How Kites Fly—A Different View—P D Cleave

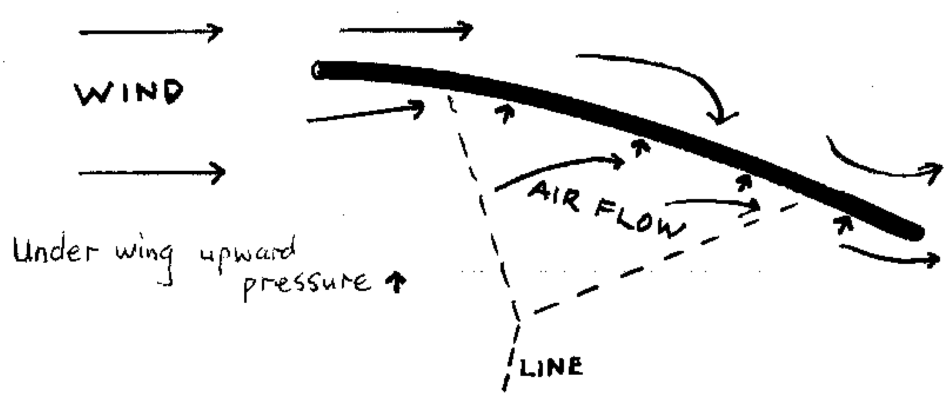
I want to emphasise that I have gained a great deal of pleasure and understanding from the articles by George Webster and in no way want to denigrate his work. However, I have a different point of view in the explanation of how kites actually fly, I am not a scientist at all, but look at things from a practical kite making and flying standpoint.

When one reads and learns about how aeronautics is based on the aerofoil wing shape, one is struck by the simple elegance of the theory: lift, drag and thrust; and it appears obvious that because kites also fly through the air, the same forces must surely apply. However, it appears to me that the theory of aeronautical flight depends upon a rigid shaped wing section, and with kites (perhaps with a few exceptions) we do not have solid aerofoil wings, we have instead a flimsy strutted structure spreading an area of very flexible material. Therefore how does the theory apply?

I suggest that the concept of "lift" is the key misconception when applied to kites. Lacking that solid aerofoil section there is not a defined shape to divert the air into separate over wing and under wing flows as to generate lift in the traditional sense. Therefore, I think the whole concept of lift as applied to kites is erroneous. I just do not think it works in this way and propose a different view.

Unfortunately, aeronautical sources are wedded to the concept of *lift* as applied to the aerofoil wing section; a force which occurs above the wing and which is the magic ingredient lifting the wing up from above. When aeronautics attempts to explain kites it is done from the standpoint that, of course, it is a form of *lift* which makes a kite fly.

However, if one takes as a starting point, that instead of looking for over wing lift, we take the contrary view that the effective force is in fact under wing upward pressure, i.e. Think of the kite as being pushed up from below rather than being lifted from above. This is a much more straightforward concept – using the principle that airflow across an inclined surface generates upward pressure against that surface, and therefore makes the kite fly. In this respect it is misleading to use aeronautical *lift* concepts as being the explanation of what makes kites fly.



So what about the upper surface? What happens there if it is not generating *lift*? The airflow across the underside produces the essential upward pressure to billow out the shape and make the kite fly, and so react against its bridle and flying line. In choosing a shape for our kite, and in its manufacture, we primarily have care for the under wing shape and its "cleanliness" which presents itself to the wind (i.e. Making seams free of ridges on this side) and since it is usually just a piece of ripstop nylon we hope the airflow over the top surface is nevertheless sufficiently smooth so as not to disturb the underlying pressure shape. However, the over wing performance is almost certainly a rather disturbed flow of air and I doubt very much whether it can in any sense produce lift.

In designing a shape for a kite we have to determine not only a suitable plan form but also give regard to allowing flexibility in its actual flying shape by also providing vertical or inclined surfaces so as to give horizontal stability.

If we set aside the aeronautical concept of *lift* as it might be applied to kites, this frees us from having to study the supposed aerofoil-like wing cross section. Instead our attention can focus on

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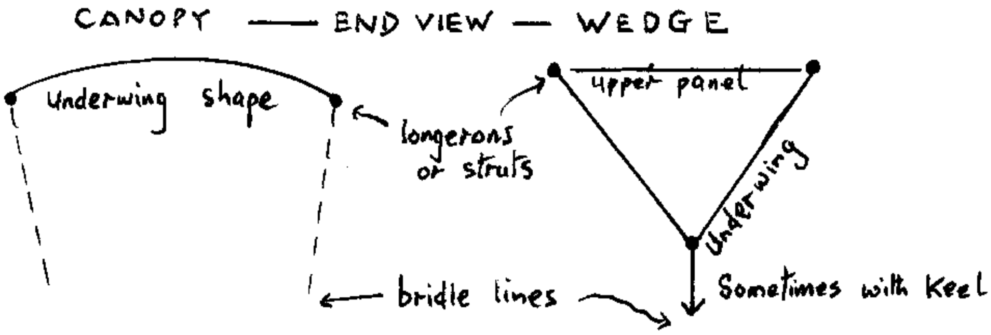
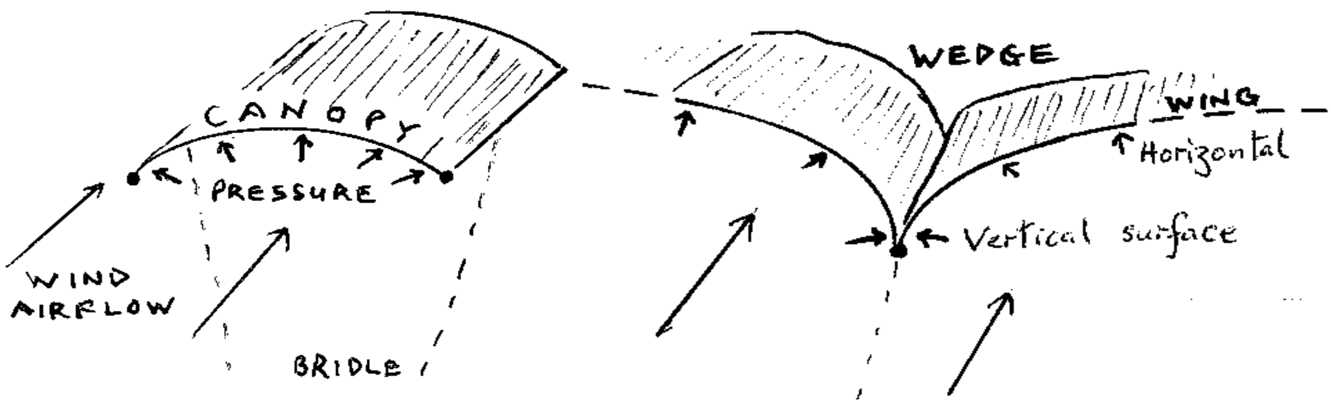
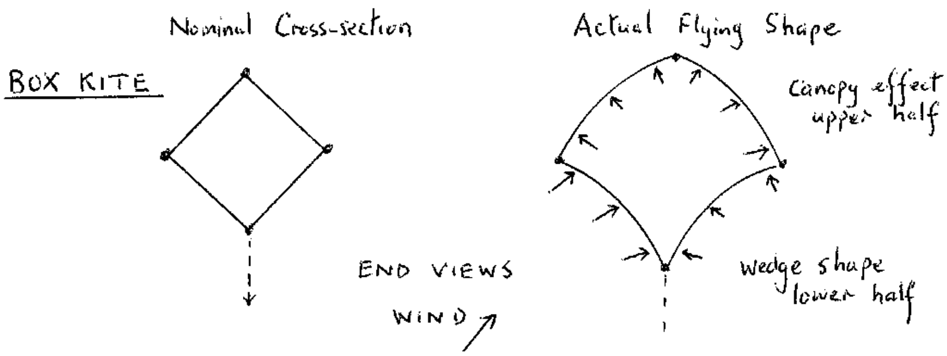
the important frontal attack shapes. It is here that the wind hits the kite and where the shape drives the airflow over the rest of the kite body. In this regard there is a simplicity because all designs can be categorised by two basic shape/flow/pressure concepts. The shapes are the Canopy and the Wedge; and the airflow across and around them determines how the wind strikes them in their inclined or attack attitude, so that the pressure directions are upwards or vertical and sideways or lateral. These are illustrated below.



In the following explanation and drawings I refer to these shapes as being the Wedge and the Canopy. When actually flying pressure is exerted primarily in a vertical direction, but there are important side pressures on the more vertical slopes which give sideways stability.



Of course there are many kite designs other than relatively simple single sheet wings like the delta. For example there are rigid constructions lie the traditional Box Kite, which has its shape maintained by internal struts. With the kite bridled from one of the longitudinal supports this presents the box shape to the wind not as a rigid square, but with the surfaces flexed into another shape by the wind pressures. Under actual flying conditions the box transforms into a Wedge shape for its lower half, and forming into a Canopy on the upper half. Each gives the other about 50/50 vertical and lateral pressures, with the lower producing inward lateral pressures (from the outside surfaces) while the upper gives outward lateral pressures (from the inside surfaces). I believe that these countervailing pressures add up to make the box a very stable flier.



The Box Kite has a relatively inefficient wing shape (i.e. It is a combination of different shapes) but is in fact a very stable flier, because its flying surfaces are effectively 50% upward pressure and 50% sideways pressure for stability. In practice the nominally square shape is distorted under wind pressure into the effective wedge and canopy shapes.

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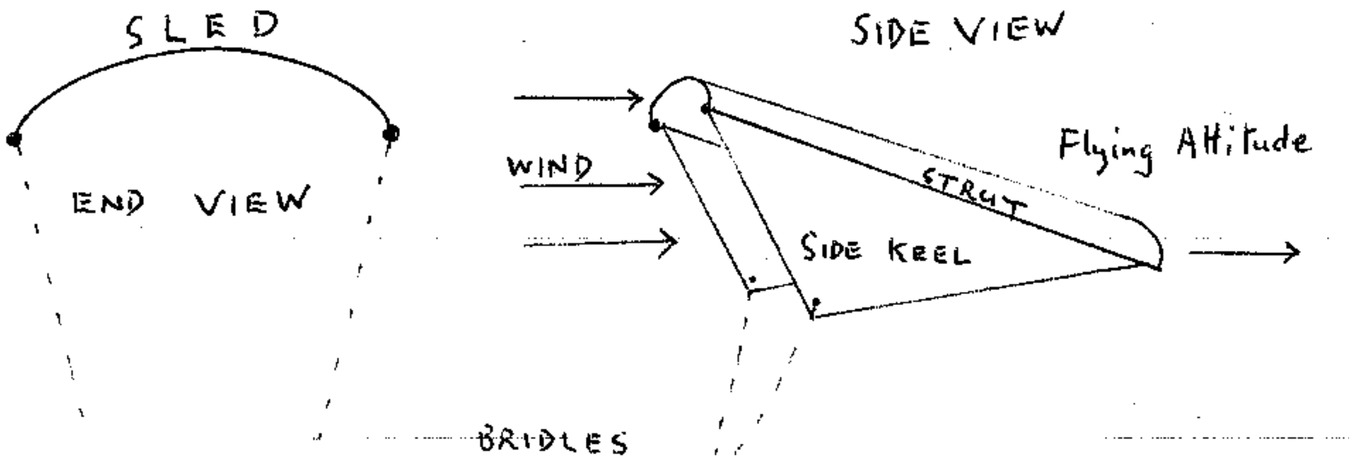
The canopy shape, in general, may well be rounded or comparatively flat, depending on design and the tension applied by the struts. In the typical sled design the main flying wing is in fact an unobstructed canopy which forms a horizontal surface in its middle section, giving the principle area of upward pressure, whilst towards the sides where the surfaces become gradually more vertical, they generate the outward pressure which impart stability.



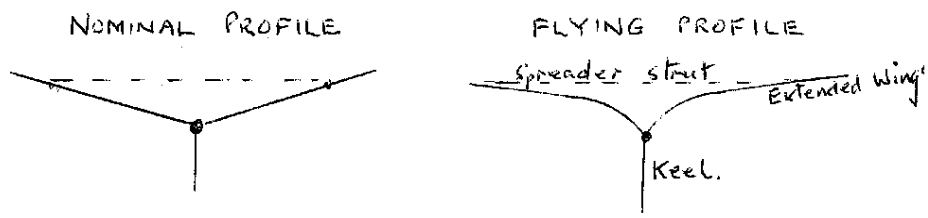
Therefore the sled design gives a comparatively flat profile front to rear (usually supported by sleeved straight spars the length of the kite), exactly contrary to the notion of an aerofoil cross section, but because of the unimpeded airflow from front to rear, the design imparts good upward pressures, which makes this simple kite a very efficient flier. There is no lift, just good airflow and upward pressure.

I go further an suggest that the Parafoil double layer soft kite also works on similar principles. The cellular structure which becomes inflated with forced air at the front, is used to give lateral shape to the whole, particularly the underside (supported by a number of bridles to help maintain the overall shape), so that it presents itself to the wind as a large rectangular under wing to derive upward pressure, with the upper shape aiding airflow, not giving lift. I believe it is very doubtful whether slow flying parafoils (or aerofoils in general) produce lift, but their large unimpeded under surfaces do produce large amounts of upward pressure, hence, in appropriate wind conditions they become very good fliers.

The wedge shape is very common and used in many kite types, and for good practical reasons, i.e. It produces both upward and sideways pressures. It is used in construction to anchor the bridles and lead into flatter but canopy like main wings – as will be seen in the example of the Delta, Conyne and Genki designs below.

The diagrams show the end attach profiles of three common kite forms and how their essential shapes behave when flying, so as to produce upwards pressure derived from the Wedge and Canopy shapes (their plan forms can be seen in most kite books).

Delta Kites



The delta is mostly a wedge shape but has canopy like outer wings. It comes in a range of plan forms of varying aspect rations, and can therefore be adapted to various wind speeds. The spreader strut is used to determine wither a tight shallow wedge and wing or to allow a more generous deeper wedge and canopy wings.

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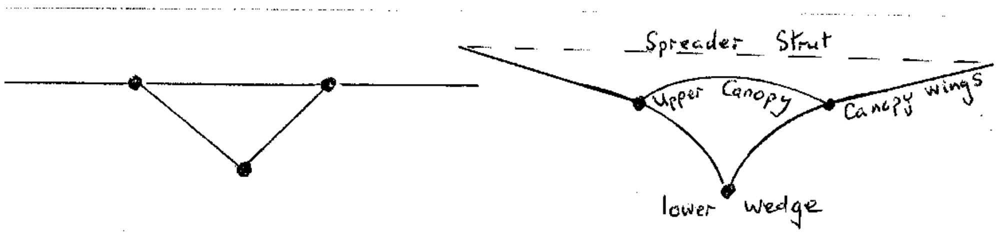
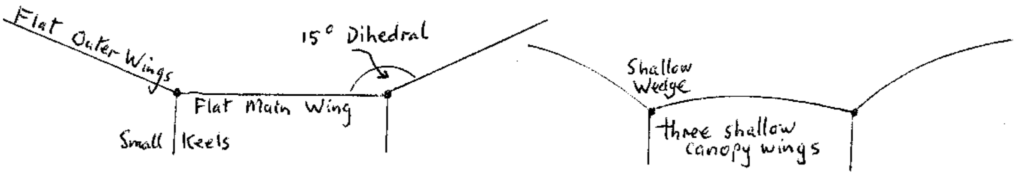
Conyn Kites



The Conyne has a distinct main wedge centre section supporting shallow or flat canopy wings. Therefore it has good flying characteristics in moderate winds. The Conyne concept is used as a main component of many other derivative designs.

Genki Kites



This model comprises three large square wings and although it does not have any Wedges as such, it does have generous dihedral which effectively imparts a very shallow wedge-like shape to each wing, giving the kite stability; especially a good flier in light winds.

Below is an extract from a letter to George expanding on some of the reasoning.

I have re-read your first article and your very interesting letter, and to be sure, you explain your views very clearly. There are parts, where of course I accept your explanations. However, I still find a sticking point with the whole concept of 'lift' as applied to kites.

In a paper by a Cranfield aeronautics engineer Professor Schaefer, I find this statement:

"Fundamentally, aerodynamic forces are due to pressure difference, and so to support a kite against gravity and tension in the line, the pressure against a kite's underside must be greater than that against the top surface..."

and similarly you yourself:

"..This downward flow, by Newton's laws has an upward reaction which pushes up the wing..."

My principle argument arises right at this point. Both sources recognise the primacy of a pressure pushing upward, this I understand and completely agree with. But the next step of calling this pressure "lift" is, I think, misleading for kitefliers. Lift, in aeronautics is essentially a force which operates above the wing, and is induced by reduced air pressure above the wing. Because of kites' low speed, flexible materials and varying wing shape, I do not believe that list in the guise of the overwing low pressure is the effective force; indeed as you suggest yourself the behaviour of the airflow above the wing is probably best described as chaotic, not a flow to produce an effective lift.

On the contrary it is the under wing upward pressure which produces the flying force; and I do not think this should be confused with lift, however conventional this terminology may be in aeronautics; I am not really bothered that, for the moment, everyone else calls it *lift*!

It seems to me to be beneficial to the design, construction and practical flying in *Kite-onautics* to study primarily the under wing flows and pressure, not the ethereal over wing lift characteristics of aircraft wings.

Following this standpoint it become very logical to moe into studying actual kite shapes which best allow flow and develop pressure; and this is where I put my proposals for analysing shapes in terms of wedges and canopies because kites are very much more complicated that their plan forms suggest, and rarely have a constant wing cross-section, let alone an aerofoil profile. I think we should study kites as a separate species rather than as some aberration of aeronautics.