INFLATED WINGS

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Abstract

Inflated wings, although limited to low speeds, could be useful in hitherto neglected areas of aviation. Their main advantages are their outstanding weight to strength ratio, their economy of construction and the possibility to furl and stow them easily.
The uses of both statically and dynamically inflated wings are considered.A very large statically inflated wing could travel solar propelled. Smaller dynamically inflated wings could make ultralight planes practical in poorer countries.They could be used as wing sails for boats and even supply auxiliary power to ships. Furled around a ski pole they could become ski tows. In agriculture, as kites, they could do some ag plane work at a fraction of the cost. In military applications they could be developed as parachutes and amphibious operations aids.

Introduction and concept

For the past four years I have been experimenting with inflated wings. I am, as stated in the Jane's Who's Who an "inventor " ,actually an empirical inventor and experimenter. I am also a journalist and an occasional science fiction writer. I work alone so my progress at the moment is sporadic and slow.

Why inflated wings ? Because, apart from their obvious disadvantages, they have advantages that, in my opinion,merit further study. The disadvantages are known.In an inflated wing the pressure inside must be higher than the pressure outside otherwise the wing will collapse. This is very easy to achieve as long as the wing doesn't move, but what is a wing without airspeed? So, considering that the pressure on the leading edge of a wing increases with the airspeed, squared, it follows that, in practice, inflated wings are only useful at low speeds. This is the reason, probably,why they have been studied by so few professionals,so far.

Yet aviation is not always necessarily the pursuit of higher, faster, bigger, costlier and, for the military, deadlier. There remains in aviation a new frontier, a dimension still relatively unknown and feared even more than space and that dimension is, in one word, cheap.

It has been growing at a fantastic rate in the last few years. I read that the sales of ultralights double every year. I wish it were true for other branches of the aviation industry.

Inflated wings are, in my opinion, a giant step for humamity in the dimension cheap. The present definition of aviation in dictionaries and encyclopedias is still limited. A better definition would be: aviation, the human uses of the sky.

If we accept this philosophy a host of new products become part of the aviation industry. For instance, kites. They may be toys but it all depends on their size. We are all here because the Wright brothers started something in 1903, and they started it with kites. And one well understands why:kites are the poor man's wind tunnel.

If a kite is big enough, for instance, if it is an inflated wing, easily furlable stowable and manoeuvrable in the sky, it could do some of the work of agricultural planes and at a fraction of the cost. It could lift loads of seeds, fertilizers, pesticides, it could run across fields along cables that could be advanced from row to row. The cables could be tensed between two tractors, even two ox carts in poorer countries. The bags of seeds,fertilizer, pesticides could help weight down the carts. Such a kite could be biplane, triplane, multiplane with planes that could be added or subtracted according to the force of the wind.

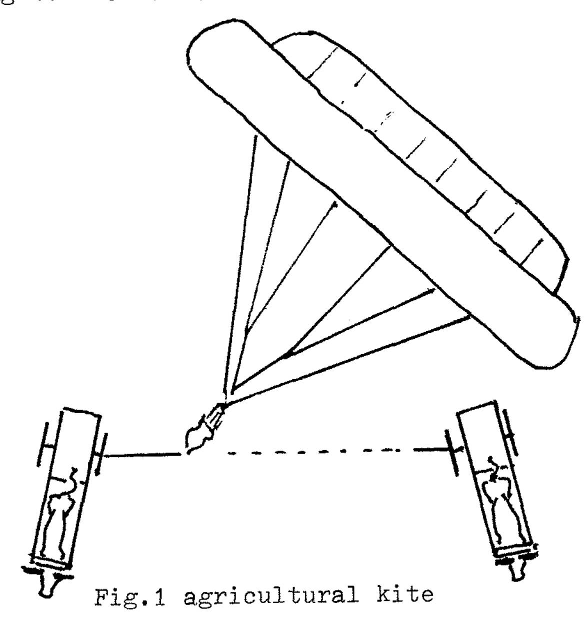


Fig.1 agricultural kite

Perhaps there is not much money in poorer countries, although there must be some good will toward suppliers of a laborsaving device but there is money in the leisure industry and there an inflatable wing, easily furled around and unfurled from a ski pole could help skiers ski uphill and therefore dispense with ski tows, with limited and crowded ski areas or with mountains altogether. And one would not be limited to skiing . The same wing sail could be used to skate on the frozen canals of Holland or windsurf along a shore. A much bigger wing sail, unfurling from a car's roof, could even make an amphibian car practical, could make a motorist dream, at least, of driving to Paris. Of course the car would not have to ride the waves. It is enough if a keel stays in the water.

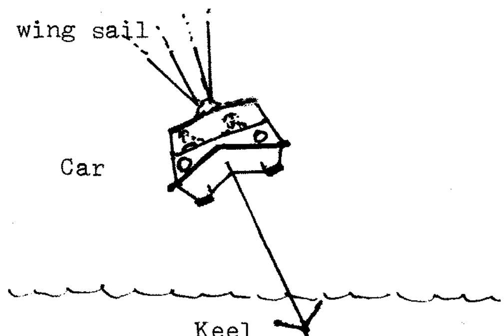


Fig. 2 Amphibian car and keel

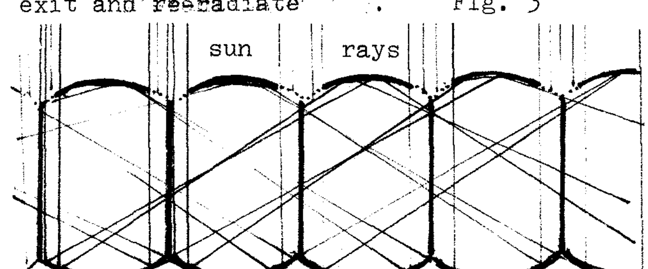
All this is about dynamically inflated kites and to better illustrate the definition of aviation as : the human uses of the sky.

Speaking of wings proper, it would be necessary to distinguish between statically and dynamically inflated wings. The statically inflated wings are the ones where the air or the gases inside are always the same. The dynamically inflated wings are the ones where air enters from the leading edge and exits from the trailing edge, in certain models, and where the pressure and the vortexes of the passing air shape the wing. This is the case with kites like the ones that Domina Jalbert builds and with the new parachutes with rectangular canopy.

As for statically inflated wings, there is at least one inflatable plane at the Patuxent Naval Air Station, in Maryland. I think it was meant to be parachuted in its deflated shape for military purposes and perhaps it did not prove very practical. Perhaps it was conceived before its time. When it was built, I believe shortly after World War II, some of the new materials that, in my opinion make inflated wings possible now, had not been developed yet. I am speaking of Mylar, Kevlar, coated rip-stop Nylon and laminations thereof like the ones now used for the sails of the America Cup boats. The second reason is that the real properties and the real advantages of inflated wings had not been put into play. An inflated wing does not have to be rooted in the fuselage like a rigid wing. If we accept the possibility of a wing high above the rest of the plane then we take full advantage of the very nature of an inflated wing. The advantage is that an inflated wing needs no rigid part that can break, only parts that can tear, rip or snap. Now as far as building a structure is concerned, if we make all the stresses tensional, renouncing all the torsional and flectional stresses, we can get much more wing out of a pound of Kevlar or Nylon than from a pound of aluminum, titanium alloy or graphite-epoxy. To have all the stresses tensional is a great saving in weight and cost. The cost however is another: that the wing must be held horizontal by shrouds like a parachute.

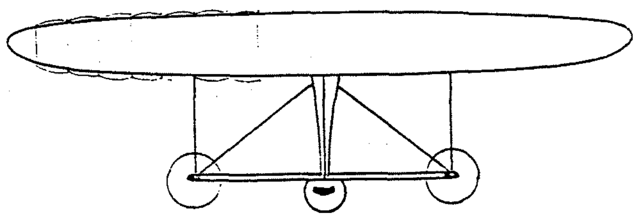
Statically inflated wings

I have explored in a previous AIAA paper the possibilities of statically inflated wings. Some could be inflated with lighter-than-air gases and then they would glide upward. The ideal L.T.A. gas would be, of course, hot air and the ideal way of heating it would be by solar energy. Solar balloons have flown already. In an inflated solar wing the first results would begin to show at about a million cubic feet which is not much when one remembers that the Hindenburg had a volume of six million cubic feet. A solar wing, after it has paid for its own weight, could provide very cheap transportation. It could be made of black Nylon or it could have transparent strips on its upper surface on the two sides of the rope ribs. All the other inside surfaces would be silvered so that the sun would enter from the transparent strips at the top, it would hit the concavities created by inflation at the bottom, along the cable ribs, the rays would be scattered in many directions and only a small part would exit and reradiate. Fig. 3



Sun rays enter from transparent strips and are reflected.

It would be a very cheap solar trap in the very nature of a statically inflated structure which, of course, tends to form concavities between the reinforcements. Solar energy would not be the only energy in such a craft. It could be helped by conventional engines and propane burners in the periods between upward glides and downward glides and in ground manoeuvres.



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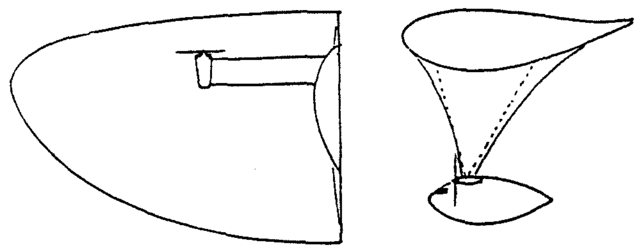

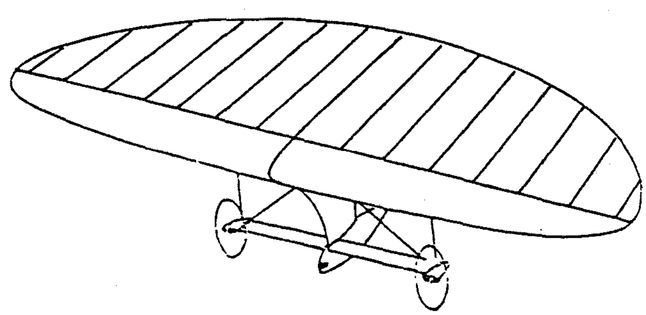

Perspektivische Darstellung des »Solar Wing« von Roselli

Fig 4
Solar wing

Inflated wings could also be useful in new attempts at man-powered flight. They are naturally elastic, they can beat and therefore propel themselves by ciliary motion, the way a bat does. All this was covered in the above mentioned AIAA paper.

Dynamically inflated wings

As for dynamically inflated wings, one obvious advantage over statically inflated wings is that they don't need to be actually inflated. They can unfurl in the wind and the wind will fill them up, shape and tense them. Another advantage is that since it is the relative wind that tenses the structure, the structure will be tensed in proportion to the strength of the relative wind. The inside pressure, in other words, will be determined, up to a certain point, from the outside pressure, thereby solving one of the problems of inflated wings.

The results so far

I started experimenting with dynamically inflated wings about four years ago with very limited means. The first one I built I called AV1 or Alavela (Italian for wing sail) number one. It had a span of 59 inches, a chord of ten and an area of 590 inches. It was made of polyethylene with ribs of dental floss and it did not work to my satisfaction. It was too small, not enough air would get into it to make it rigid, the ribs were too few, the shape was not the airfoil I had in mind. Moreover the rigging would tangle hopelessly even before I could take the thing out of the car and try to unfurl it. Yet for a few brief moments of flight it proved its potentialities and encouraged me to build AV2. AV2 was made of Mylar with ribs made of Nylon thread. It had a span of 81 inches, a chord of 21, an area of 1701 square inches. The first problem, once again, was the shape. In every inflated thing there is a balloon bursting to come out so it was especially at the trailing edge, which had to taper to a wedge, that I experienced disappointment. To increase the number of ribs was the obvious solution but an increase in weight was also the obvious new problem so the obvious new solution was to increase only the number of partial ribs at the trailing edge.

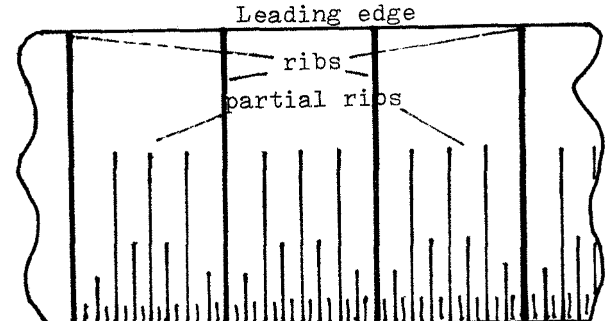

Fig. 5

AV2 proved to me that one could make good use of a phenomenon that bedeviled the Wright brothers until they added rudders to their"flyer" and that is the phenomenon of reverse yaw. An inflated wing does not need ailerons because it is easily warpable. When the tip of a trailing edge is pulled down by the line that connects it to the operator the lift and the induced drag are increased at that wing tip. The lift is nullified by the pull so the wing takes its revenge by reverse yaw. In other words that particular wing tip retrocedes and the other tip comes forward. But now a new imbalance is introduced: the forward tip is nearer to the operator while the cables are of equal length . The wing, therefore, must become vertical and in so doing it has to weathervane on the side where the cable is pulled,so the wing can be manoeuvred left and right to sail against the wind, just like an ordinary sail.

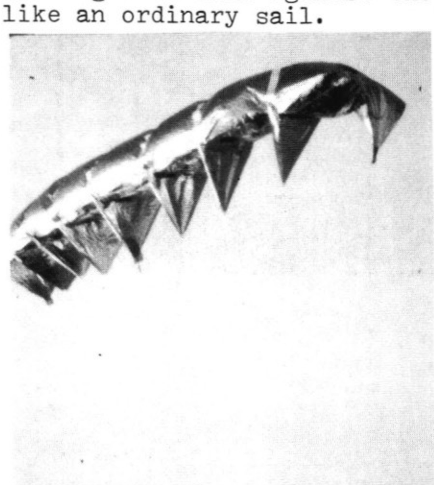

Fig. 6 AV2

Fig. 7 AV2 and control stick

Fig. 8
Left aileron down

Fig. 9 Right aileron down

However this would be no ordinary sail because it would have no mast. The height of a mast limits the performance of a boat; without mast this performance could be extended. With the proper mechanical systems for winding and unwinding cables and wing sails we could go back to very efficient sail ships or to ships with auxiliary wing sails. When one thinks that a supertanker needs a barrel of oil just to run its own length one can see the convenience of wing sails that could be easily furled and unfurled, would require no masts, little space on the deck and few or no crew members to manoeuvre them.

AV2 showed also that an inflated wing is flexible not only along its longitudinal and its lateral axis but also along its vertical axis.In other words it has variable geometry as would be said of an F 111 and,although variable geometry may have some future use in inflated wings,it was, at the moment,a big nuisance. In the necessary new vocabulary that my wife and I had to adopt to talk of these new things we came to call"comedy"the coming forward of the wing tips and"tragedy"the swept back geometry, from the shape of the mouths in the Greek masks of comedy and tragedy

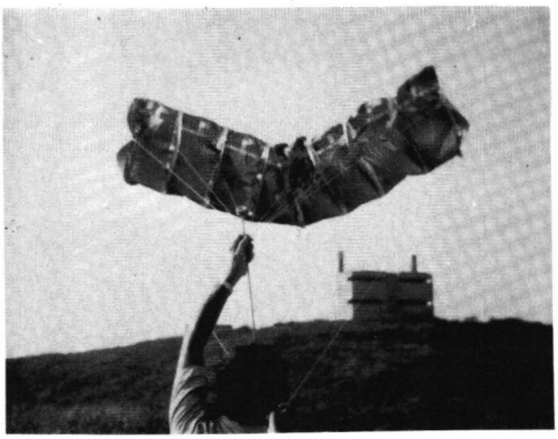

Fig. 10 "Comedy "

Fig. 11 " Tragedy "

Actually " comedy " proved much more bothersome than " tragedy " because it would occur when the inflated wing, in kite form,was manoeuvred by the control stick to come overhead as much as possible, which negated the possibility of many other experiments. If the operator pulled too hard on the forward part of the control stick the wing would simply shut itself like a book. The remedy,however was soon found: make the wing tips fly at the same speed as the wing roots by increasing the induced drag at the tips. Instead of the washout frequently found in the wings of general aviation planes an inflated wing often needs a wash in.

The following wing: AV3 was to research how much I could get away with in aspect ratio with a given chord.

Fig. 12 AV 3

The chord is what determines the dimension of the object when furled so it was interesting to learn how much wing area one could furl around a ski pole, for instance. AV3, therefore, had a wing span of 260 inches, a chord of 21 and an area of 5460 square inches. It would not be capable of carrying me but the question was: could a wing capable of carrying a man to a safe glide be rolled eventually to a shape not much bigger than an umbrella ? Could it be stuck in a back pack or in the knapsack of a mountain climber?

The answer was yes but not with a monoplane configuration. The high aspect ratio introduced new difficulties in manoeuvering because now there was so much more to twist and flex along all axes.First of all the rigging had to fight the natural tendency of the wing to billow in the wind, which was robbing it of much lift,and to keep the wing as straight as possible. Secondly, as it was found out,a very straight wing was also very unstable and there would too much tragedy and comedy, that is too much flexibility along the vertical axis.A compromise had to be found and even this compromise proved extremely unstable especially when it came to manoeuvering it left and right by reverse yaw.Fiberglass sticks at the wing tips along the longitudinal axis would give better leverage extending the apparent chord but introduced new problems in the furling and unfurling. Besides, the new wing span required much longer cables and that gave the rigging all the opportunities it had always sought to tangle. Under the absolute rule of the Murphy's law of the perversity of inanimate object I tried 74 documented riggings and then I lost count. I figure that the rigging I am using now could be number 90 or 95.

Fig. 13 AV 3 straightened

Fig.14 AV3,left aileron down

The ultimate solution was to chop AV3R90 or 95 in two and make it into a biplane which I designated as AV3B1. In the biplane configuration the lower wing would have a much shorter wingspan thus requiring much shorter cables with a big saving in weight and complications.

Fig. 15 AV 3 B (biplane)

However the biplane configuration does not solve every problem. Although it has the same wing area as the entire monoplane it is not as efficient. The upper wing tends to fly in the aerodynamic shadow of the lower wing. It is necessary therefore to stagger it forward and this is not simple. Once again the best way to convince some part of the craft to come forward seems to be giving it less induced drag than the part that should stay behind. At the moment of this writing I am experimenting with AV3BR12 which means I am at my twelfth rigging of the biplane configuration of AV3 but I am getting bored with the whole AV3 because, as I found out, Mylar tends to become brittle and fragile with the sun, the wind, perhaps the salt or the iodine of the sea air so AV3BR12 is by now practically all patches which makes it much heavier than it should be. I am therefore building AV4 in red ripstop Nylon. Red because it photographs better against the sky, rip stop Nylon because it is more reliable than Mylar. AV4 will have a chord of I.12 meters a lower wing with a wing span of five meters to which an upper wing with a wing span of seven meters may be added later on, to which a third wing, for a triplane configuration may be added still later on. The third wing would have a wing span of nine meters all together the biplane will have a wing area of 13.44 square meters, the triplane a wing area of 23.52 square meters.

Much of my difficulty now is mechanical because I don't have a lathe and therefore I cannot build myself a winder more or less like the reels that are used for fishing lines. However I think that this is a minor problem and that, once the commercial desirability of furling and unfurling wings is evident somebody could come up with a mechanical device that allows rapid and tangleproof furling and unfurling of cables and wings.

Some possible uses

I think that the uses of inflated wings are many. I will try and review the ones that occur to my mind.

As a sail. The main advantage is that it would require no mast.Its manoeuvre would require little effort since the wind will do the work for the crew by moving the wing sail left or right as desired in order to tack against the wind.It would, however require a minimum of wind to lift. Further research will tell if it would also allow to sail in the eye of the wind which would be theoretically possible with a hyperzenithal wind sail, in practice an inflated kite that can be manoeuvered upwind of the line or lines representing gravity.There may be fantastic possibilities in hyperzenithal kites and inflated wings and, for the moment,the only way to find out is, for me, my own empirical way.

As a wing for ultralight planes,especially new ultralight planes meant for poorer countries.Here the dimension " cheap ", mentioned before, could really become the new frontier of aviation. If we can produce a flying machine that flies not necessarily faster than thirty miles per hour, not necessarily higher than a few hundred feet, not necessarily further than a hundred miles but is capable of carrying pilot and sack of grain or pilot and sick mother or pilot and pregnant wife or pilot and goat to town we won't have achieved much in terms of modern aviation unless the whole contraption costs not necessarily more than five hundred dollars and can be stowed under the bed or over the cow. Such a craft, possible with inflated wings, would not only benefit the poorer countries of the world but would also bring about great social changes and of the type desired in the West. We must add here that an inflated wing, having no spar,can be produced continuously from a template, can be rolled like fabric and sold like fabric. Say a farmer is big and fat: he would probably need fifteen meters of wing.A smal and scrawny farmer could buy only ten, twelve yards.

In due time immense psychological changes that we cannot gauge here could very likely occur. There is a great difference between people who can only travel by collective conveyances such as a train or a bus and people who have a steering wheel in their hands and can cause a vehicle to go left or right.Steering wheels have a way of seeping into drivers'minds, they give ideas.Some of us may have observed this phenomenon,which we could call " centaurization",that is the identification with one's conveyance. The horse created a social class, the car makes for free citizens, the big motorcycle tends to transform the rider into a rebel and a bully. Who knows what a cheap ultralight would bring about ?Perhaps the solution to the East-West confrontation is not, excuse the heresy, a costlier bomber but a cheaper personal air transport.

As parachutes.A tangleproof system of winding and unwinding the furled wing and its cables from a control stick is, of course,the prerequisite.This, however, is just a mechanical problem: a winder, a reel,a winch, a windlass could easily be fabricated with means I presently don't have. Unlike parachutes, inflated winds would not decelerate a fall, they would change it into a glide, even more so than modern rectangular parachutes. The extended glide could be useful in reaching friendlier territory, in the case of a military pilot, or land on ships at sea. The glide could be extended ever further by adding to the escape rig a small engine and a propeller. Thus the pilot of a crippled plane could escape in another plane albeit much slower.

Inflated wings could also extend the use of parachutes in military operations. Instead of jumping down from a high flying plane troops could jump up from low flying planes, which would have military advantages. And, speaking of jumping up, even trucks, boats, ships could lift troops, kite-style, to make them glide above obstacles or water toward their objective.The ultimate exercise would be, of course parachuting from a submarine, not impossible with inflated wings.Moreover, once landed,a soldier would not have a useless parachute to dispose of but a potentially useful vehicle. For instance in snowy or frozen countries the wing could be used as a sail to ski or skate toward the objectives.

In summation, I have been working on inflated wings and I have accumulated some experience about them. I keep dilogent track of my mistakes and I have accumulated 319 of them , to date.But they are mistakes out of the way, mistakes I need not repeat, mistakes that somebody else would have to repeat,perhaps. I would like to quote some bibliography on the subject but it seems that if books are going to be written about inflated wings I will have to write them. I am in unknown territory. I know from experience that lone explorers like me must cross bureaucratic deserts among dried out skeletons of other inventors who did not make it, as amply illustrated by my past and present correspondence with the patent office. I know that after the bureaucratic desert comes the legal jungle with dinosaurs of the established interest groups ready to swallow me in one gulp but I spend my Sundays on windy beaches with my patient and understanding wife in the hope of doing something useful.