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KITE BALLOON
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Fig. 2

Fig. 3

Fig. 4

Fig. 10
This invention relates to kite balloons. Although, as will be apparent, the balloon may be adapted for many uses and may be produced in numerous sizes, it is particularly designed for sea rescue work. The sea rescue model will be chosen as the preferred example.

The limitations imposed by sea rescue must be borne in mind. In the first place, the balloon must be light enough and small enough to be packed in an aviator's "ditching kit." Its volume cannot exceed the gas capacity of a sea gas generator. It must inflate fully at the very low pressures characteristic of such a generator. In addition, the balloon must be simple, rugged and long lasting. It must withstand tropic sunshine and violent winds. It must hold a radio antenna and frequently other notification devices aloft for an indefinite period, and this must be accomplished with 26 ounces of weight and a space allotment of but 125 cubic inches.

At present, aviators are provided with a spherical antenna balloon of about 30 cubic feet capacity and two collapsible box kites to launch when the wind forces the balloon down to the sea. Admittedly, this is an unsatisfactory expedient, yet no kite balloon until this present invention has been usable. The most successful kite balloon, the common barrage balloon, is too complicated in structure and design to be practicably reduced to such proportions, and when reduced suffers from the characteristic of all kite balloons, which is that the tension on the flying cable rises steeply with increasing wind. In small models, aerodynamic stability—i.e., the ability of the balloon to fly or be towed without lunging or yawing—all but vanishes. Since the largest size of sea generator will produce but 40 cubic feet of hydrogen and one cubic foot of hydrogen will lift but 32 grams, the weight of the entire balloon and the flying cable or antenna together cannot exceed 1050 grams, for a certain amount of residual or free lift is necessary in order to launch the balloon successfully. It follows that 1050 grams of material cannot make a strong enough structure to withstand the heavy wind strain thrown on both the antenna and the casing.

It is among the objects of this invention to produce a kite balloon which has stable flight characteristics, which is notably free from yaw and leap-frogging in high winds, which is self-limiting in the pull imposed by wind on both cable and casing, which will maintain its aerodynamic stability across a wide range of internal pressure. It is an additional object to produce a small captive balloon which may be flown from sea level to several thousand feet without change or adjustment, which is self-adjusting to rapid changes in gas volume such as are caused by tropic sunlight, and which has long flying life. In addition, it is among the objects of this invention to produce a simple kite balloon which may be packaged within the assigned size and weight limitations and may be completely inflated at very low pressures.

These and other objects will become apparent from the specification and from the drawings, in which:

Figure 1 shows a kite balloon embodying the present invention aloft and anchored to a life raft;

Figure 2 is a side view of the balloon with the tail shown partially in section;

Figure 3 is a fragmentary perspective view of the tail of the balloon;

Figure 4 is an exploded view of that portion of the tail illustrated in Figure 3;

Figure 5 is an elevation partially in section of a portion of the tail strut assembly;

Figures 6 and 7 are side views of the balloon illustrating the action of certain operating structures of the balloon;

Figure 8 is a cross-section through the balloon taken on the line 8—8 of Figure 1 when the balloon is modified to carry certain signalling equipment;

Figure 9 is an enlarged fragmentary section taken on the line 9—9 of Figure 8;

Figure 10 is a fragmentary perspective view of the tail of the balloon, incorporating a modified operating structure;

Figure 11 is a side elevation of a modified form of the balloon when fully inflated and in flight;

Figure 12 is the same view but illustrates the appearance of the balloon after some gas has diffused; and

Figures 13 and 14 are transverse sections on a plane of the balloon located adjacent the tail.

Figure 13 shows the condition of the balloon when fully inflated; Figure 14 shows the condition when diffusion has taken place.

My kite balloon 15 comprises a gas bladder 16 within a fabric casing or envelope 16 carrying lifting fins and rudder fins 17—17. Preferably, the casing is composed of nose and tail patches 20 and 21, respectively joined by the lunes 19. All parts are joined by sewn seams 22 at their margins, but other seaming techniques, thermoplastic fusion or cementing, may be used. The fabric casing 16 is distended by the gas bladder
18, preferably a thin, gas-retentive membrane of polymerized chloro-butadiene 1,3. Other materials of a rubber-like nature are also useful, but have been found to be slightly more permeable to hydrogen. Because the steadied flight characteristics are thereby secured, an ellipsoida1 shape is desirable for the nose and body portions of the casing 16. The tail falls away to a foreshortened teardrop.

Concerning inflation, the general law is that, if two containers of different diameters having exposable walls are connected together, that container having the greater diameter will expand to the exclusion of the smaller unless the difference in their diameters be small. A sharply streamlined bladder follows this general law. Its small diameter tail will not inflate at the low pressures which produce full expansion of its nose and body. To permit the full inflation of the balloon at low pressures (2" water column) it is necessary to hold the ratio of maximum casing diameter to the diameter at the tail in the relation of small whole numbers. If the ratio is greater than this, the tail will not inflate until too high a pressure is reached.

The wire or lifting, and the rudder or stabilizing fins 17—17 are approximately triangular pieces of a strong fabric such as baloon cloth and are symmetrically placed adjacent the tail in the vertical and horizontal axial planes of the balloon by sewing them to the casing along certain of the seams 22. The fins 17—17 are held distended by a strut assembly 25, which will be described hereafter.

The elastic bladder is of single piece construction preferably formed to have relaxed dimensions approximately equal to the dimensions of the casing or envelope 15. Therefore, when fully inflated at sea level, the bladder is not under material elastic stress. By avoiding elastic stress at sea level, the balloon is given a high flight ceiling, it has the ability to withstand substantial temperature changes, and full inflation of the balloon at very low initial pressures is possible.

The bladder 18 is placed in the casing 16 through the hole 26, formed in the tail patch 21. The tail section of the bladder terminates in the inflation valve 27. As this is the standard rubber valve now adopted for sea rescue and meteorological balloons, it is not further described.

It should be noticed that the fins 17—17 do not extend to the end of the tail, but that their tips are located several inches towards the nose of the balloon (see particularly Figure 4). The tail strut assembly 25 comprises a pressure plate 30 carrying radiating spring strut rods 31, which are detachably held in the sockets 35, formed in the plate 30. To give collapsibility so that the struts may be folded into a parachute pack, each rod consists of two telescoping members 33 and 34 formed from a springy alloy of aluminum or magnesium. When extended, they are locked by the spring detent 36 which is coiled around the member 33 in such manner that its two ends 37 extend through diametrically opposite holes 38 in the member 33. The detents lock by dropping into a transverse hole 39 in the member 34. The free ends of the strut rods 31 are fitted into fabric pockets 32 stitched to the extreme tip of each fin. The assembly is located by passing the neck of the inflation valve 27 through a central aperture in the plate 30.

Since, when the balloon is inflated, the fin tips do not lie in the plane of the pressure plate 39, but lie towards the nose, the strut rods 31 are substantially bowed and exert a strong backward pull at the tip of each fin. This, in turn, reacts through the pressure plate to urge the tail of the balloon inward towards its nose. If collapsibility is unimportant, crossed wood sticks or metal strut rods 31' lashed at their intersection 30' are equally useful (Figure 10).

The bridge or rigging 40 consists of two v-shaped loops 41 and 42, preferably parachute cords, made fast at each end to loop patches 43 sewn on the casing 16 and so located on the lune seams 22 that the forward pair and rear pair of loop patches straddle the center of rotation of the balloon. The rear loop 42' of the bridge 40 terminates in an elastic link 45 which is preferably a strong rubber cord, but may be a metallic pull-spring. The outer end of the link 45 and the forward bridge 42 are made fast to the concentration ring 44 which may be equipped with a swivel 46, if desired. The mooring line 41 or antenna is attached to the concentration ring assembly.

The operation of the balloon is as follows. At the factory, the pressure plate 30 is slid over the valve stem 27 and fixed in place. Then the tips of the strut rods 31 are made fast in the fin pockets 32 so that there are no loose pieces of the assembly. The balloon is packed in a small, mill board box provided with a ripping cord which should be tied to the raft before the user commences to inflate the balloon. A pull on the cord splits the box along its seams. The inner end of the ripping cord is attached to a strong cord finger loop 46, which is made fast about the neck of the inflation valve 27. The nozzle of the gas generator is then inserted in the valve 27. By slipping the loop 45 over the fingers and grasping the handle of the gas generator, the balloon inflates nose-up. Since the plate 30 is already in place, and the tips of the strut rods already made fast in the pockets 32, it is only necessary that, during inflation, the strut rods be extended and their ends be slipped into the plate sockets 35. The antenna sleeve 47 is locked to bridge swivel 48. When inflation is complete, the generator nozzle is pulled out of the inflation valve, which automatically closes. Finally, the rip-cord mooring is cast off and the balloon is away.

Conventional kite balloons increase their angle of attack as the wind velocity rises, and this characteristic has been amplified by designers since it steadies the balloon and reduces yaw. Quite to the contrary, my balloon presents its maximum angle of attack to the lightest wind and progressively decreases that angle as the velocity rises. Yawing is overcome by making the rudder surfaces at least equal in area to the lifting planes. As the wind increases, link 45 stretches. This pulls down the nose, elevates the tail and reduces the lift to safe limits. Predetermined flight characteristics are given by choosing the correct stress-strain characteristics of the link 45.

Assume a light wind blowing in the direction of "A," Figure 1. The balloon then carries its nose at a substantial angle to the horizon and the angle is near its maximum. As the velocity of the wind rises and the wind increases, link 45 elongates, as shown in Figure 6. Although the wind continues to blow from the direction shown by the arrow, the angle of attack and hence the pull both on the casing and flying wire are reduced.
As hydrogen diffuses from the envelope, the tension of the bowed strut rods exerted through the pressure plate \(33\) pushes in the tail. Until all tension is relaxed, the aerodynamic characteristics of the balloon are substantially unaltered. This design permits a large change in volume of gas within the envelope (in a balloon having the specifications given below, 16%) without changing the ability of the balloon to fly.

The progressive change in the position of the strut assembly is illustrated by comparing Figures 1, 6 and 7. The balloon illustrated in Figure 7 is nearing the end of its flight. The struts, now lying in a plane, hold the fins distended but further diffusion of hydrogen will cause the fins to slacken.

When the fins slacken, the balloon may be hauled down. If no hydrogen is available, it may be pumped up with air. Obviously, the added air does not increase the existing free lift of the balloon, but it does restore its aerodynamic flying characteristics so that the balloon may again be flown with the aid of the wind. So far, sea rescue balloons also carry an internally mounted signalling apparatus, the efficiency of which depends upon the exact maintenance of the angular relation of the members. For this purpose, it is essential that the cloth forming the envelope \(16\) stretch equally both in warp and weft directions. So far, only woven nylon and certain parachute rayons have exhibited the necessary uniformity of stretch.

Such apparatus is inserted by placing grommets \(63\) at accurately spaced locations on the casing \(16\). Molded rubber mounting studs \(62\) are pushed against the bladder \(18\) at points which align accurately with the grommets \(63\). Then, from inside the bladder, a lashing is seized around that portion of the bladder which is forced inwardly by the stud in such a manner that the shank of the stud is permanently enfolded by a small portion of the unpunctured bladder \(18\). The lashing \(68\) terminates in an elastic link \(67\) which supports the apparatus (see Figure 9). The dialtable head of the stud \(62\) is then pushed through the grommet hole. Its engagement with the head of the grommet prevents its withdrawal into the casing.

In addition to maintaining the angles accurately, a casing which expands equally imparts another property, namely, an over-all volumetric increase without altering the flight characteristics of the balloon. For example, a balloon having a casing of rip-stop nylon parachute fabric of 30-denier warp and filling weighing one ounce per square yard and sewn with nylon thread when filled with hydrogen to a pressure of four inches (water) had a volume of 40.4 cubic feet. The pressure was increased to 15 inches and the volume increased to 47 cubic feet. Thus the balloon may increase more than 16% in volume without distortion. The bowed spring tail struts permit an additional volume change of at least 18%, as has been explained. Because the balloon may increase 2% in volume, it has a phenomenal ceiling and may be subjected to wide temperature variations.

The typical sea rescue balloon has the following dimensions as rigged to signal at the international distress frequency:

| Length | 6' 6'' |
| Diameter | 3' 2'' |
| Wing spread | 4' 2'' |
| Total weight of balloon | 735 grams |
| Gross lift (at 4'' gas pressure) | 1295 do |

This balloon is ready for flight when the gas pressure is .08 inch of water and the volume is 33.9 cubic feet. At this pressure the struts are straight, as shown in Figure 7. When the gas pressure reaches 4 inches of water, the balloon completely fills the casing and the struts are bowed, as shown in Figure 2, and the balloon has a capacity of 40.4 cubic feet.

With a link having approximately the stress-strain characteristics given, this balloon maintains an angle of approximately 45° to 90° horizontal, independent of winds between a mile-and-a-half and 45 miles per hour. It will fly in winds of about two miles per hour when the free lift of the balloon alone is 100 grams and then will support a flying line weighing 300 grams.

A further example of the spring-pressed volume adjustment characteristics of the improved balloon is shown in the alternative construction illustrated in Figures 11 to 14, inclusive. This structure is particularly adapted for one man use since no parts need be fitted together at the time of launching. The balloon is ready for flight as soon as it is inflated.

The envelope \(70\) is constructed in the same manner as the envelope \(16\) and is inflated by the bladder \(71\), which is similar to the bladder \(18\), both of which have been previously described. The balloon is provided with lifting and rudder fins \(72\) which, like the previously described fins \(17\), are textile wings sewn to the casing \(10\) along certain of the seams \(73\) between the lunes in such a manner that when the fins are extended they lie in the plane of the vertical and horizontal axes of the balloon shown in Figures 13 and 14. The fins are held extended by light strut rods \(74\) which are anchored in suitable pockets \(75\) and \(76\), which are sewn to the tips of the fins \(72\) and to the envelope \(70\), respectively. An air pocket is avoided if the strut is placed on the lower side of the lifting fins. Loops \(77\) are sewn on the envelope \(10\) on the seams \(73\) which are intermediate the fins \(72\). Two elastic links \(78\) are attached to each loop. The outer ends of the links are attached to a cable \(19\) which passes through the pockets \(78\) and downwardly on the other side of the fin to join the opposite elastic link \(18\). The arrangement is best shown in Figures 13 and 14. The rigging \(80\) and its attachment to the casing \(10\) is similar to the rigging \(40\) which has been previously described.

When the balloon is inflated, the struts are urged outwardly. The elastic links \(18\) are therefore stressed and exert a countering balance push upon the rods \(14\) downwardly towards the axis of the balloon. As the gas diffuses from the balloon, the rods \(14\) are progressively pushed further inwards in a manner shown in Figure 14. Fins \(72\) are rigidly extended until the diffusion of gas has progressed to a point where all tension on the elastic links \(78\) has relaxed. If packing in very small compass is unnecessary, rigid fins may
be substituted for the fabric fins 72—72. The fin itself then becomes the strut, and separate struts are not needed.

This system permits large volumetric changes in the gas within the balloon without altering the aerodynamic characteristics of the balloon. This action takes up all slack in the envelope and allows the gas in the envelope to pass through considerable volumetric changes without permitting the aerodynamic characteristics of the balloon to be altered and holds the fins 72 rigidly extended until the progressive diffusion of the gas has reached a point where all tension of the elastic links 78 has relaxed (see Figure 14).

The designs of the balloons which have been described have been most successful. The balloons have been towed by surface craft at more than 30 knots an hour. They have flown in 45 mile winds and have never recorded line tensions which come near the breaking strength of the antenna or the flying line. They have flown exclusively as kites in winds of one-and-a-half to two miles an hour and have lifted as much as 933 grams in winds of two-and-a-half miles an hour. The free lift of the balloons has been reduced until only a tree-top high length of antenna could be supported; even then the balloons have been launched straight up between trees, have caught the wind and flown. This makes them have great value in jungle rescue work. They maintain an antenna at a high angle to the horizontal practically independent of wind velocities. Obviously, the design is suitable for larger and more rugged balloons, but it has successfully solved the problem of making a very light balloon dependable and effective in all weathers but the wildest storm. In addition, the simple bellows-like action of the spring-pressed envelope permits long continued flights, which previously could only be secured by the use of more complicated and heavier gas control apparatus.

I claim:

1. An inflatable kite balloon comprising a body provided with fins and having spring means acting on the fins and reacting on the body to maintain the fins extended and compress the body.

2. A kite balloon comprising an envelope provided with lifting and stabilizing fins and having external spring means bearing upon the envelope and responsive to changes in the volume of gas within said envelope to compress said envelope and to maintain said fins in an extended position.

3. A kite balloon comprising an envelope and lifting and stabilizing fins, and having spring-pressed means working externally of the envelope to compress said envelope as the internal pressure falls to maintain the aerodynamic characteristics of the balloon.

4. A kite balloon having lifting and stabilizing fins normally incapable of self-support and spring-urged struts holding said fins in distended position and normally loaded by the internal pressure in the balloon envelope to exert pressure upon the envelope to compress said balloon volumetrically and maintain said fins in distended position despite volumetric changes of the gas within the balloon.

5. An ovoid kite balloon having lifting and stabilizing fins adjacent the tail and having the tips of said fins lying in a plane forward of the tail, struts having their outer ends fastened to the tips of said fins bearing upon the tail and normally urged rearwardly by the internal pressure of said balloon to exert a rearward pull at said fin tips.

6. In a balloon having an inflatable ovoid body, the combination of opposite fins on said body near the tail thereof, and a rod having its ends anchored to the tips of opposite fins and extending across the tail of the balloon and urged rearwardly thereby when the balloon is inflated.

7. A balloon having an inflatable envelope, opposite non-rigid fins flaring outwardly from said envelope and spring means between said envelope and fins responsive to volumetric changes of the envelope and reacting to compress the envelope to maintain the fins extended.

8. An ovoid kite balloon having rudder fins located in the vertical axial plane of the balloon and symmetrically positioned above and below the axis, lifting fins located in the horizontal axial plane of the balloon and symmetrically positioned on each side of the axis, struts extending between the balloon envelope and the tips of said fins and urged outwardly by gas pressure within the balloon holding said fins extended, and spring tensioned members to urge said struts inwardly against the balloon.

9. A balloon having an inflatable ovoid body, outwardly projecting fins located near the tail of said body, and spring means anchored to said fins and engaged and loaded by the tail when the body is inflated.

10. The combination of a captive balloon having lifting fins capable of sustaining the balloon in moving air and normally presenting the maximum angle of attack to still air, a flying bridge, and spring actuated means responsive to an increase in dynamic lift and operative to reduce the angle of attack in proportion to said increase in dynamic lift, thereby limiting the strain imposed on said bridge and said balloon.

11. The combination of a captive balloon having lifting fins adjacent its tail surface, a flying bridge attached to the balloon in advance of its center of rotation; a second bridge attached to the balloon rearwardly from its center of rotation and a spring linking connecting said rear bridge to a common concentration point, whereby the angle of attack of said balloon is reduced with increasing wind pressure upon said fins.

12. An ovoid captive balloon normally flying with its axis at an angle above the horizon, having laterally extending lifting fins, a concentration ring lying beneath the body of the balloon, a harness having forward and rear members connecting the balloon to the concentration ring and spring means interposed in the rear harness member adapted to elongate said member proportionately to an increase in lifting force and thereby to reduce the angle between the axis of the balloon and the horizon.

13. A kite balloon having a casing of woven material capable of stretching along both warp and weft directions to substantially an equal extent, an elastic bladder within the casing, and lifting fins capable of imparting aerodynamic lift to said balloon, whereby the gas in said balloon may increase in volume without distorting said casing.

14. A kite balloon having an elastic bladder and a surrounding casing, reinforced apertures provided in said casing at spaced intervals on a diameter of said balloon, and anchoring means provided on said bladder projecting through and engaging the margins of said apertures to fix the position of the elastic bladder with respect to the casing.
15. A kite balloon having an elastic bladder and a surrounding casing, reinforced apertures provided in said casing at spaced points on a diameter of said balloon, and anchoring means provided on said bladder supporting an internal structure in said bladder and engaging the margins of the apertures to maintain the alignment of said internal structure.

16. A balloon for flying an enclosed device, having a casing of a woven material capable of expanding substantially equally in warp and weft directions, an elastically expansible gas-holding bladder within the casing containing said device, and angularly spaced elastic suspensions for the device engaging both the bladder and the casing.

17. An Lvold captive kite balloon of the non-venting type, having a spring-pressed tail section adapted to compensate for changes in the volume of gas within the balloon.

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