(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
17 February 2005 (17.02.2005)

PCT

(10) International Publication Number
WO 2005/014392 A1

(51) International Patent Classification[7]: B64C 31/06

(21) International Application Number: PCT/NZ2004/000178

(22) International Filing Date: 6 August 2004 (06.08.2004)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
527454 7 August 2003 (07.08.2003) NZ
528497 26 September 2003 (26.09.2003) NZ

(71) Applicant *(for all designated States except US)*: **PETER LYNN LIMITED** [NZ/NZ]; 105 Alford Forest Road, Ashburton (NZ).

(72) Inventor; and
(75) Inventor/Applicant *(for US only)*: **LYNN, Peter, Robert** [NZ/NZ]; 105 Alford Forest Road, Ashburton (NZ).

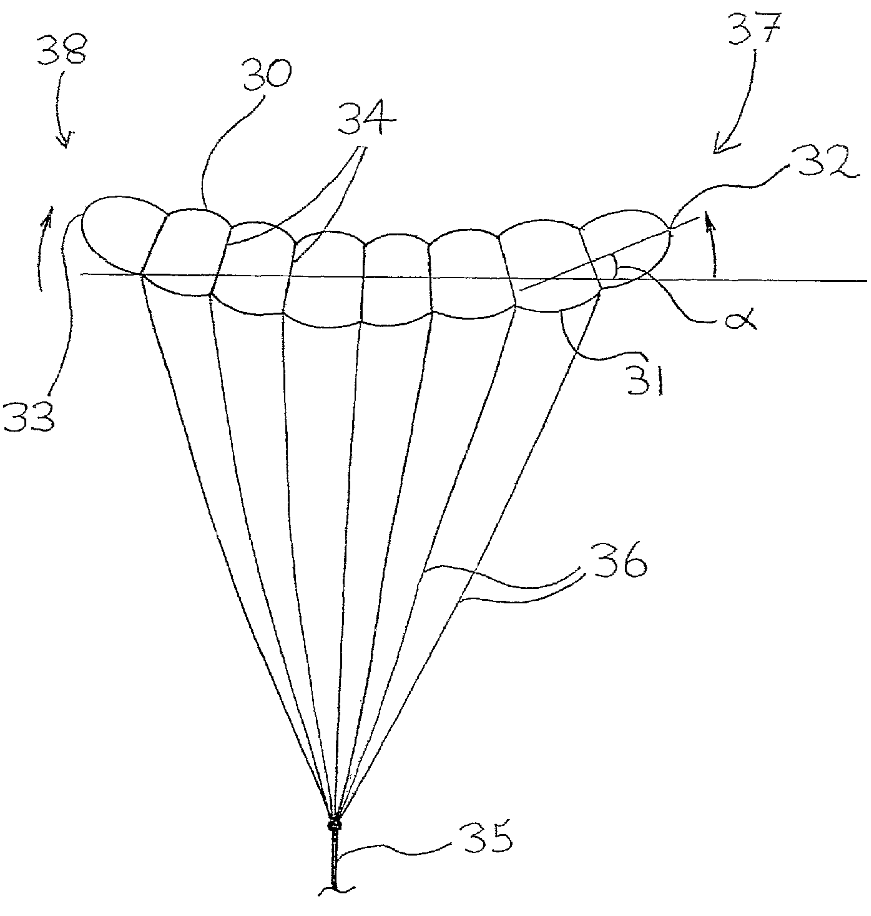
(74) Agent: **BALDWIN SHELSTON WATERS**; PO Box 852, Wellington, 6001 (NZ).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PL, PT, RO, SE, SI,

[Continued on next page]

(54) Title: RAM AIR-INFLATED KITE



(57) Abstract: A ram air inflated soft kite (spanwise section depicted) has upper (30) and lower (31) skins joined at sides (32, 33) and trailing edge (not shown). The leading edge (not shown) has openings allowing ram air-inflation. Skins (30, 31) are connected inward of their edges by links (34) consisting of chordwise extending ribs or cords spaced spanwise and chordwise. Curvature of the kite is produced by the shape of links (34) or by altering their spacing, eg closer, in the spanwise direction, on upper skin (30) than on lower skin (31) so that wingtips (37, 38) curve upwards, preferably at 15°, to form a dihedral. Yaw and edging type instability in higher aspect ratio kites may be controlled by varying the depth of the leading edge of the kite at wing tips (37, 38) relative to the depth at the centre of the wingspan.

WO 2005/014392 A1

SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

RAM AIR-INFLATED KITE

Field of the Invention

The invention relates to a kite and particularly to a ram air inflated single line soft kite.

Background to the Invention

The following background description is given to assist understanding of the invention and should not be interpreted as defining the prior art.

As used in the following description the following technical terms have the meanings set out below.

Definitions:

Aspect Ratio: A term from aerodynamics, for a rectangular kite, aspect ratio is defined as wingspan divided by chord (chord is the kite's length in the direction of airflow). For other shapes, aspect ratio is defined as span squared divided by area.

Bridles: For single line kites, means the multiple lines attached to the kite end of the main flying line that distribute the flying line load out to multiple attachment points on the kite.

Dihedral: A term also in general use in aerodynamics. For a kite specifically, dihedral is any form for which the tips or outer ends of its wing or lifting surface are in a plane at an upwards tending angle to that of the central section of its wing or lifting surface. For aeroplanes, dihedral is often achieved by attaching essentially straight wings at an angle to its body, or by building in an upward bend or kink where the wing tips attach to the wing's centre section, but for kites is more usually contrived by curving the entire wing or lifting surface so that its tips or outer ends are angled upwards relative to the centre section. Shapes that curve or angle downwards towards the wingtips are defined as having Anhedral.

Longitudinal Dihedral and Longitudinal Anhedral: the same form effect as Dihedral and Anhedral but disposed in the chordwise (also called longitudinal or flow wise) direction rather than spanwise. A kite with both Dihedral and Chordwise Dihedral will generally have a convex lower surface.

Edging or "super stability": In many ways the opposite to Yaw instability, Edging is the tendency for a kite to, relatively slowly, lean progressively more towards one side until ultimately it touches the ground. Not to be confused with asymmetrical flying caused by dimensional or structural asymmetry's in the kite's construction, for a perfectly symmetrical kite, Edging can occur equally to either side depending on whichever direction is initiated by some minor perturbation.

Flare : A usually triangular piece of fabric or sheet material fixed along one of its sides to the skin of a kite and with a bridle line attached to the point opposite that side such that the bridle loads are spread and distributed into the kite's skin, and the flare, so tensioned, provides lateral area to stabilise the kite. Flares can also be other than triangular and have multiple bridle lines attached to them, in which case they are usually called keels.

Luffing: Is the tendency for a kite's angle of attack to become suddenly negative. Usually occurring in turbulent winds or when overflying, the result will be loss of line tension and in extreme cases, a luffing single line kite can flutter to the ground out of control.

Parafoil. The original and now generic form of, ram air inflated soft kite usually using ribs to set the spacing between its upper and lower skins and generally using flares for bridle attachment, that was invented by Domina Jalbert in the 1950's.

Planar: A planar kite generally has all its lifting surfaces disposed in one plane, although it may be curved by way of chordwise and/or spanwise curvature when viewed from the side or front. A planar ram air inflated kite will have greater area in plan than in its thickness..

Ram air inflation: Means, for soft kites, constructed so as to have substantial internal spaces, such as parafoils and their derivatives, that external air from or near from a flow stagnation point is bled into the internal spaces to inflate them to slightly above the average external air pressure, thereby providing form and shape to hold against compressive loads applied by aerodynamic and bridling forces. This form of internal pressurisation is called ram air inflation.

Rib; Soft kites that are constructed with internal spaces to accept ram air inflation frequently use panels called ribs, to connect their outer surfaces at multiple joints, so holding these outer skins at the desired distance apart. Ribs are usually disposed chordwise and can be full or partial. They are also sometimes called risers or profiles.

Single Line Kite; A kite that can generally stay flying while attached by a flying line or lines to just one anchoring point without continual flier input, notwithstanding that stay lines may be used to connect the kite to extra anchoring points when wind conditions are strong, turbulent, or when the kite's range of movement must be limited for reasons such as safety or lack of space.

Soft kite: A kite constructed entirely or substantially entirely from woven fabric or some other similar flexible sheet material (such as plastic film), and that uses internal pressure from ram air inflation to hold its main form, and that does not require conventional rigid members such as sticks, tubes or rods for this purpose.

Thru cord: Soft kites that are constructed with internal spaces to accept ram air inflation can use multiple cords instead of or in combination with ribs, to hold the outer surfaces at the desired distance apart. These are called thru cords.

Yaw: The tendency for a kite to swing around an axis roughly coincident with its flying line. Yaw instability occurs when this swinging becomes a series of violent figure-eight's of increasing amplitude which can then transition to looping. It is the most common form of kite instability, especially for smaller kites, and can usually be mitigated by adding appropriately positioned lateral surfaces, a tail, tails, or other trailing drag devices. When referring to kites, Yaw instability is sometimes called "volatile instability".

Kites generally fall within two broad classifications. The first is single line kites (defined above) which are capable of stable flight when flown from a single line without continual flier input and the second is steerable kites where the flier more or less continually controls the kite by way of multiple lines. The second classification includes traction kites and sports kites.

Steerable ram air inflated soft kites are commonly used for skiing, kite buggying, kite sailing, kite boarding and etc. Such kites can adopt a substantially semicircular spanwise profile in use (see WO 02/096753 for example) but are more usually of the parafoil type with multiple bridle lines.

The applicant wishes to produce a ram air inflated single line soft kite of generally planar form that is suitable for displaying graphics, such as a flag, logo, picture, or patchwork style designs. However, such kites can exhibit many different forms of instability. In particular, edging can be a problem for larger and higher aspect ratio planar form ram air inflated single line soft kites, and yaw can be a problem for smaller and lower aspect ratio planar form ram air inflated single line kites unless they have some inherent lateral stabilisation mechanism.

The applicant has noticed, and it is known, that the use of curvature, both spanwise and/or chordwise can be a useful design element for stabilising ram air inflated single line soft kites and especially but not only, that spanwise dihedral can reduce edging behavior in such kites that are also of higher aspect ratio and reduce yaw in such kites that are of lower aspect ratio.

Ram air inflated single line soft kites are generally constructed with an upper skin, a lower skin and either fabric panels (also called ribs, risers or profiles) or thru cords, or some combination of these, connecting the lower skin to the upper skin at different places.

Figure 1 shows a perspective view of a rectangular ram air inflated single line soft kite. The kite has an upper skin 1 and a lower skin 2 which are joined together along the wingtip edges 3, 4 and the trailing edge 5. The leading edge 6 is open (or includes openings) to allow ram air inflation of the kite. The upper skin 1 and the lower skin 2 are also joined by thru cords 7 distributed across the wingspan, to hold the skins at the desired distance apart. Thru cords 7 are also distributed along the chord of the kite to define the desired aerofoil. The kite has a left hand wingtip 8, a right hand wingtip 9 and a centre span region 10. The main flying line 11 is connected to the kite by a number of bridles 12.

Figure 2 shows a perspective view of a second rectangular ram air inflated single line soft kite. This kite differs from the kite shown in figure 1 in that the upper skin 1 and the lower skin 2 are joined by ribs 15 distributed across the wingspan, rather than by thru cords.

Edging type instability can be mitigated by various changes, including decreasing a kite's aspect ratio, moving a kite's centre of gravity towards the trailing edge, reducing or changing the position of lateral area, reducing the aerodynamic drag at the wing tips relative to the centre, and by reducing the amount of drag provided by any trailing devices such as drogues or tails.. Yaw type instability can be mitigated by various changes, including increasing a kite's aspect ratio, moving the kite's centre of gravity towards the leading edge, increasing or changing the position of lateral area, increasing the aerodynamic drag at the wingtips relative to the centre and by increasing the amount of drag provided by any trailing devices such as drogues or tails.

Unfortunately, making changes such as these to cure edging or yaw instability is not always possible because of graphical, constructional or other requirements or because they cause other flying problems.

For many styles of single line planar kites, applying curvature in various ways is a powerful tool for the reduction of both edging and yaw tendencies..

The conventional means of contriving curvature for planar soft kites is to vary the length of the bridles across the span and chord of the kite. For example, to create spanwise dihedral, those bridles nearer the tips or outer edges of the kite's lifting surface are made longer than those attached to the centre section. Aerodynamic forces acting on the kite then bend and distort the kite's upper and lower surfaces and the linking elements (ribs and/or thru cords) connecting them together, thereby causing the planar form to assume spanwise dihedral. Longitudinal dihedral can be similarly contrived by shortening the bridles that are attached in the kite's mid chord sections.

Figure 3 shows a spanwise section of a ram air inflated single line soft kite. The upper skin 1 and lower skin 2 are connected by linking elements 20 that are approximately parallel to each other when the kite is inflated, but without aerodynamic forces sufficient to bend the structure to form a dihedral and tighten the outer bridle lines.

Figure 4 shows the kite of figure 3, when the kite is inflated and subject to aerodynamic loads sufficient to bend the structure into a dihedral form and tighten the outer bridle lines.

For kites that are relatively thin, that is with rib depths and/or thru cords that are short in relation to the kite's overall dimensions; wingspan, and chord, and that are flying in relatively stable wind, using bridle lengths to curve the basically planar form is generally effective.

However, for kites with thicker sections, that is with deeper ribs and/or longer thru cords in relation to the kite's overall dimensions, wingspan, and chord, at some wind speeds, it is not unusual that the kite's structural form and its internal pressure rather than bridle lengths will be the prime determinant of its shape, and in this case, bridling alone cannot be relied on to create curvature- and this may have consequent deleterious effects on flying. For example, for kites such as this that do not have dihedral inherent in their structure, lengthening the wing tip bridles will just cause these lines to hang loose rather than allowing aerodynamic forces to bend the wingtips up into a dihedral effect because these forces will not be sufficient to overcome the spanwise beam strength that derives from the kite's upper and lower skin, the connections between these, and the internal pressure.

For kites with thick sections, bridling, by itself, can therefore be ineffectual in creating spanwise and/or chordwise curvature in some, or even all, wind strengths. Even with thinner section kites for which bridling is usually an effective way to contrive curvature, in very light winds and during overflying and drift back situations, there are times when the kite's form with respect to curvature will be determined by internal pressure and the geometry of the kite's skins and ribs and/or thru cords rather than by bridle length.

Further, although it may be thought that a kite's inherent curvature (spanwise and chordwise) and the kites bridling should generally match, there are occasions when it is desirable to have the bridle loads force the kite into some shape that is not the same as it will take when unloaded. To contrive this, some sections of a kite may be deliberately made with thinner sections so that bridle loads can sometimes dominate form. An example of this is to use bridle lengths to cause more chordwise (that is longitudinal) anhedral than is inherent in the kite's structural form so that the kite will usually fly efficiently but in an overflying or unloaded situation, will revert to a shape that is more resistant to the luffing (though less efficient).

A kite's spanwise and chordwise curvature has a powerful effect on its flying behaviour and this plus the added advantage for designers of being able to exploit differences between the inherent curvature and the bridled curvature make means to control the inherent curvature of prime value. This invention discloses new ways to control the curvature inherent in the structure of planar ram air inflated soft kites that primarily use thru cords as the linking elements between their upper and lower skins.

Considering a spanwise section of such a kite, it is conventional for the linking elements to be approximately parallel with each other- that is the distance between their attachment points on the lower skin will be approximately the same as the distance between their attachment points on the upper skin. An exception to this is common for the case of some higher performance parafoils, especially steerable parafoils, in which each skin panel is carefully shaped, usually being wider in its spanwise dimension in its centre chord area than at leading or trailing edges, with the upper panels often being substantially wider at this position than the lower skin panels. This is generally done to improve aerodynamic efficiency and usually has the effect of causing mild anhedral which is rarely if ever of value in improving the flying behaviour of single line kites.

It is an object of the invention to provide a ram air inflated single line soft kite of generally planar form with desirable flying characteristics, or to at least provide the public with a useful choice

Summary of the Invention.

The basis of one aspect of this invention is to contrive a structure for soft ram air inflated generally planar single line kites so as to create inherent curvature that does not depend or does not solely depend on bridle dimensions and external aerodynamic forces. Three ways to do this are described but these are by way of example only as other means to the same end are also possible.

The first example for creating spanwise upwards curvature or dihedral is for connections between the upper and lower skins to be attached such that they are not parallel with each other but, in the spanwise sense, are spaced further apart at their attachment to the lower skin than to the upper skin. As an alternative way of describing this, in the spanwise sense, in at least some sections of a kite so constructed, the distance between where adjacent upper to lower skin attachments are connected with the upper skin will be shorter than the distance between where they are attached to the lower skin. A similar method can be used to create chordwise (longitudinal) upwards curvature or dihedral. Also, a similar method can be used to create downwards curvature or anhedral either across the wingspan or along the chord of the kite. This is achieved by having the connections between the skins spaced further apart at their attachment to the upper skin than to the lower skin.

The second example for creating spanwise upwards curvature or dihedral is that an internal cord or cords and/or extra panel or panels are attached between, or near to between, at least some of the attachment points of the thru cords and/or ribs to the top skin and that these internal cord(s) and/or panel(s) are shorter in spanwise dimension than the kite's top skin in that vicinity. Again, similar methods can be used to create chordwise (longitudinal) upwards curvature or dihedral, or downwards curvature or anhedral either across the wingspan or along the chord of the kite.

The third example for creating spanwise upwards curvature or dihedral is that, when at least some of the linking elements connecting the upper skin to the lower skin are thru cords, extra diagonal internal cords are attached to at least some of the attachment points of the thru cords to the upper skin and diagonally across to or near to the attachment points of adjacent or near to adjacent thru cords to the lower skin. Again, similar methods can be used to create chordwise dihedral or downwards curvature or anhedral either across the wingspan or chordwise.

The effect of any of these three or combinations of these three means of contriving inherent curvature is that, unless the bridle dimensions do not match the desired form and the kite's inherent shape is overwhelmed by bridle loads , a kite so constructed will exhibit the desired curvature.

It is not necessary for every spanwise section of such a kite to be constructed in either of these ways, in fact there may be good reasons to vary the curvature effect in different sections of the kite.

In particular, for ram air inflated single line soft kites using either of these constructional devices to create inherent spanwise dihedral, it will often be useful to dispose most of this dihedral effect towards the kite's wingtips so that the kite's centre section is less likely to collapse under the compressive loads generated by the spanwise components of bridle tension, and/or so that when such a kite is flying at one edge of the wind, it will be less inclined to fold a wingtip under.

It can also be beneficial to use spanwise anhedral, at least over part of the kite's wingspan. In general, spanwise curvature is a strong determinant of kite behaviour and, in practice, many different curvatures (from maximum dihedral consistent with not causing compressive collapse, to anhedral) and combinations of curvatures will be used for different kites and for specific conditions to achieve satisfactory flying.

Longitudinal curvature, that is curvature along the chord of the kite, is also important. Longitudinal dihedral generally provides resistance to luffing.. Parts of the kite along the chord can also benefit from a positive camber. In particular, chordwise anhedral (especially positive camber in the kite's top skin) positioned near the leading edge may provide greater lift, improved lift to drag ratio and/or cause the kite's lift centre of pressure to be nearer the leading edge, assisting luff resistance.

According to a first aspect the invention provides a ram air inflated single line kite having non-rectangular upper and lower skins joined together along their edges except for such openings as may be required for inflation, or to control inflation or to eject material, wherein the skins are connected together between their edges by linking elements at intervals across the wingspan and wherein over at least a portion of the wingspan the spacing between linking elements across the wingspan is smaller between connections of adjacent linking elements to the upper skin than between connections of adjacent linking elements to the lower skin such as to produce a non-rectangular generally planar form exhibiting upwards curvature or dihedral towards each wing tip when the kite is inflated.

According to a second aspect the invention provides a ram air inflated single line kite having generally rectangular upper and lower skins joined together along their edges except for such openings as may be required for inflation, or to control inflation or to eject material, wherein the skins are connected together between their edges by linking elements at intervals across the wingspan and wherein over at least a portion of the wingspan the spacing between linking elements across the wingspan is smaller between connections of adjacent linking elements to the upper skin than between connections of adjacent linking elements to the lower skin such as to produce a generally rectangular and generally planar form exhibiting upwards curvature or dihedral towards each wing tip when the kite is inflated.

According to a third aspect the invention provides a ram air inflated single line kite having non-rectangular upper and lower skins joined together along their edges except for such openings as may be required for inflation, or to control inflation or to eject material, wherein the skins are connected together between their edges by an array of linking elements and wherein over at least a portion of the wingspan the linking elements are shaped and/or connected to the upper and lower skins such as to produce a non-rectangular generally planar form exhibiting upwards curvature or dihedral towards each wing tip when the kite is inflated.

According to a fourth aspect the invention provides a ram air inflated single line kite having generally rectangular upper and lower skins joined together along their edges except for such openings as may be required for inflation, or to control inflation or to eject material, wherein the skins are connected together between their edges by an array of linking elements and wherein over at least a portion of the wingspan the linking elements are shaped and/or connected to the upper and lower skins such as to produce a generally rectangular and generally planar form exhibiting upwards curvature or dihedral towards each wing tip when the kite is inflated.

According to a fifth aspect the invention provides a ram air inflated single line kite having upper and lower skins joined together along their edges except for such openings as may be required for inflation, or to control inflation or to eject material etc., the kite exhibiting curvature over at least part of its area when inflated,wherein the skins are connected together between their edges by linking elements and wherein the linking elements are connected to the skins and arranged such as to substantially define the shape of the kite when inflated.

According to a sixth aspect the invention provides a ram air inflated single line kite having upper and lower skins joined together along their edges except for such openings as may be required for inflation, or to control inflation or to eject material etc.wherein the skins are connected together between their edges by linking elements and wherein the leading edge has a depth that is greater in a region near each wingtip than in the centre of the kite's wingspan when the kite is inflated.

According to a seventh aspect the invention provides a ram air inflated single line kite having upper and lower skins joined together along their edges except for such openings as may be required for inflation, or to control inflation or to eject material etc.,
wherein the skins are connected together between their edges by linking elements and wherein the leading edge has a depth that is smaller in a region near each wingtip than in the centre of the kite's wingspan when the kite is inflated.

According to an eighth aspect the invention provides a ram air inflated single line kite having upper and lower skins joined together along their edges except for such openings as may be required for inflation, or to control inflation or to eject material etc.,
wherein the skins are connected together between their edges by linking elements and wherein over at least a portion of the kite's area the spacing between linking elements is different between connections of adjacent linking elements to the upper skin than between connections of adjacent linking elements to the lower skin such as to produce a generally planar form exhibiting curvature over at least part of the kite's area when the kite is inflated.

According to a ninth aspect the invention provides a ram air inflated single line kite having upper and lower skins joined together along their edges except for such openings as may be required for inflation, or to control inflation or to eject material etc.,
wherein the skins are connected together between their edges by linking elements and wherein over at least a portion of the kite's area, one or more spacing elements are attached between, or near to between, at least some of the attachment points of the thru cords and/or ribs to either the upper or lower skin and that these spacing elements are shorter in spanwise dimension than the kite's skin in that vicinity such as to produce a generally planar form exhibiting curvature over at least part of the kite's area when the kite is inflated.

According to a tenth aspect the invention provides a ram air inflated single line kite having upper and lower skins joined together along their edges except for such openings as may be required for inflation, or to control inflation or to eject material etc.,
wherein the skins are connected together between their edges by linking elements and at least some of the linking elements are thru cords;
and wherein over at least a portion of the kite's area, extra diagonal internal cords are attached to or near to the attachment points of the thru cords to the upper skin and diagonally across to or near

to the attachment points of adjacent or near to adjacent thru cords to the lower skin and that these diagonal internal cord(s) are adjusted in length so as to distort the kite's shape in their vicinity such as to produce a generally planar form exhibiting curvature over at least part of the kite's area when the kite is inflated.

Using rib profiles to create longitudinal dihedral is known. The invention provides other methods of creating curvature.

Preferably the ram air inflated soft kite has the following features:

It is a single line kite: That is, a kite that can stay flying while attached to just one anchoring point without continual flier input, notwithstanding that stay lines may be used to connect the kite to extra anchoring points when wind conditions are strong, turbulent, or when the kite's range of movement must be limited for reasons such as safety or lack of space.

It is a soft kite, generally without rigid elements, making it safer to use, easier to pack, often less expensive to make and generally more robust.

It has an upper and a lower skin joined together along their edges excepting for sand holes big enough to allow ejection of minor foreign items that may get trapped in the internal space(s) but not so large as to reduce inflation unacceptably, and excepting for any opening or openings, valve or valves, or gauze panels to accept and control ram air inflation, and connected at multiple points by linking elements (ribs and/or thru cords).

It is ram air inflated: Not requiring any sticks or other structure, nor tubes that require pump inflation. Notwithstanding that the kite is ram air inflated as its primary means of holding its form, in special circumstances sticks, rods, tubes or other stiffeners may be used for subsidiary purposes such as, but not only, to define graphics, for easier launching, or to resist loss of inflation during extreme turbulence.

It may or may not have a tail or tails or other trailing stabilising devices.

It may or may not have flares and/or keels as connection points for the bridles and to provide lateral area.

Ram air inflation can be by facilitating the ingress of air from at or near a flow stagnation point by way of openings, gauze, or valves.

The dimensions of the upper skin, the lower skin and connections between these will be such that in at least some sections of a kite so constructed, the distance in the spanwise and/or chordwise direction between where adjacent linking elements are connected with the upper skin will be different than the distance between where they are attached to the lower skin;

or, an internal cord or cords and/or extra panel or panels are attached between, or near to between at least some of the attachment points of the thru cords and/or ribs to the upper skin or lower skin and that these internal cord(s) and/or panel(s) will be shorter in spanwise and/or chordwise dimension than the kite's skin in that vicinity;

or, for kites in which at least some of the linking elements connecting the upper and lower skins are thru cords, an extra diagonal internal cord or cords is/are attached to or near to, at least some of the attachment points of the thru cords to the upper skin and diagonally across to or near to the attachment points of adjacent or near to adjacent thru cords to the lower skin and that these diagonal internal cord(s) are adjusted in length so as to distort the kite's shape in their vicinity.

or some combination of these three methods will be used.

The advantageous effect of these features or a combination being to create a curvature effect that is inherent in the kite's structure rather than being dependent on bridle lengths and aerodynamic forces.

The applicant has found that inherent spanwise dihedral generally improves stability and particularly, can improve the resistance to edging instability that is a particular problem for some higher aspect ratio ram air inflated soft single line kites and especially for larger scale versions of such kites and, can improve resistance to yaw instability that is a particular problem for some lower aspect ratio ram air inflated soft single line kites and especially for smaller scale versions of such kites and that in many cases, the more inherent dihedral that can be built into the kite's structure, the greater the stability improvement will be up to the limit imposed by sections of such kites collapsing under bending loads and/or the compressive effect of spanwise components of bridle tension. Because of the limiting effect imposed on the use of inherent dihedral by compressive and bending collapse in the kite's centre sections it can be advantageous to dispose inherent dihedral more towards the tips. This can be achieved by having less variation in the spanwise direction differences between the attachment points of the ribs and/or thru cords to the upper and lower skins in the centre section of the kite than towards the wingtips. Alternatively, this can be achieved by using spanwise internal cord(s) and/or panel(s) adjacent to the top skin and shorter in spanwise dimension than their adjacent top skin panels only in the wingtip sections. Some combination of these two methods can also be used.

By disposing inherent dihedral preferentially toward the kite's wingtips the effective resistance to edging or yaw can be greater without increasing the tendency towards centre collapse that having a larger proportion of the dihedral in the centre sections can cause. However, such preferential spanwise disposition of dihedral is an optional rather than an essential feature of this invention and there are specific kites for which it may be desirable to use very different spanwise disposition of dihedral. In some kites it may also be desirable to use spanwise anhedral, at least in some sections.

Also, the applicant has found the curvature generating techniques that are disclosed by this invention to be of great value for creating chordwise (longitudinal) dihedral which is generally known to improve luff resistance for ram air inflated single line soft kites, and in particular that a version of the second curvature generating system disclosed (that is the use of internal cord(s) adjacent to the top skin, disposed in the chordwise direction and shorter in dimension than their adjacent top skin panels) is particularly useful because such cords can be made to be adjustable post manufacture or at any subsequent time during the life of the kite so as to precisely tune for the amount of chordwise dihedral in different sections of the kite required to prevent luffing without unnecessary loss of aerodynamic efficiency.

The invention thus provides a ram air inflated single line soft kite having inherent spanwise dihedral that generally improves flying characteristics and in particular reduces the tendency of the kites to exhibit edging or yawing type instability.

The invention also provides a ram air inflated single line soft kite that has inherent chordwise dihedral that generally improves flying characteristics and in particular reduces the tendency of such kites to luffing.

The invention provides a single line kite of a design that may be utilised for kites of rectangular form. The invention also allows ram air inflated soft kites to be constructed without flares.

Further aspects of the invention will become apparent from the following description which is given by way of example only.

Description of the Drawings

Examples of the invention will now be described with reference to the accompanying drawings in which:

Figure 1 shows a front, underneath perspective view of a first example of a ram air inflated single line soft kite which incorporates an open leading edge and in which upper and lower skins of the kite are linked by thru cords.

Figure 2 shows a front, underneath perspective view of a second example of a ram air inflated single line soft kite which incorporates an open leading edge and in which upper and lower skins of the kite are linked by ribs;

Figure 3 shows a spanwise section view of an inflated ram air soft single line kite with ribs or thru cords that are approximately parallel with each other and in the absence of aerodynamic forces sufficient to bend the kite's structure and tighten the bridle lines.

Figure 4 shows a spanwise section view of an inflated ram air soft single line kite with ribs or thru cords that are approximately parallel with each other and subject to aerodynamic forces sufficient to bend the kite's structure and tighten the bridle lines thereby creating a dihedral effect.

Figure 5 shows a spanwise section view of an inflated ram air soft single line kite according to a first aspect of the invention with ribs or thru cords attached to the lower skin at wider spacings than their attachment to the upper skin so as to contrive a dihedral effect by virtue of internal pressure when inflated and independent of external aerodynamic forces.

Figure 6 shows a spanwise section of one set of upper and lower skin panels and their adjacent ribs or thru cords of a ram air inflated single line soft kite according to a second aspect of the invention showing an extra internal cord or panel adjacent to the top skin that is shorter in spanwise dimension than the top skin panel in that vicinity, contrived to create a dihedral effect dependent only on panel and cord geometry and on internal pressure, and independent of external aerodynamic forces.

Figure 7 shows a chordwise section of the kite of figure 5 or figure 6.

Figure 8 shows a chordwise section of a kite exhibiting chordwise curvature;

Figure 9 shows a second chordwise section of a kite exhibiting chordwise curvature;

Figure 10 shows a cross-section, including a sharply angled thru cord;

Figure 11 shows a cross-section including a diagonal thru cord; and

Figure 12 shows a kite with varying depth across the leading edge.

Description of preferred embodiments

Figure 5 shows a spanwise section of a ram air inflated soft kite. The kite has an upper skin 30 and a lower skin 31 which are joined along their side edges 32, 33 and trailing edge (not shown). The leading edge (not shown) may be open, or may have openings or valves, to enable inflation of the kite. Openings may also be provided in the upper or lower skin or along their edges to enable ejection of foreign material.

The upper skin 30 and lower skin 31 are connected together between their edges by linking elements 34 distributed at intervals over the wingspan. The linking elements 34 may be ribs or thru cords or a combination of ribs and thru cords or similar elements. Where the linking elements are thru cords, these are also distributed chordwise along the kite. Where the linking elements are ribs these are preferably oriented along the kite (as shown in Figure 2). However, ribs, or some ribs, may also be oriented across the kite, with some or all of the linking elements in this case being distributed at intervals over the chord of the kite, rather than the wingspan. Generally, the linking elements form an array of linking elements.

Thru cords are preferred to ribs in some applications, as they require much less material. Particularly in large kites this can result in significant savings in materials and cost.

The main flying line 35 is connected to bridle lines 36. The bridle lines 36 may be connected directly to the lower skin 31 or to linking elements 34. There are preferably no flares or similar extensions of the skin below the lower skin 31 to which the bridle lines are attached, as in some kites. In this embodiment the length of lower skin 31 across the wingspan is greater than the length of the upper skin 30 across the wingspan, preferably more than 5% greater.

The wingtips 37, 38 are curved upwards, creating a dihedral. The upwards curvature can be defined by the degree of curvature α. Preferably, the degree of curvature is between 5° and 45°, and is more preferably between about 10° to 20°, and most preferably about 15° when the kite is inflated. Curvature outside of this range may be suitable for some kites.

The upwards curvature is created by connecting the linking elements and the upper and lower skins, such that the spacing between linking elements across the wingspan is smaller between connections of adjacent linking elements to the upper skin than between connections of adjacent linking elements to the lower skin. Preferably, the spacing between connections to the upper skin is at least 5% less than the spacing between connections to the lower skin over the region(s) of curvature.

The upwards curvature may be exhibited in certain sections of the kite, while other sections are substantially flat. For example, the curvature may be confined to regions of about one third of the wingspan in width near to each wingtip, while the central span region (around one third of the wingspan in width) may be substantially flat.

In the case where the ribs or some ribs are oriented across the kite, upwards curvature or dihedral can be achieved by suitable shaping of these ribs.

Figure 6 shows a spanwise section through a second embodiment of a soft ram air inflated kite. The upper skin 30 between adjacent linking elements 34 forms an upper skin panel 42, while the lower skin 31 between adjacent linking elements 34 forms a lower skin panel 43.

Spacing element 45, typically in the form of a cord, panel or tape, maintains the desired spacing between linking elements 34 across the wingspan near to the upper skin. The spacing element 45 is adjacent to the upper skin and may be attached to the upper skin 30 at the same points as the linking elements 34 are attached to the upper skin. The spacing element 45 may be provided over only certain sections of the wingspan to confine the upwards curvature to certain regions of the wingspan, as described above.

Figure 7 shows a longitudinal section of a soft ram air inflated kite, showing the trailing edge 50 and the leading edge 51.

A kite according to either of the embodiments shown in Figures 5 to 7 could be made from fabric or plastic or other suitable sheet material. Examples of suitable material are ripstop nylon, polyethylene film and TYVEK (made by Dupont).

A pattern or graphics could also be applied to the kite, preferably to both the lower and upper skins: either the same design being applied to each skin; or a different design being applied to each skin; or a design being applied to only one skin leaving the other plain. The pattern or graphics could have a decorative effect or could depict a flag or logo. The patterns or graphics on the upper and/or lower skins could be formed from printed, painted, patchworked or appliqued material or a combination of these.

The aspect ratio of the kite is preferably in the range 0.5 to 2.0, more preferably in the range 0.6 to 1.6. The aspect ratio of the kite is preferably about 1.6, the golden rectangle ratio, which corresponds to the aspect ratio of many flags. Alternatively, the aspect ration may be 2, which corresponds to some flags.

To eliminate luffing and to improve stability in overflying and other situations, the kite will preferably have longitudinal dihedral (dihedral along the kite's chord). The kite may have longitudinal dihedral over any part of its area, in combination with any spanwise form, including spanwise dihedral.

Such longitudinal dihedral may be contrived by varying the chordwise spacings of adjacent linking elements connecting the upper and lower skins in similar fashion to contriving spanwise dihedral by variation of spanwise spacing of adjacent linking elements, as described above. As for spanwise dihedral, the distance between adjacent linking elements will generally be greater where they are attached to the lower skin than where they are attached to the upper skin. In the case where the linking elements, or some of the linking elements, are ribs disposed in a chordwise direction rather than thru cords, longitudinal dihedral could be contrived by suitable shaping of such ribs, as is well known to knowledgeable kite designers.

Longitudinal dihedral, specifically, hollowing the upper skin,is advantageous in preventing luffing of the kite, as shown in Figure 8. In Figure 8 curvature is achieved by using cord attachment spacings on the upper skin 30 closer than those on the lower skin 31, creating chordwise upwards curvature in the middle chord area 67. The two cells nearest the leading edge 51 have generally parallel thru cords 69, allowing the nose to point slightly downwards (relative to the general chordwise curvature of the kite), thereby improving launching and aerodynamic efficiency. This shape may be combined with anhedral in an area near the leading edge 51 to provide improved lift, as described above.

The use of different spacings of thru chords to achieve curvature can be extended as shown in Figure 9. A diagonal thru cord 55 is attached at one end to the lower skin 31 at the leading edge 51, and at the other end to the upper skin 30 rearward of the leading edge. This creates upwards curvature in the lower skin at the leading edge, creating a positive angle of attack α in the lower skin near the kite's leading edge. This results in greater resistance to luffing. In this example, the spacing between adjacent thru cords 55 and 57 is reduced to zero at the upper skin. However, the spacing may be greater than zero, and the cords may overlap, as will be described below.

When diagonal thru cords are used at the leading edge, it is often possible to eliminate some or all kite bridles except those to the leading edge. This can make manufacture and flying easier. The kite shown in Figure 9, for example, does not require a bridle connected to the lower skin near the thru cord 57.

A further advantage of using diagonal or substantially diagonal thru cords is that they can be adjusted, post manufacture and at any time during the life of a kite, to tune the kite's flying characteristcs for particular conditions or requirements.

Also shown in this figure is the use of a diagonal thru cord 58 to achieve dihedral near the trailing edge 50, giving the advantages of dihedral near the trailing edge, as described above.

For ease of manufacture, attachment points for these diagonal thru cords will generally be shared with the existing thru cords described above, although attachment points may be provided purely for the diagonal thru cords.

Figure 10 shows a sharply angled thru cord 60, used to add curvature. Figure 11 shows an overlapping thru cord 61, also used to add curvature.

Diagonal and overlapping thru cords may also be used to create resistance to harmonic oscillations. When substantially parallel thru cords are used, aerodynamic effects can create oscillations, especially towards the trailing edge of the kite, and especially in stronger winds. This occurs because substantially parallel thru cords provide little resistance to bending forces because they have almost no sheer resistance. These oscillations can noticeably affect aerodynamic efficiency, can be unattractive to viewers, and may even be destructive of the kite's structure in rough winds. Angled thru cords provide some sheer resistance, thereby controlling these oscillations.

Diagonal and overlapping thru cords may also be used to contrive curvature in the spanwise direction. In particular, diagonal thru cords may be used to achieve dihedral near the wingtips, as an aid in preventing tip collapse when a kite is towards the edge of its wind envelope. Again, these diagonal thru cords may or may not overlap adjacent thru cords.

The curvature effects achieved using thru cords may also be achieved using a combination of thru cords and other linking elements such as ribs. For example, ribs (or partial ribs) could be provided in one section of the kite, while thru cords are used in other sections of the kite where curvature is required.

For smaller kites, the leading edge preferably does not have the same depth across the span of the kite but is deeper near the wingtips 37, 38 than in the centre span area 62, as shown in Figure 12.

The advantageous effect of this feature is that aerodynamic drag generated by the leading edge is concentrated at points on the kite furthest from its yaw centre so as to have the maximum effect on damping out yaw instability. In the leading edge centre span area, where aerodynamic drag has less beneficial effect on yaw stability, the leading edge opening is shallower. This minimises overall drag on the kite and so enhances its overall performance.

Preferably the ratio of the depth near the wingtips to the depth at the centre of the wingspan is in the range 1.2:1 to 3:1, ideally about 2:1.

This works well with kites of aspect ratio up to about 1.5 that are also less than about 10 square metres in planar area. However, for larger kites of this aspect ratio and even for smaller very high aspect ratio kites (say aspect ratio AR above 2.0), this type of leading edge can cause edging (super stability). Because very large ram air inflated kites contain a great mass of air (as much as 4 tonnes of air for kites that in themselves weight just 200kgms) when such a kite leans over to one side or the other of the wind, restorative forces can be insufficient to correct this lean against the inertial effect of the contained internal mass of air. before the kite falls to the ground at the edge of the wind. For example, ram air inflated kites larger than about 10 sq.m with aspect ratios greater than 1.5 will generally not benefit from leading edges that are deeper at the wingtips than in their centre span area.

In practise , for kites with aspect ratios greater than about 1.5 that are also larger than about 10 square metres, favourable behaviour has been found when the leading edge is narrower towards the wingtips than in the centre of the wingspan, as this can ameliorate edging problems. In this case the ration of depth near the wintips to depth in the centre of the wingspan is preferably between about 0.8:1 and 0.5:1, ideally about 0.75:1.

While the present invention has been illustrated by the description of the embodiments thereof, and while the embodiments have been described in detail, it is not the intention of the Applicant to restrict or in any way limit the scope of the appended claims to such detail. Additional advantages and modifications will readily appear to those skilled in the art. Therefore, the invention in its broader aspects is not limited to the specific details, representative apparatus and method, and illustrative examples shown and described. Accordingly, departures may be made from such details without departure from the spirit or scope of the Applicant's general inventive concept.

Claims

1. A ram air inflated single line kite having non-rectangular upper and lower skins joined together along their edges except for such openings as may be required for inflation, or to control inflation or to eject material etc.,

wherein the skins are connected together between their edges by linking elements at intervals across the wingspan and wherein over at least a portion of the wingspan the spacing between linking elements across the wingspan is smaller between connections of adjacent linking elements to the upper skin than between connections of adjacent linking elements to the lower skin such as to produce a non-rectangular generally planar form exhibiting upwards curvature or dihedral towards each wing tip when the kite is inflated.

2. A ram air inflated single line kite having generally rectangular upper and lower skins joined together along their edges except for such openings as may be required for inflation, or to control inflation or to eject material etc.,

wherein the skins are connected together between their edges by linking elements at intervals across the wingspan and wherein over at least a portion of the wingspan the spacing between linking elements across the wingspan is smaller between connections of adjacent linking elements to the upper skin than between connections of adjacent linking elements to the lower skin such as to produce a generally rectangular and generally planar form exhibiting upwards curvature or dihedral towards each wing tip when the kite is inflated.

3. A kite as claimed in claim 1 or 2, further comprising bridle lines connected directly to the upper or lower skins.

4. A kite as claimed in any preceding claim, wherein at least some of the linking elements are thru cords.

5. A kite as claimed in any preceding claim, wherein at least some of the linking elements are ribs.

6. A kite as claimed in claim 5, wherein the ribs include mesh or cross venting sections or valves, to enable airflow through the ribs.

7. A kite as claimed in any preceding claim, wherein the length across the wingspan of the lower skin is greater than the length across the wingspan of the upper skin.

8. A kite as claimed in claim 7, wherein the length across the wingspan of the lower skin is more than 5% greater than the length across the wingspan of the upper skin.

9. A kite as claimed in any preceding claim, wherein a spacing element maintains the desired spacing across the wingspan between connections of adjacent linking elements to the upper skin.

10. A kite as claimed in any preceding claim, wherein over at least a portion of the wingspan the spacing between linking elements across the wingspan is around 5% smaller between adjacent linking elements near the upper skin than between adjacent linking elements near the lower skin.

11. A kite as claimed in any preceding claim, wherein a degree of curvature or dihedral towards each wing tip is in the range 5° to 45° to a plane through a central region of the kite when inflated.

12. A kite as claimed in claim 11, wherein the degree of upwards curvature is in the range 10° to 20° to a plane through a central region of the kite when inflated.

13. A kite as claimed in claimed 12, wherein the degree of curvature is approximately 15° to a plane through a central region of the kite when inflated.

14. A kite as claimed in any preceding claim, wherein the upwards curvature or dihedral towards each wing tip is exhibited predominantly within a region near to each wing tip, when the kite is inflated.

15. A kite as claimed in claim 14, wherein the region near to each wing tip is approximately one third of the wingspan in width.

16. A kite as claimed in any preceding claim, wherein a pattern or graphics is/are applied to the lower skin.

17. A kite as claimed in claim 16, wherein the pattern or graphics is/are also applied to the upper skin.

18. A kite as claimed in claim 16 or 17, wherein the pattern or graphics depicts/depict a flag.

19. A kite as claimed in any preceding claim, wherein the upper and lower skins are patchworked.

20. A kite as claimed in any preceding claim, wherein the aspect ratio of the kite is in the range 0.5 to 2.0.

21. A kite as claimed in claim 20, wherein the aspect ratio of the kite is in the range 0.6 to 1.6.

22. A kite as claimed in claim 20, wherein the aspect ratio of the kite is about 1.6.

23. A kite as claimed in any preceding claim, wherein the upper and lower skins are made from fabric.

24. A kite as claimed in claim 23, wherein the upper and lower skins are made from TYVEK or plastic sheet material.

25. A ram air inflated single line kite having non-rectangular upper and lower skins joined together along their edges except for such openings as may be required for inflation, or to control inflation or to eject material etc.,

wherein the skins are connected together between their edges by an array of linking elements and wherein over at least a portion of the wingspan the linking elements are shaped and/or connected to the upper and lower skins such as to produce a non-rectangular generally planar form exhibiting upwards curvature or dihedral towards each wing tip when the kite is inflated.

26. A ram air inflated single line kite having generally rectangular upper and lower skins joined together along their edges except for such openings as may be required for inflation, or to control inflation or to eject material etc.,

wherein the skins are connected together between their edges by an array of linking elements and wherein over at least a portion of the wingspan the linking elements are shaped and/or connected to the upper and lower skins such as to produce a generally rectangular and generally planar form exhibiting upwards curvature or dihedral towards each wing tip when the kite is inflated.

27. A kite as claimed in claim 25 or 26, wherein at least some of the linking elements are spanwise ribs.

28. A kite as claimed in claim 27, wherein the ribs include mesh or cross venting sections or valves, to enable airflow through the ribs.

29. A kite as claimed in any preceding claim, wherein over at least a portion of the wingspan the linking elements are shaped and/or connected to the upper and lower skins such as to produce a form exhibiting upwards curvature or dihedral along the chord of the kite, when the kite is inflated.

30. A ram air inflated single line kite having upper and lower skins joined together along their edges except for such openings as may be required for inflation, or to control inflation or to eject material etc., the kite exhibiting curvature over at least part of its area when inflated,

wherein the skins are connected together between their edges by linking elements and wherein the linking elements are connected to the skins and arranged such as to substantially define the shape of the kite when inflated.

31. A kite as claimed in claim 30, wherein the spacing between linking elements across at least part of the wingspan is different between connections of adjacent linking elements to the upper skin than between connections of adjacent linking elements to the lower skin, such that the kite exhibits curvature across at least part of its wingspan when the kite is inflated.

skin than between connections of adjacent linking elements to the lower skin, such that the kite exhibits curvature across at least part of its wingspan when the kite is inflated.

32. A kite as claimed in claim 31, wherein the spacing between linking elements across at least part of the wingspan is smaller between connections of adjacent linking elements to the upper skin than between connections of adjacent linking elements to the lower skin, such that the kite exhibits upwards curvature or dihedral across at least part of its wingspan when the kite is inflated.

33. A kite as claimed in claim 32, wherein the kite exhibits upward curvature or dihedral in a region near each wing tip.

34. A kite as claimed in claim 31, wherein the spacing between linking elements across at least part of the wingspan is larger between connections of adjacent linking elements to the upper skin than between connections of adjacent linking elements to the lower skin, such that the kite exhibits downwards curvature or anhedral across at least part of its wingspan when the kite is inflated.

35. A kite as claimed in claim 30, wherein the spacing between linking elements along at least part of the kite's chord is different between connections of adjacent linking elements to the upper skin than between connections of adjacent linking elements to the lower skin, such that the kite exhibits curvature along at least part of its chord when the kite is inflated.

36. A kite as claimed in claim 35, wherein the spacing between linking elements along at least part of the kite's chord is smaller between connections of adjacent linking elements to the upper skin than between connections of adjacent linking elements to the lower skin, such that the kite exhibits upwards curvature or dihedral along at least part of its chord when the kite is inflated.

37. A kite as claimed in claim 36, exhibiting upwards curvature or dihedral along part of its chord near the trailing edge when the kite is inflated.

38. A kite as claimed in claim 35, wherein the spacing between linking elements along at least part of the kite's chord is larger between connections of adjacent linking elements to the upper skin than between connections of adjacent linking elements to the lower skin, such that the kite exhibits downwards curvature or anhedral along at least part of its chord when the kite is inflated.

39. A kite as claimed in claim 38, exhibiting downwards curvature or anhedral along part of its chord near the leading edge when the kite is inflated.

40. A kite as claimed in claim 30, wherein the linking elements include a first linking element that crosses a second linking element when viewed perpendicular to a first plane, such as to define a curvature of the kite in the first plane when inflated.

41. A kite as claimed in any one of claims 32 to 40, wherein a spacing element maintains the desired spacing between linking elements.

42. A kite as claimed in any one of claims 30 to 41, wherein at least some of the linking elements are thru cords.

43. A kite as claimed in any one of claims 30 to 41, wherein the linking elements are through cords.

44. A kite as claimed in any one of claims 30 to 43, having an area of less than five square metres, wherein the leading edge has a depth that is greater in a region close to each wingtip than at the centre of the wingspan.

45. A kite as claimed in any one of claims 30 to 43, having an area of more than ten square metres, wherein the leading edge narrows towards the wingtips.

46. A kite as claimed in any one of claims 30 to 45, being a rectangular kite.

47. A ram air inflated single line kite having upper and lower skins joined together along their edges except for such openings as may be required for inflation, or to control inflation or to eject material etc.,

wherein the skins are connected together between their edges by linking elements and wherein the leading edge has a depth that is greater in a region near each wingtip than in the centre of the kite's wingspan when the kite is inflated.

48. A kite as claimed in claim 47, wherein the ratio of the depth of the leading edge in the region near each wingtip to the depth of the leading edge in the centre of the kite's wingspan is in the range 1.2 :1 to 3:1, when the kite is inflated.

49. A kite as claimed in claim 48, wherein the ratio is about 2:1.

50. A ram air inflated single line kite having upper and lower skins joined together along their edges except for such openings as may be required for inflation, or to control inflation or to eject material etc.,

wherein the skins are connected together between their edges by linking elements and wherein the leading edge has a depth that is smaller in a region near each wingtip than in the centre of the kite's wingspan when the kite is inflated.

51. A kite as claimed in claim 50, wherein the ratio of the depth of the leading edge in the region near each wingtip to the depth of the leading edge in the centre of the kite's wingspan is in the range 0.8:1 to 0.5:1, when the kite is inflated.

52. A kite as claimed in claim 51, wherein the ratio is about 0.75:1.

53. A kite as claimed in any one of claims 50 to 52, wherein the linking elements are connected to the skins and arranged such as to substantially define a generally planar form exhibiting spanwise upwards curvature or dihedral in a region near each wingtip when the kite is inflated.

54. A ram air inflated single line kite having upper and lower skins joined together along their edges except for such openings as may be required for inflation, or to control inflation or to eject material etc.,

wherein the skins are connected together between their edges by linking elements and wherein over at least a portion of the kite's area the spacing between linking elements is different between connections of adjacent linking elements to the upper skin than between connections of adjacent linking elements to the lower skin such as to produce a generally planar form exhibiting curvature over at least part of the kite's area when the kite is inflated.

55. A ram air inflated single line kite having upper and lower skins joined together along their edges except for such openings as may be required for inflation, or to control inflation or to eject material etc.,
wherein the skins are connected together between their edges by linking elements and wherein over at least a portion of the kite's area, one or more spacing elements are attached between, or near to between, at least some of the attachment points of the thru cords and/or ribs to either the upper or lower skin and that these spacing elements are shorter in spanwise dimension than the kite's skin in that vicinity such as to produce a generally planar form exhibiting curvature over at least part of the kite's area when the kite is inflated.

56. A kite as claimed in claim 55, wherein each spacing element is an internal cord or extra panel.

57. A ram air inflated single line kite having upper and lower skins joined together along their edges except for such openings as may be required for inflation, or to control inflation or to eject material etc.,
wherein the skins are connected together between their edges by linking elements and at least some of the linking elements are thru cords;
and wherein over at least a portion of the kite's area, extra diagonal internal cords are attached to or near to the attachment points of the thru cords to the upper skin and diagonally across to or near to the attachment points of adjacent or near to adjacent thru cords to the lower skin and that these diagonal internal cord(s) are adjusted in length so as to distort the kite's shape in their vicinity such as to produce a generally planar form exhibiting curvature over at least part of the kite's area when the kite is inflated.

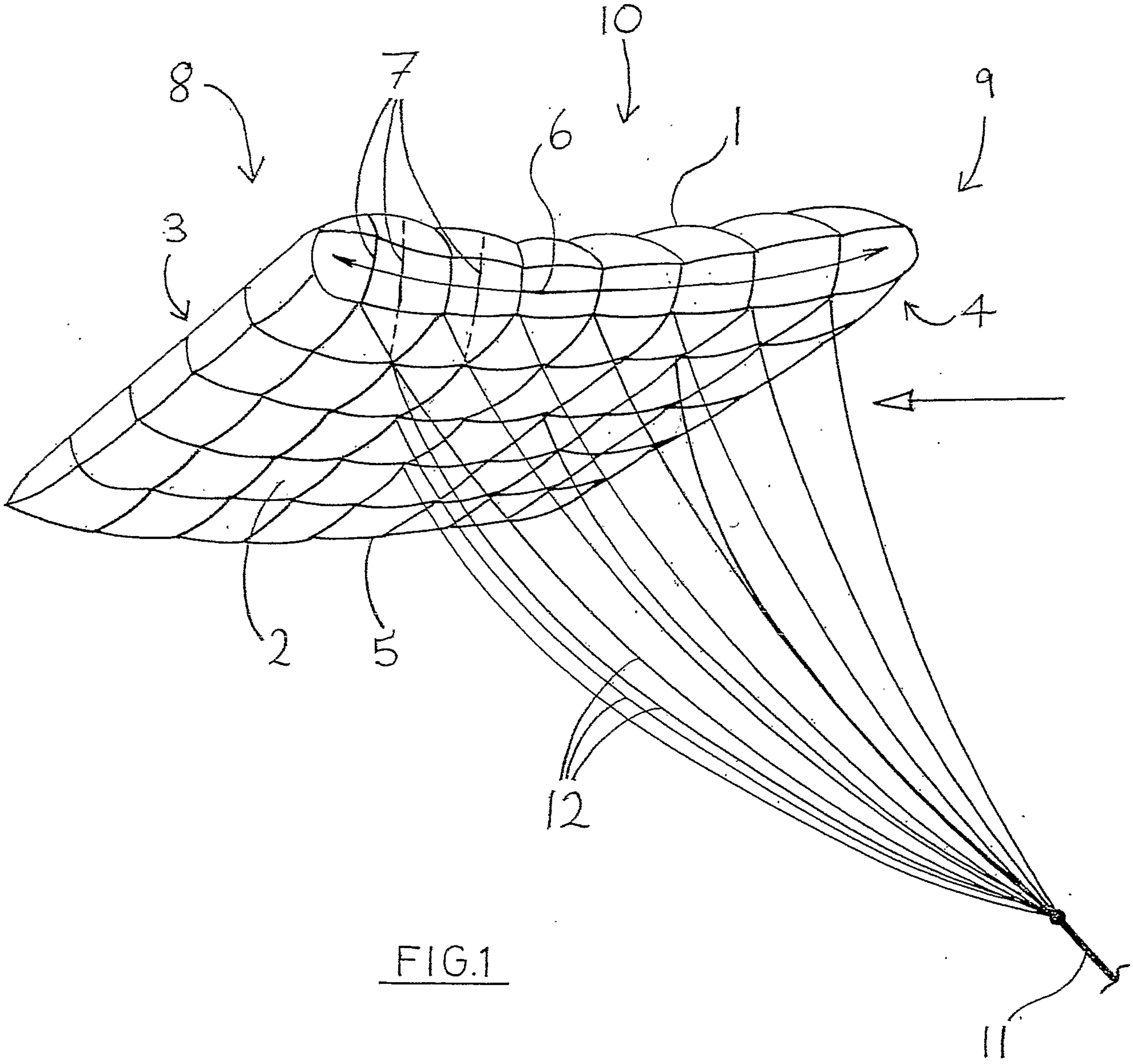


FIG.1

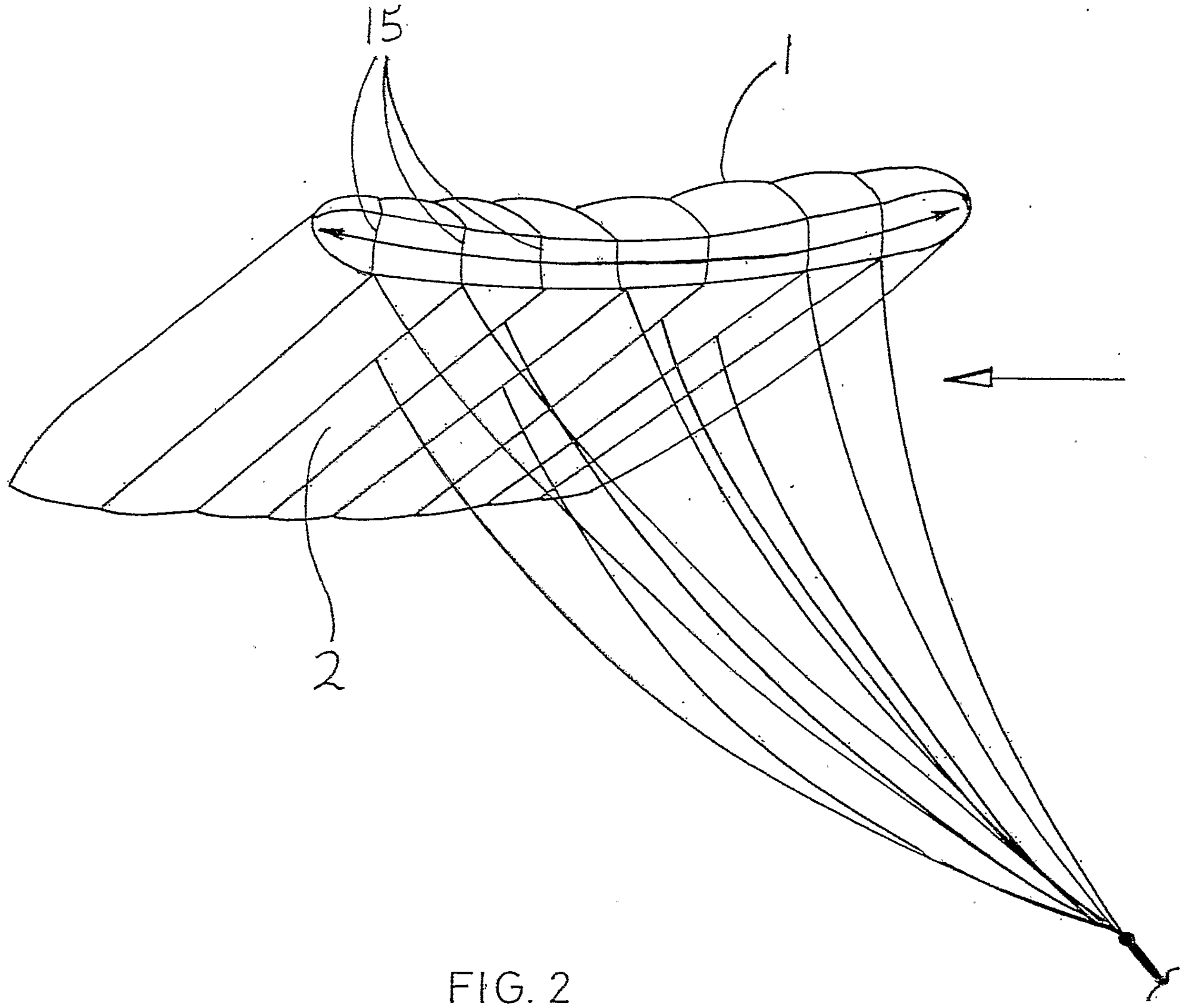


FIG. 2

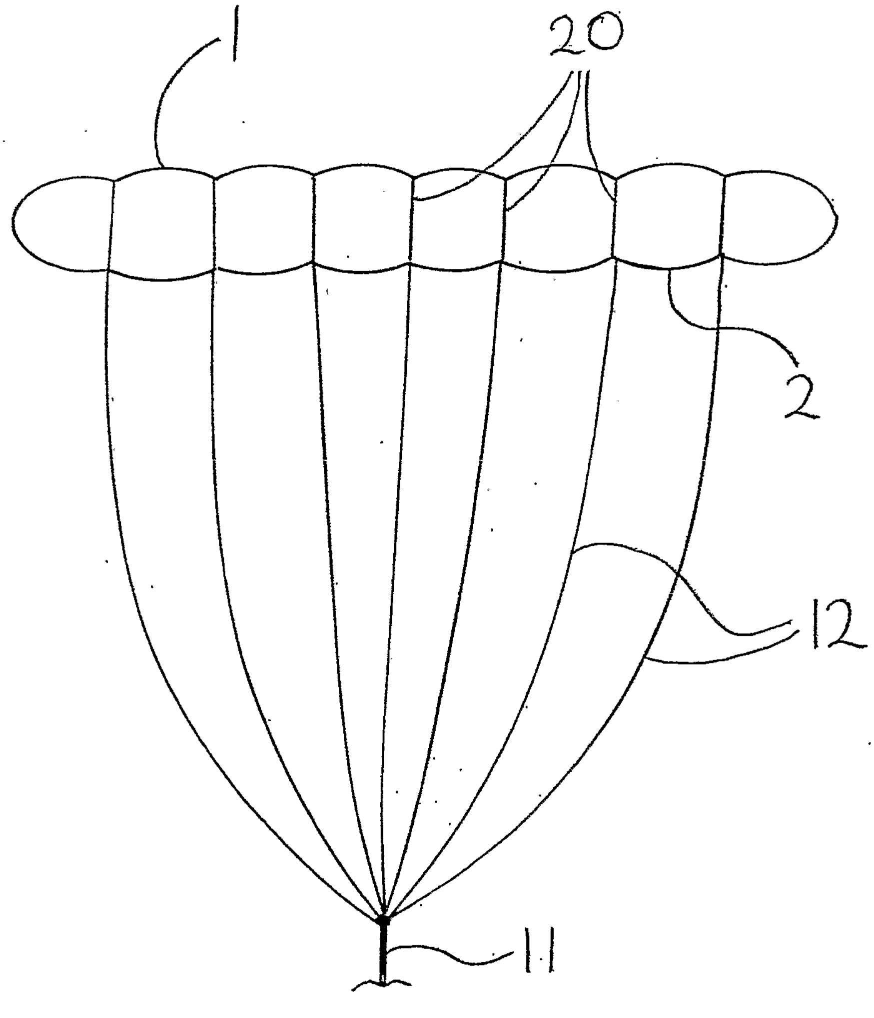


FIG.3

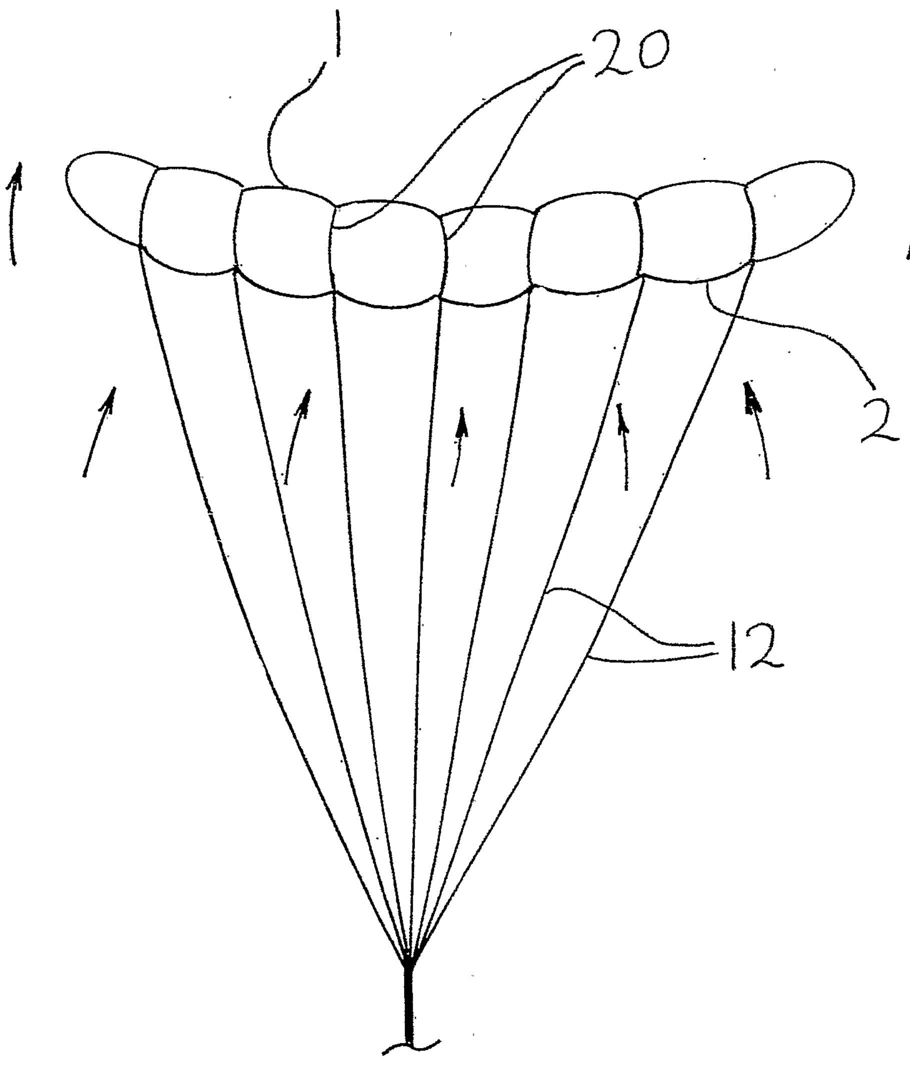


FIG.4

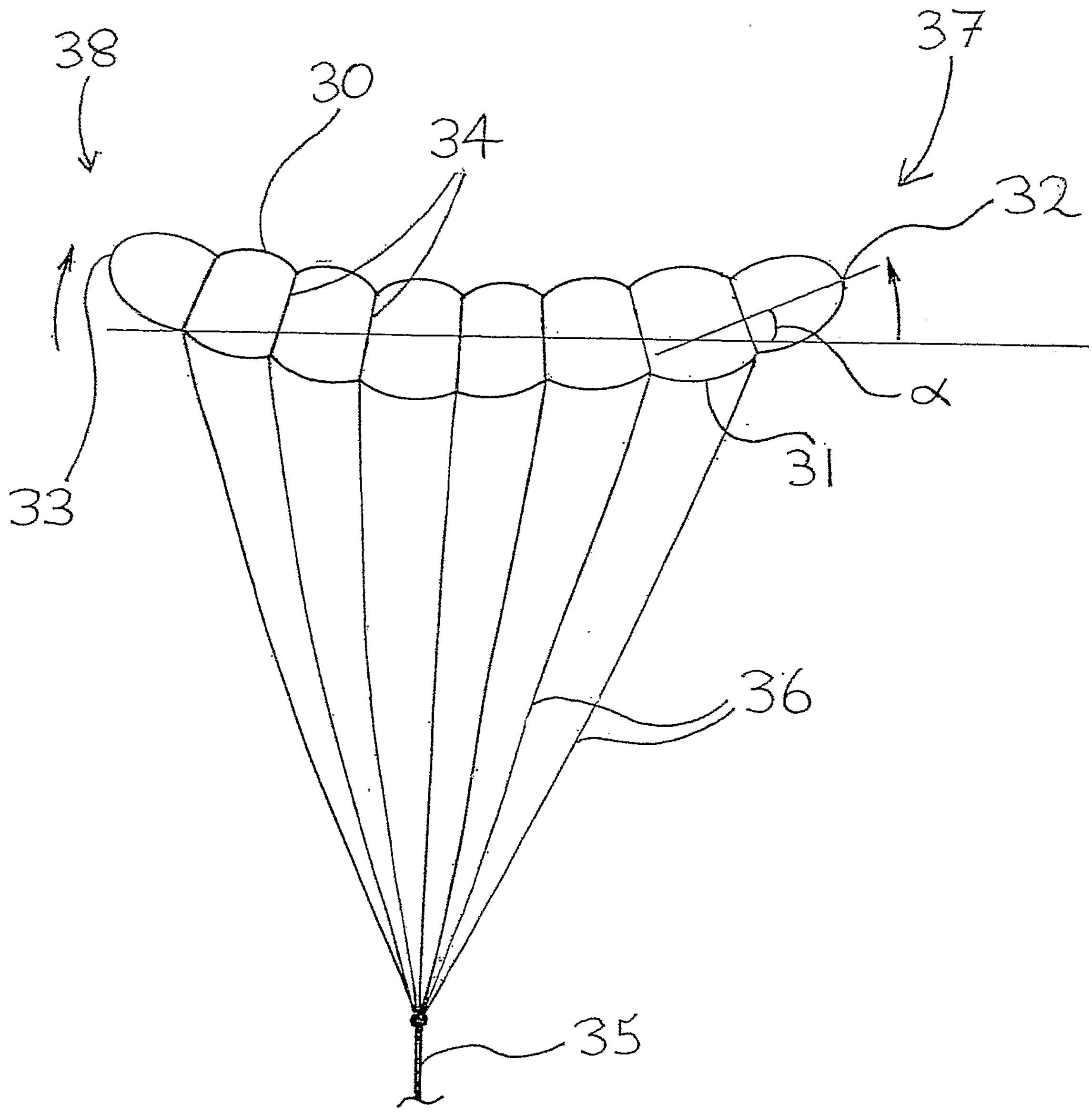


FIG. 5

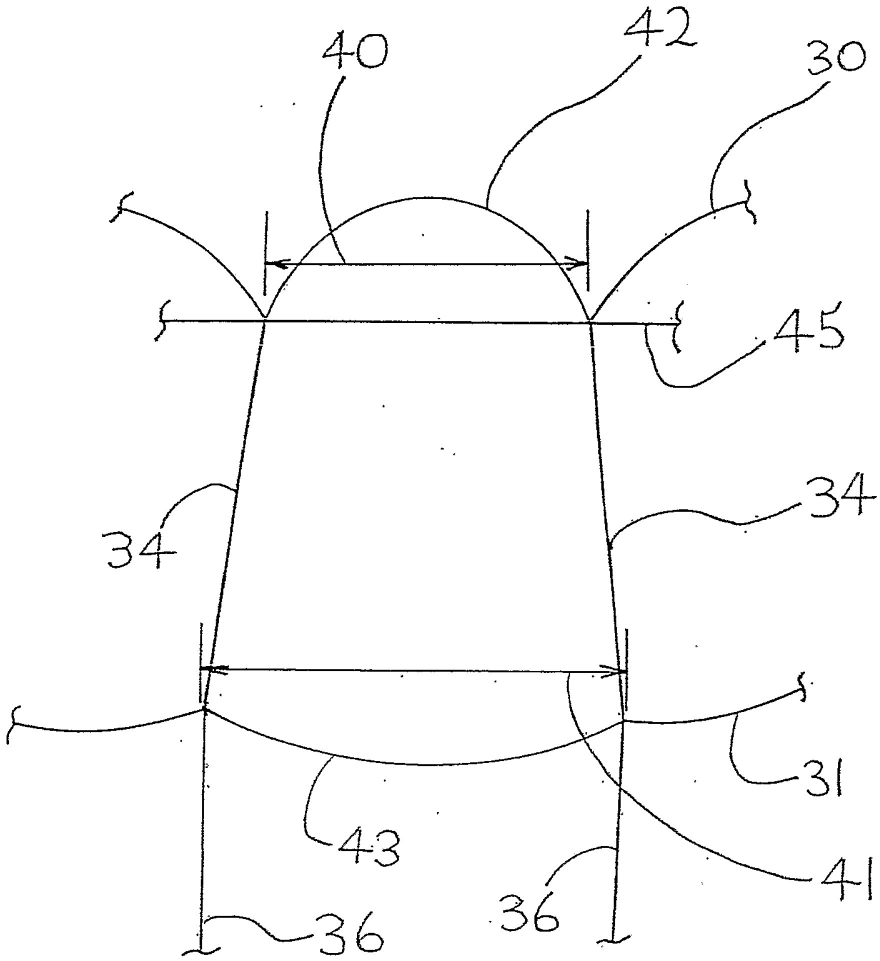


FIG.6

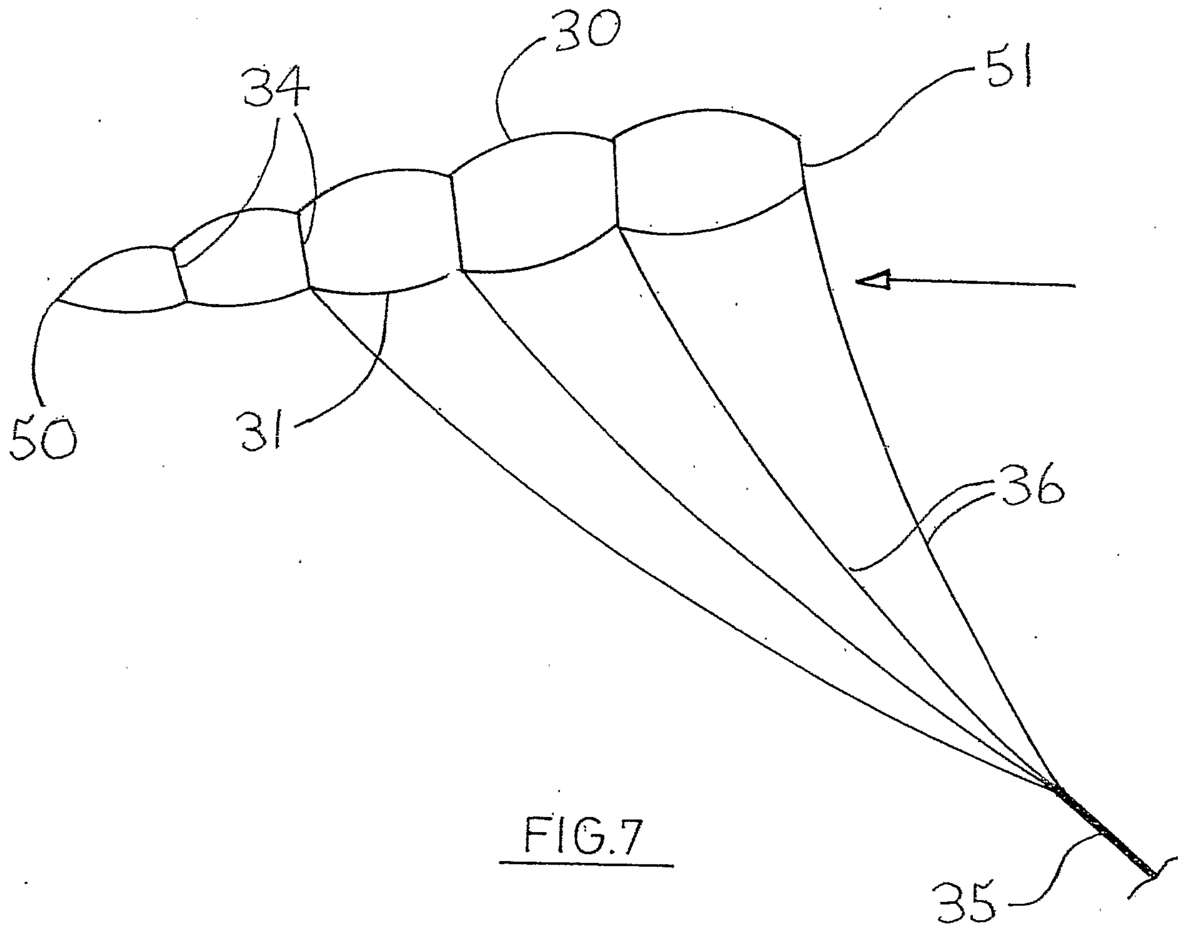


FIG.7

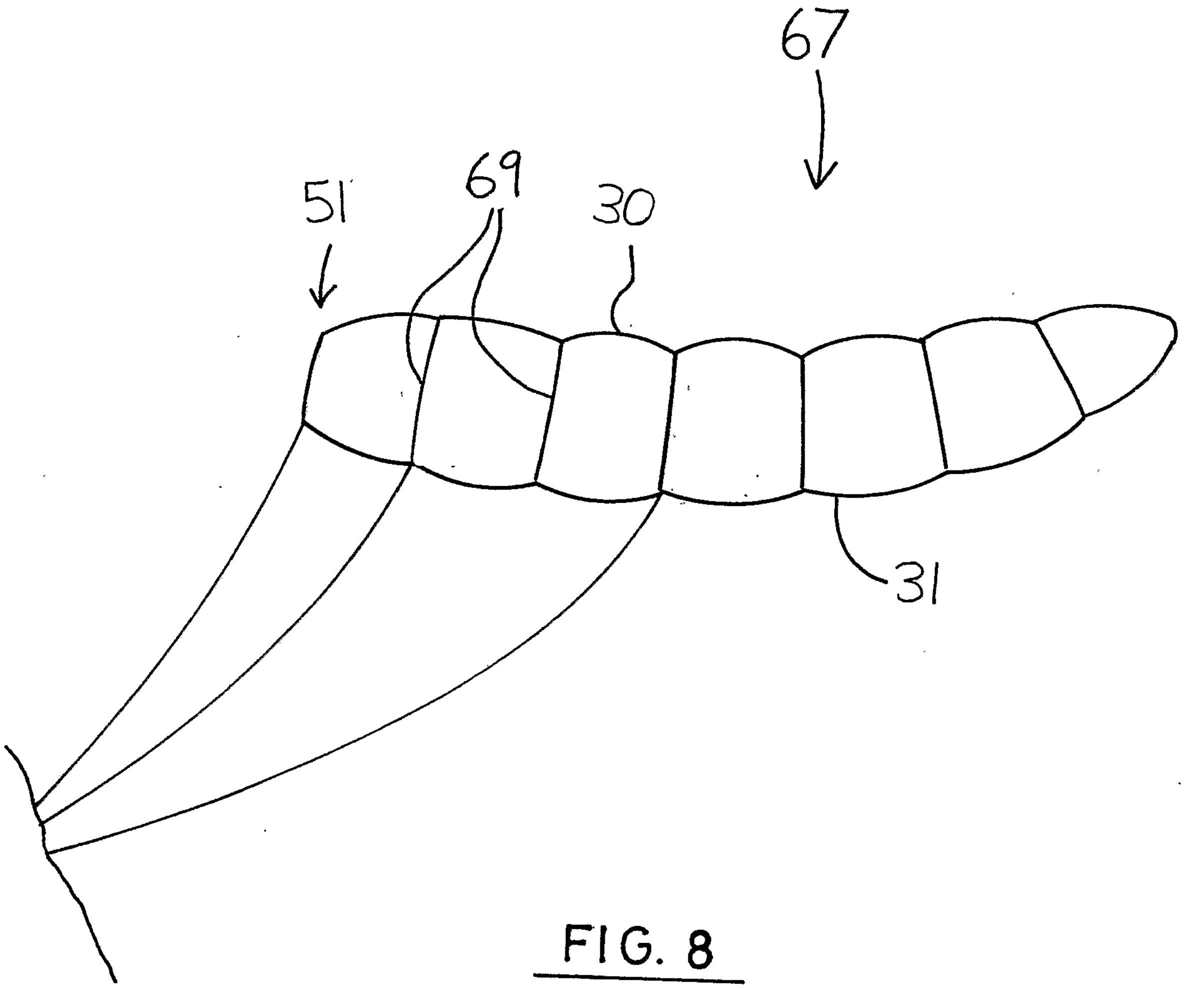


FIG. 8

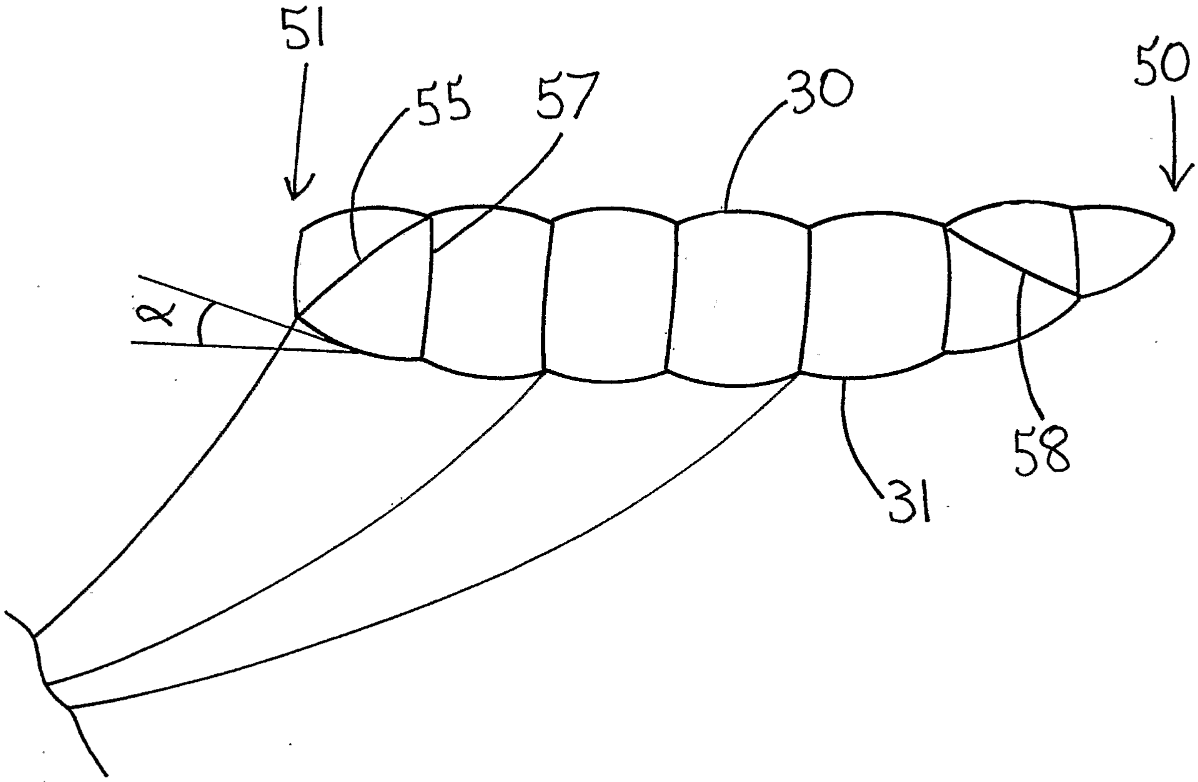


FIG. 9

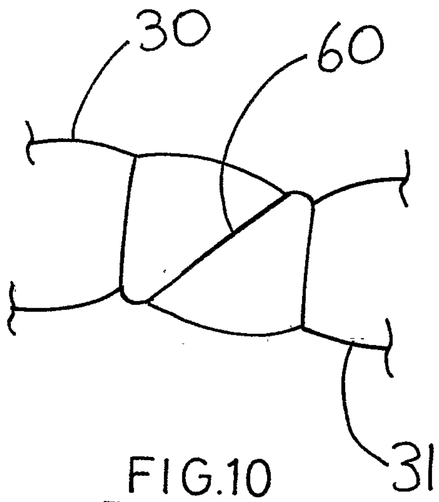


FIG.10

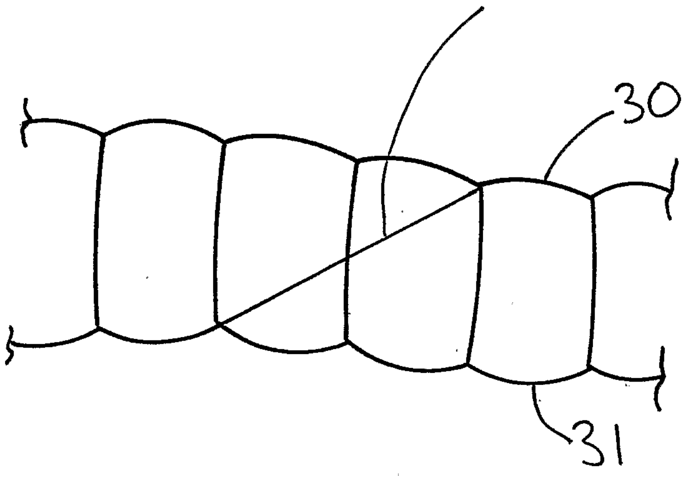


FIG. 11

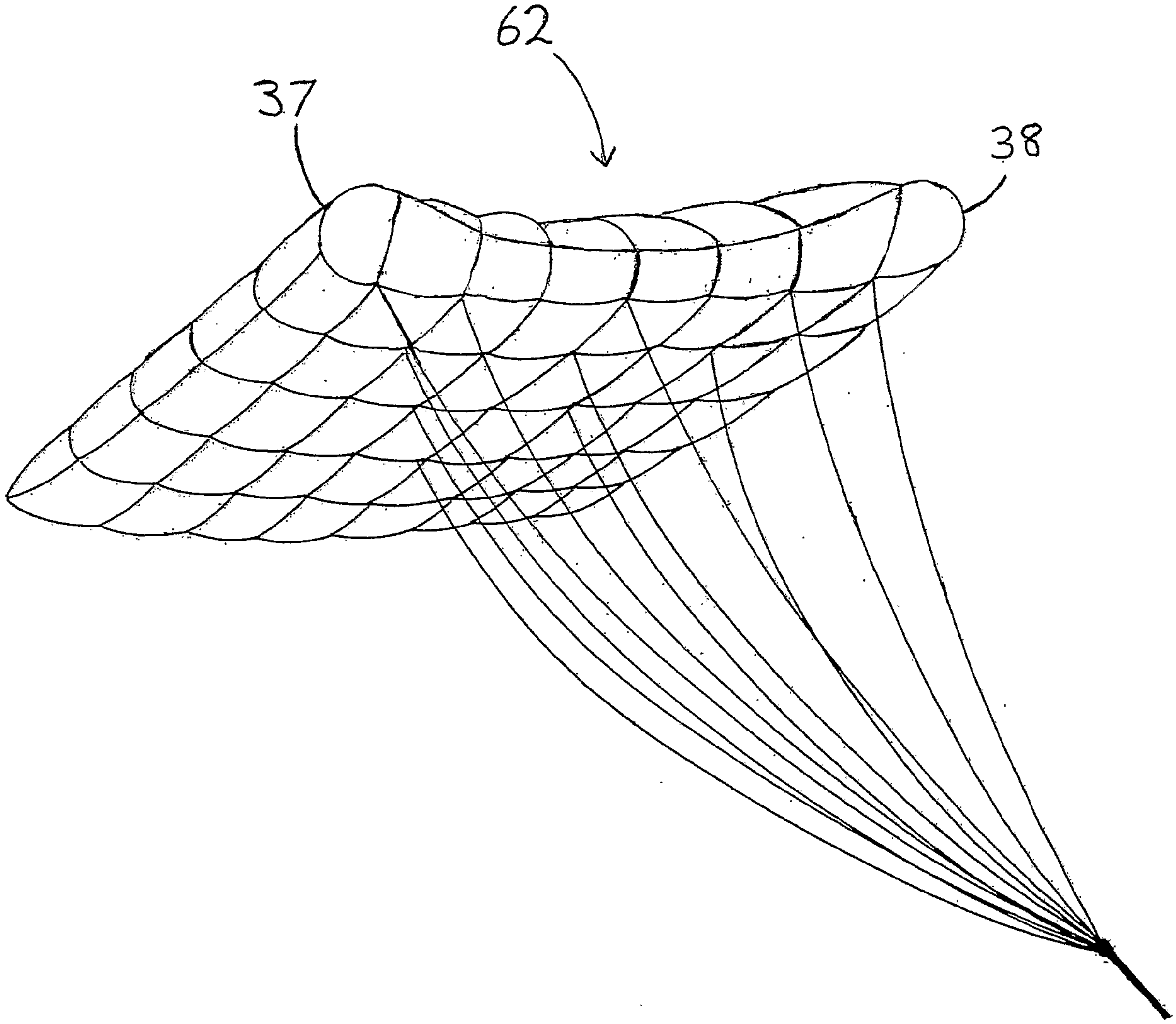


Figure 12

INTERNATIONAL SEARCH REPORT

International application No.
PCT/NZ2004/000178

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl. 7: B64C 31/06

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
Refer to electronic databases consulted below.

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
Derwent World Patent Index and USPTO and esp@ce Internet sites: using keywords: ram, inflate, kite, parachute, parasail and similar terms

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4399969 A (GARGANO) 23 August 1983 See whole document but in particular lines 32-65 of column 7.	30-31, 34, 46, 54
X	US 4389031 A (WHITTINGTON) 21 June 1983 See whole document but in particular Figs 1-2	30, 42-43
X	GB 2084090 A (PARA-FLITE INC) 7 April 1982 See whole document but in particular Fig 3	30

☐ Further documents are listed in the continuation of Box C ☒ See patent family annex

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
13 October 2004	21 OCT 2004

Name and mailing address of the ISA/AU	Authorized officer
AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA E-mail address: pct@ipaustralia.gov.au Facsimile No. (02) 6285 3929	**I.A. KILBEY** Telephone No : (02) 6283 2115

INTERNATIONAL SEARCH REPORT

International application No.
PCT/NZ2004/000178

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
   because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
   because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
   because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a)

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. Claims 1-46 and 54-57 directed to ram air-inflated kites exhibiting curvature when inflated due to the shaping, spacing, etc of linking elements between the upper and lower skins of the kite.

2. Claims 47-53 directed to ram air-inflated kites where the depth of the leading edge is either larger or smaller at the wingtips than it is at the centre of the kite's wingspan.

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☒ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/NZ2004/000178

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report		Patent Family Member					
GB	2084090	AU	75218/81	CA	1172228	DE	3137304
		FR	2490587	IL	63867	US	4470567
				ZA	8106329		

Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.

END OF ANNEX