of gliders.



Photo : Ozone



The R11, the first paraglider with an Ozone Sharknose.

OZONE'S SHARKNOSE

By Fred Pieri and the Ozone team

Fred Pieri, one of the designers and aerodynamicians from the Ozone team, explains for us in detail how the Sharknose works, along with its secrets and advantages...

Photo : Ozone



THE PARAWORDS

Glossary

Chord : The chord is the line which goes from the leading edge to the trailing edge along a cell.

Pressure coefficient: This gives the pressure at a given point as a percentage of the maximum available pressure at the stagnation point. It is abbreviated to PC in this article.

Angle of attack: The angle formed between the Chord and the air flow striking the profile. For a normal paraglider, it varies as follows: 3° during maximum acceleration, 7° with hands up and 15° at the stall point.

Wingspan: Distance between the wing tips, and thus perpendicular to the chord.

Stagnation point: Point on the profile perpendicular to the trajectory of the air molecules. This is where the air flows around the profile separate. The pressure is the maximum here: PC = 1.

Sharknose : This is the name of the technology covered by this article. The name, of course, comes from the shape of the front profile which resembles a shark's nose

A paraglider is a flexible air-foil under which the pilot is suspended. In order to enable us to fly, the air-foil has an aerodynamically shaped profile, which generates lift. The lifting forces also exert a force which “stretches” the glider along its span. However, along the chord the aerodynamic forces are virtually useless. It is the internal pressure in the sail which “stretches” the glider along the chord axis.

We have recently proven, with the XXLite, that it is possible for a wing to fly without internal pressure (the air-foil being open due to the almost total lack of a bottom

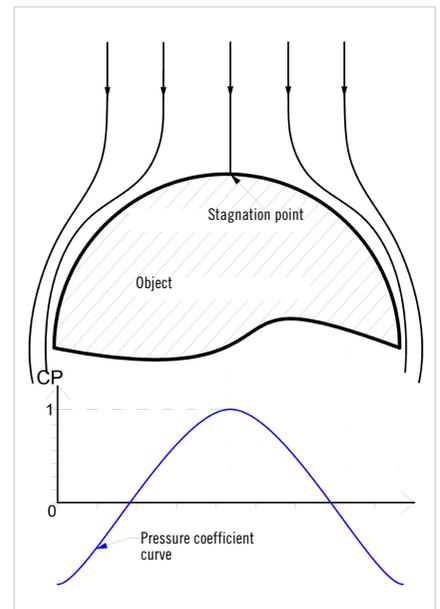
surface). During our performance testing with this single-surface design, we tried to vary its angle of attack.

Varying the angle of attack, of course, allows us to vary the speed of the aircraft. The higher the internal pressure, the better the mechanical stability of the sail.

A designer should therefore attempt to maximise internal pressure. However, internal pressure has a certain limit which cannot be exceeded.

The area of the profile which is perpendicular to the direction of the air particles is called the stagnation point.

Stagnation point and pressure coefficient curve.



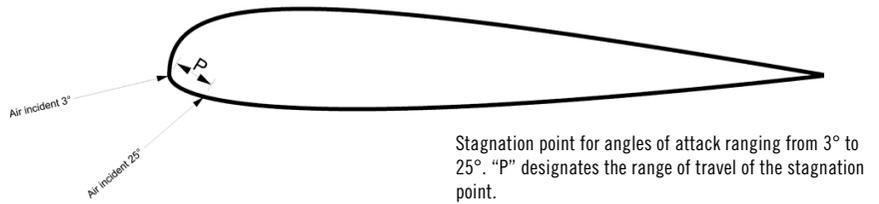


After the R11, which had a Sharknose, Ozone brought out the Enzo 1 for competitions, but this wing didn't have a Sharknose. It was only from the Enzo 2 onwards that Ozone introduced the Sharknose in its certified competition wings.

It is at that point that the airstream separates into two parts, one part will flow over the top surface and the other over the bottom surface.

For a given flying speed, pressure is at a maximum at the stagnation point. This pressure shall be the reference for all other pressures in the rest of this article (and in all literature on the subject for that matter).

Pressure is expressed as a Pressure Coefficient (PC), such that pressure at the stagnation point is equal to 1. $PC = 1$.



$PC = 0.5$ means that pressure measured at that point is equal to half the pressure at the stagnation point.

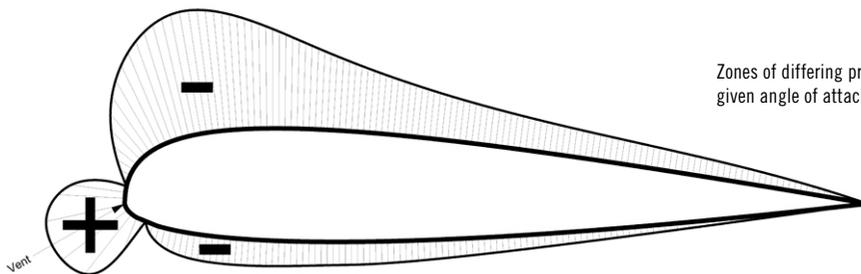
Therefore one needs to place the air intake at the stagnation point in order to get internal pressure with a PC of 1. However the stagnation point isn't fixed along the profile, it moves according to the angle of attack. The air intakes need to be positioned at the same level as the stagnation point to get an internal pressure of $PC=1$. Unfortunately this stagnation point isn't fixed on the profile, it changes according to the angle of attack.

The compromise is therefore

- If the air intake is located near the front of the stagnation point range, we get excellent internal pressure at low angles of attack (i.e. accelerated), but not at all at high angles (i.e. when brake is applied); this will produce a glider with poor inflation characteristics and which won't exit parachutal stalls easily.



Another effect of the Sharknose is that the air intakes are set back and as a consequence, this completely closes the nose, increasing the efficiency of this part of the profile. The nose bites at the air better.



Zones of differing pressure along the profile for a given angle of attack.

- If the air intake is located towards the back of the stagnation point's range, it is the opposite: good pressure at high angles with long brake travel. But at low angles of attack pressure will be very low and the sail won't retain its shape when accelerated (meaning a loss of performance) and after a certain angle the air intake will enter a depressurised area and produce a frontal collapse.

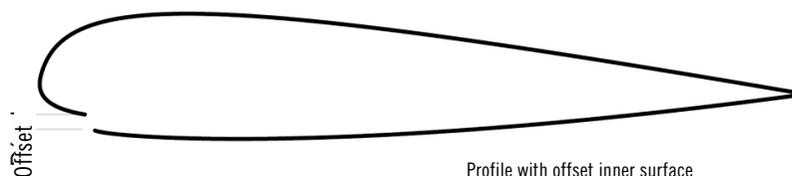
So what to do?

In most cases the air intake is located in the middle of the range and is rather large in size, which is the accepted compromise most designers live with. But, let's try to improve on that: One of the solutions would be to make the intake as large as the range of travel. Unfortunately, pressure inside the glider isn't equal to

the sum of pressure at the air intake but more something like the average (in the same way that adding water at 20°C to water at 30°C doesn't produce a water temperature of 50°C). A paraglider with a very large air intake would end up with less internal pressure than a glider with classic air intakes, moreover with bad flight behaviour at high angles of attack: difficult exit from parachutal stalls and full stalls, flat spin tendencies and bad behaviour at low angles: sail deformation and frontal collapses. Another solution is to use valves, for example two air intakes, with a valve behind each intake which closes when internal pressure is superior to internal pressure in front of the air intake. The idea works very well in theory but is very hard to put into practice, since it often results in air leaks, which makes it difficult and expensive to manufacture.



The construction technique also produces drag-inducing folds on the surface of the glider. I think most manufacturers have tried to find a solution with valves, but none have demonstrated any real advantage and often the idea wasn't carried over from one model to the next with only a few exceptions (mostly on acro gliders) perhaps due to marketing rather than technical considerations. The last option to improve the compromise is to move the inner surface panel towards the bottom, as shown below:



This profile shape enables us to set back the air intake while keeping a satisfactory amount of internal pressure at low angles of attack. The drawback of this profile is that it creates a step in the airflow; it generates increased drag at low angles of attack and in the event of a stall this step will create turbulence at the intake. This does not help recovery.

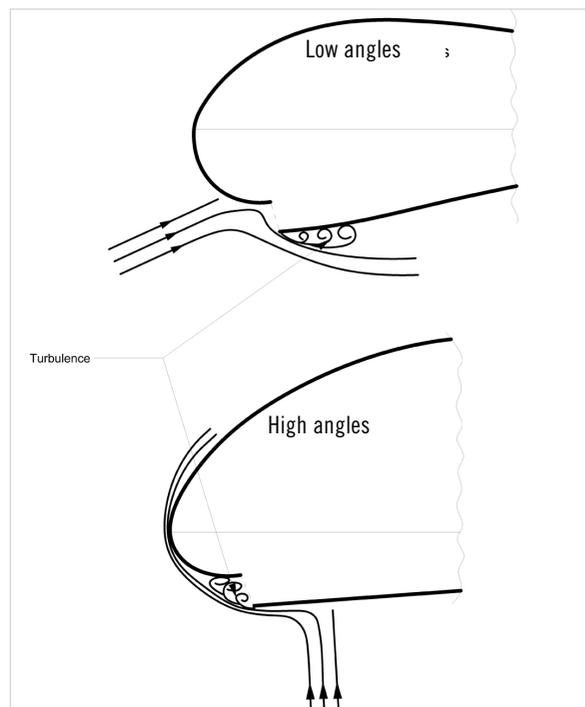


Illustration of high and low angles on profiles with offset inner surface

The Slalom, Ozone's most recent paramotor wing, doesn't have a Sharknose yet. According to Fred Pieri, the technology will almost certainly be adopted by this type of wing.



Delta 2: the first production wing for the general public with a Sharknose.

SHARKNOSE

The idea behind the Sharknose is to add a concave part in the usual range of the stagnation point. This concave part will greatly reduce the size of the stagnation point's range. Before we go any further the following drawing will help visualise the concept : This concave part shall be con-

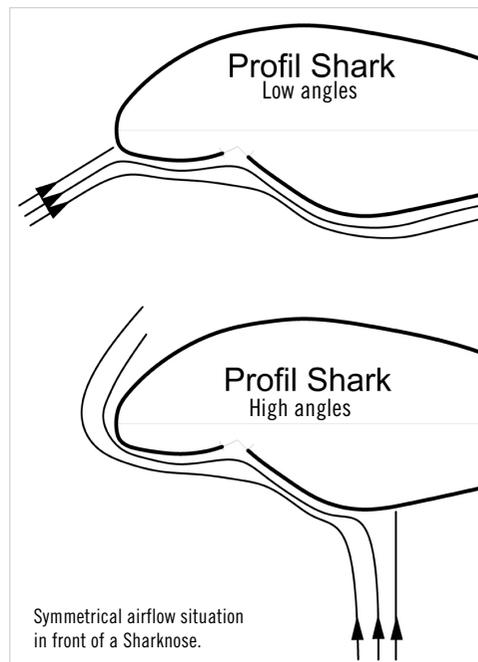
sidered as an area where the airflow slows down. It produces the opposite effect to a "venturi" by presenting a larger area where the air will flow more slowly, knowing that the more the airflow slows down in a given area, the closer to 1 the PC of this area will be (the extreme case being zero speed at the stagnation point where $PC = 1$).

Basic layout of a Sharknose profile.





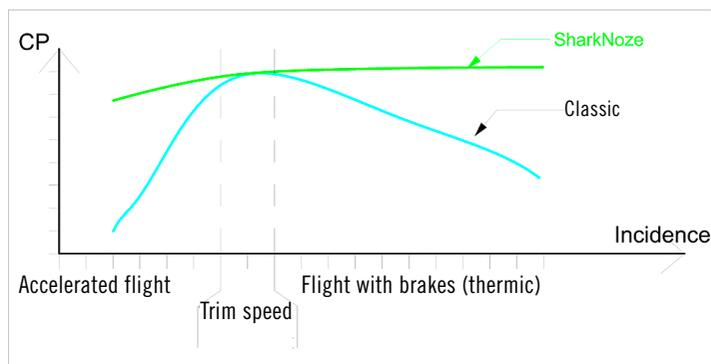
One of the big advantages of a Sharknose lies in its symmetrical shape; it works in exactly the same way whether the airflow in front of the intake goes one way or the other. Same drawing as page 10, but with Shark profiles:



The symmetrical shape, added to a rounded profile enables satisfactory behaviour at both low and high angles of attack without added drag.

Moreover, with the stagnation being less mobile, we were able to reduce the size of the intake and therefore to obtain more even pressure in front of it.

Here is a chart showing internal pressure in a traditional profile and in a Sharknose profile according to the angle of attack:



PC inside the wing relative to the angle of attack.

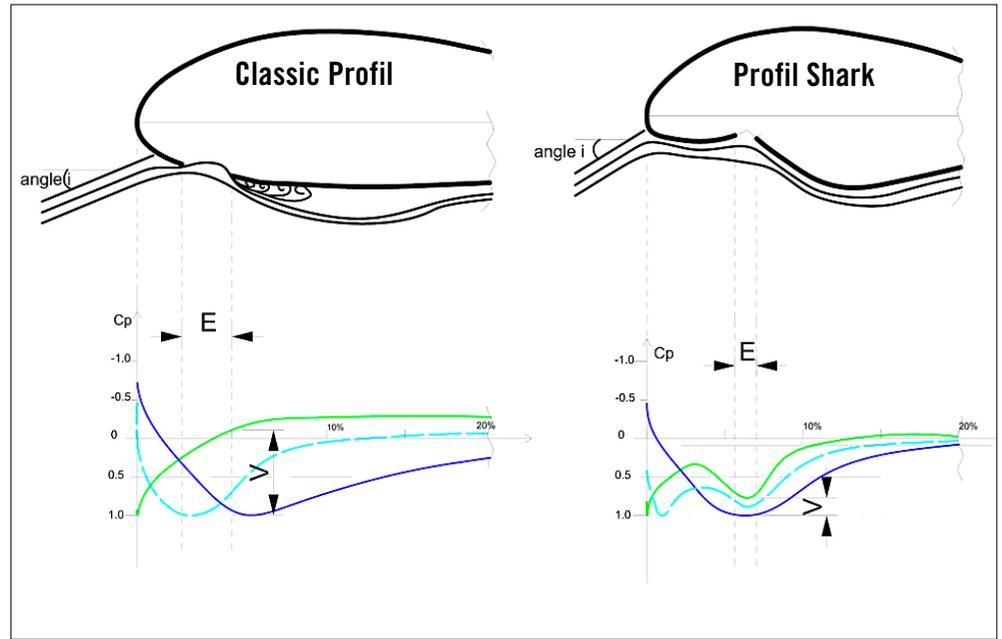
Winter 2010/2011, an enthusiastic Luc Armant revealing the workings of the Sharknose.



Photo : Julian Cisterna/Ozone

The Shark above the water...a Delta 2.

Here are two graphs, showing pressure along the inner surface according to 3 different angles of attack for a normal profile and then for a Sharknose profile.



The smaller the size of the V range, the easier it is to locate the air intake, the closer the V range is to PC=1, the higher the pressure inside the canopy. We can clearly see a smaller range for the stagnation point to move along the Shark profile. This is the ideal location for the air intake.

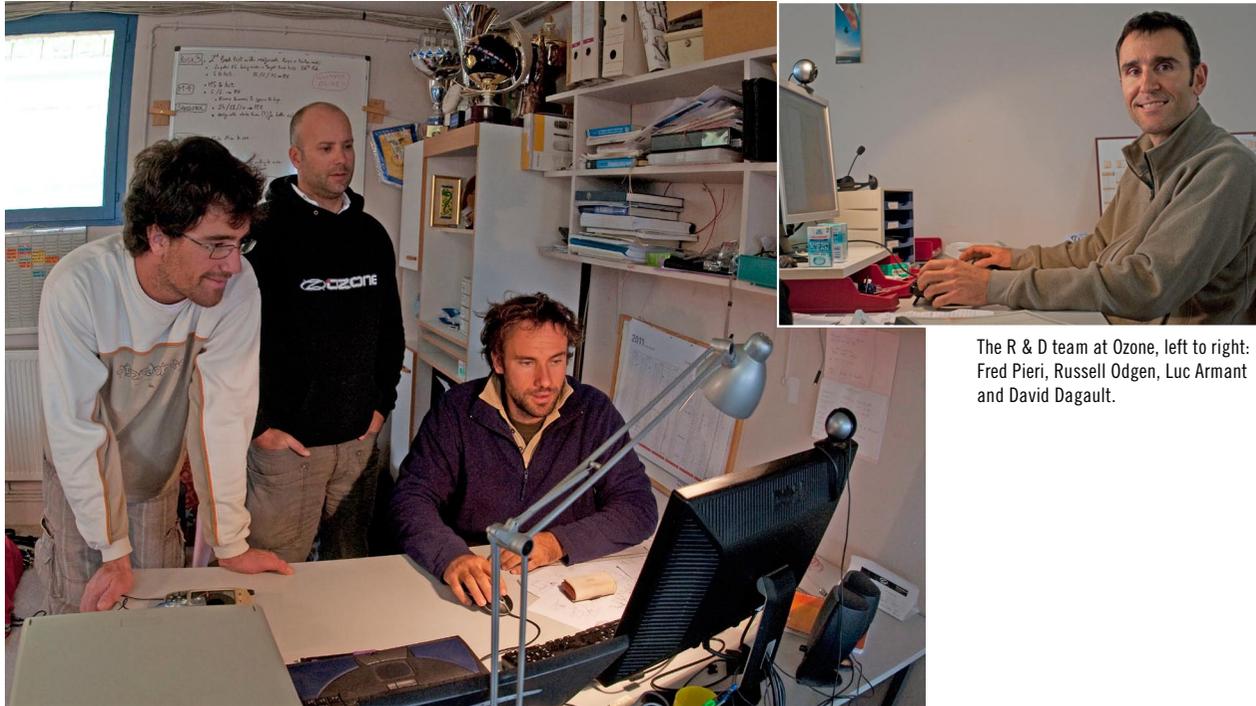
Illustration of PC along the inner surface at three different angles of attack. In green angle of attack 3°, in turquoise 10° and in blue 20°. E is the size of the air inlet. V is the variation of PC at the level of the air intake.

But what are the advantages for the pilot ?

The Sharknose enables:

- A glider with greater stall resistance at low speeds and with a longer brake range : this is useful in thermals to give extra speed to the wing in strong lift or when top landing in a tight spot requiring precision.
- Added strength for the profile at high speed, the gain in internal pressure allows the R11 to fly at over 70 km/h. The Sharknose has allowed the R11 to become the designs with probably the largest and most useable speed range.

Photos : Sascha Burkhardt



The R & D team at Ozone, left to right: Fred Pieri, Russell Odgen, Luc Armant and David Dagault.

- This leads to reduced drag from the air intakes, hence a better glide and, although this is more difficult to link to theory, a better climb rate in thermals.

These conclusions form the basis for our application for a patent. Let's go over the history of the SharkNose at Ozone.

History and current position.

The first draft of the Sharknose appeared as we were searching for a profile which would behave properly at low speeds and have high internal pressure at high speed. Having rapidly built an internal rib as a prototype, we validated its technical feasibility and tried simplifying production as best we could.

We decided to build an R10.2 with this profile; having said that, after a week's brainstorming and digital modelling the profile had only the name and origin in common with the first version!

The prototype arrived and after some adjustments to the sail, at last we witnessed the speed improvement we were hoping for, which was in fact much bigger than expected, with bigger brake travel as well. Happiness all around! That is how the R11 project started.

In the meantime we started thinking about writing up the patent.

A few months later, the R11 and the shark profile arrived in the hands of pilots and shortly thereafter, dominated the 2011 season. Later in the year, politics took over and "Open Class" gliders were banned from competition.

We started working on a certified competition glider: several prototypes were tested, the shark versions flew well but being the first to bring a glider of this type to certification, we decided not to rock the boat: an EN D glider with 2 lines and an aspect ratio of 7.5 was already enough of a shock.

Other brands produced a competition wing, some with their own SharkNose, which displayed the same advantages as ours. In the meantime at Ozone, research and tests continued at full steam, constantly improving the design. Our patent application at INPI made slow progress in the administrative validation procedure.

Finally we received the validation letter for our patent in November 2011 and it was published in September 2012.

The big question was: what are we going to do with the patent? In theory a patent provides the holder – under the condition that



This prototype of the LM5 had a Sharknose.

the technology is made public – with a legal advantage in order to prevent it from being used by a competitor, or to set up a licensing system. It is worth pointing out that in a patent everything is explained, much like in an instruction manual. Since Ozone has no wish to seek royalty payments or to get involved in litigation - as our goal is simply to obtain the best designs possible – we have decided to leave the patent free to use but we will

simply ask for a small logo to be displayed in the wing. We are proud to be able to share this innovative design and the fact that it contributes to the evolution of our sport is a source of great satisfaction to us. From our point of view, we are continuing to develop the SharkNose and we are starting to apply it to other exciting new wings in our range, such as the Delta 2.. ■

Fred Pieri/Ozone, January 2013



Julian Cisterna/Ozone - Mantra M5

At take off, the leading edge of the wing already has the desired form...

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