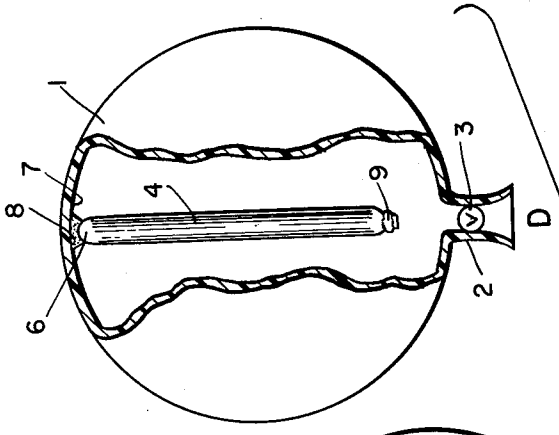
July 21, 1964 E. W. MERRILL 3,141,636

STREAMLINED METEOROLOGICAL BALLOONS

Filed July 6, 1962



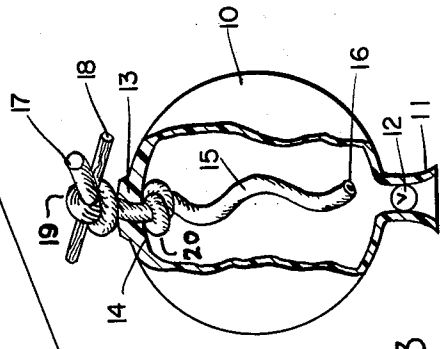
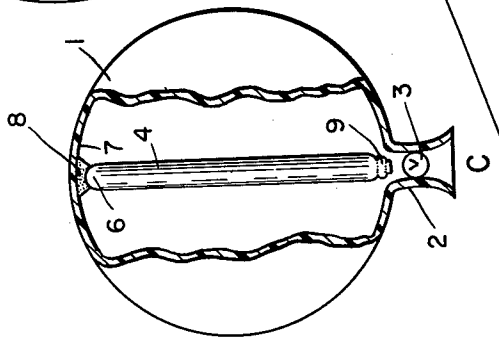
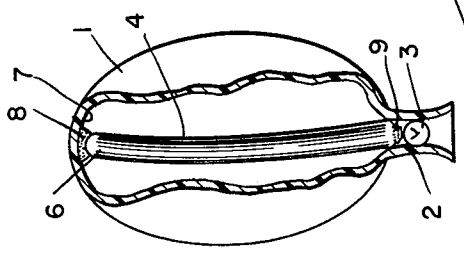


Fig. 3





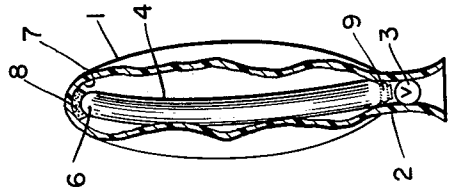


Fig. 2

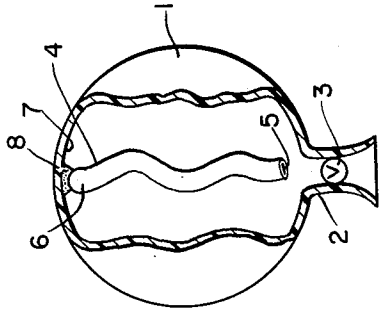


Fig. 1

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3,141,636

STREAMLINED METEOROLOGICAL BALLOONS

Edward W. Merrill, Belmont, Mass., assignor to W. R. Grace & Co., Cambridge, Mass., a corporation of Connecticut

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This invention relates to balloons useful for meteorological purposes and is particularly directed to aerodynamically streamlined balloons capable of relatively great ascensional velocities.

The free-flying meteorological balloons customarily employed in upper atmospheric sounding flights are partially inflated with lifting gas at the time of launching and continue to expand during ascent due in part to the decreases in external pressure of the surrounding atmosphere until maximum expansion volume is attained and rupture of the envelope occurs. These balloons are usually made from expansible, elastomeric materials, such as films of natural and synthetic rubbers. They are generally constructed in a spherical or near-spherical shape since wide deviations from this design have been limited due to the elastic nature of the envelopes and, therefore, their tendency to assume a spherical form.

Though these galloons meet the demands of modern weather-forecasting methods for reaching high stratospheric levels, because of their shape, they tend to be slow-rising and at times of high stratospheric wind velocities may travel considerable horizontal distances before reaching bursting altitude. While it has been proposed to increase the ascension rate by using additional quantities of lifting gas, this procedure has not been altogether satisfactory since it has accomplished only slight increases in vertical acceleration. Moreover, inflation of the balloon beyond certain limits tends to reduce vertical speeds due to increased air resistance which causes a flattening of the top of the balloon whereby the horizontal diameter is increased and the vertical diameter decreased. It is obvious that by adding attachments to the underside of the balloon in order to produce stabilizing fins, an elongated tail, etc., considerable improvement in ascension velocity could, in principle, result because of the reduction of aerodynamic drag. Such methods, however, entail two severe limitations: (1) considerable material weight may be required thereby reducing free lift and consequently ascension velocity; (2) attachments of any kind to a thin and ever-extending elastomeric envelope may provide foci of high stress which will initiate premature rupture of the envelope.

According to the present invention, it is now possible to construct a self-destructible, expansible meteorological balloon which is streamlined in shape and which is fast-rising during at least half of its total ascent. This is accomplished by inserting an elongated inflatable tube of an inelastic thin film within an expansible envelope adapted to receive and contain a predetermined amount of lifting gas and pressurizing the tube with lifting gas until it reaches its inflating capacity. The tube is of sufficient length and capable of containing adequate pressure so that when fully inflated it assumes the shape of a rigid strut. The strut forces and maintains the envelope in the shape of a prolate spheroid up to any given diameter including maximum diameter before rupture. Because of the gentle stress which the strut exerts against its forward wall and because the "payload" attached dependently from the balloon, for example a radiosonde, effectively keeps the major axis of the ellipsoid more or less vertically aligned, the balloon is urged to ascend substantially vertically and rises at a rate substantially exceeding that of a spherical balloon of equal volume and

"free lift." Consequently, the streamlined balloon of this invention will reach a given altitude with less horizontal drift than the equivalent spherical balloon because the ratio of vertical velocity vector to wind-produced horizontal velocity vector is substantially greater with the streamlined balloon. Also, there is a substantial increase in ascension rate with the result that the average gas temperature within the balloon remains high for a longer period of ascension.

The present invention will be more clearly understood from a reference to the attached drawings and the ensuing discussion relating thereto:

FIGURE 1 is partly in section showing the assembled balloon.

FIGURE 2 illustrates various stages of the balloon during inflation and ascension, with the stages labeled A to D and represented partly in section.

FIGURE 3 shows an assembled balloon partly in section which represents a further embodiment of the present invention.

Referring now more particularly to the drawings, the novel balloon consists of an expansible envelope 1 of generally spherical shape having a neck or gas inlet portion 2 which is provided with a suitable closing means, such as valve 3. An elongated inflatable, inelastic tube 4 having an open end 5 and an opposed closed end 6 is permanently secured within the envelope 1. The tube is secured by its closed end 6 to the inside surface of the forward wall 7 of the envelope by adhesive 8, or other suitable means, so that when fully inflated it remains longitudinally fixed in vertical alignment with the inlet portion 2. When the tube is pressurized to its full inflating capacity, it assumes the shape of a rigid strut as illustrated at A to D, FIGURE 2. Inflation is carried out by passing a lifting gas into the tube through open end 5 and then closing the end by suitable means, such as heat sealing, when the tube is fully inflated. The closed end, illustrated at 9, then nests loosely in inlet portion 2.

In FIGURE 3, a readily assembled balloon is shown which illustrates another embodiment of the present invention. The balloon consists of an expansible envelope 10 of generally spherical shape having a neck or gas inlet portion 11 provided with a suitable closing means such as valve 12 and a thickened elastic portion 13 provided with an aperture 14 diametrically opposed to inlet portion 11. An elongated inflatable inelastic tube 15 having an open end 16 and an opposed closed end 17 is permanently secured within envelope 10. The closed end 17 of tube 15 is passed through aperture 14 and the tube at its closed end 17 is affixed by knot 19 to stop-stick 18 and by knot 20 or secured by other suitable means, so that the tube 15 remains in longitudinal vertical alignment with inlet portion 11 when fully inflated.

The balloon is shown in FIGURES 1 and 3 with the expansible envelope partially inflated with lifting gas at ground level and with the inflatable tube in a flaccid condition.

In FIGURE 2 at A, the balloon is shown at ground level but with the inflatable tube pressurized with lifting gas and sealed-off at end portion 9 to form a rigid elongated cylindrical strut. The strut forces the partially inflated expansible envelope into an ellipsoidal shape. At B, the balloon is shown at a low altitude during ascent where the volume of gas inside the expansible envelope has substantially doubled. At C, the balloon is shown at a higher altitude where the diameter of the envelope is approximately equal to the length of the strut. At D, the balloon is shown at about bursting altitude with the expansible envelope fully expanded and the strut withdrawn from the inlet 2 of the envelope.

An example of a streamlined balloon constructed according to the present invention is as follows:

Example

Inflatable, inelastic tube:

Material—polyethylene film irradiated, biaxially oriented	6 mils, thickness.
Length	20 ft.
Diameter	1 ft.
Inflated pressure	20 p.s.i.a (6 p.s.i.g.).
Inflating gas	Hydrogen.
Total thrust against balloon envelope	650 lbs. at 20 p.s.i.a.

Standard high altitude sounding balloon (neoprene envelope):

Diameter at ground level with 280 ft.^{3} hydrogen	8 ft.
Diameter at 100,000 ft. altitude	30 ft.
Dimensions at ground level with 280 ft.^{3} hydrogen and containing the above inelastic tube at 20 p.s.i.a.:	
Length	20 ft.
Maximum diameter	5 ft.

The cylindrical tube of polyethylene film sealed at one end and open on the opposite end is inserted inside the envelope of the high-altitude sounding balloon. The tube is positioned so that its open end is accessible at the neck portion of the envelope. The envelope of the balloon is inflated with 280 ft.^{3} of hydrogen. Thereafter, the tube is pressurized to 20 p.s.i.a. (6 p.s.i.g.) with light gas and sealed-off at its open end inside the envelope to form a rigid strut whereby the envelope is extended into an ellipsoidal shape. As the envelope expands during ascent, it gradually reassumes a spherical shape. The envelope becomes essentially non-stressed at a level where the expanded diameter is equal to the length of the strut and, beyond this point, the balloon remains substantially spherical in shape until brusting altitude is reached.

The streamlined shape of the balloon may be maintained up to any given altitude by pre-selecting the length of the tube to correspond to the non-stressed, spherical shape normally assumed by the envelope at various levels during ascent. Depending upon the size of the balloon employed and its estimated minimum ceiling, it is preferred to select a tube length which will maintain the streamlined shape of the envelope at least through the zone of greatest drag coefficient occurring at altitudes of 50,000 to 60,000 feet. In order to achieve maximum vertical speeds with large capacity balloons, tubes having a length approximately equivalent to maximum envelope diameter may be used. For example, a tube selected to give a rigid strut 30 feet in length could be employed in the specific example above wherein the balloon would maintain a streamlined shape throughout a major part of its ascent.

The tube may be fabricated from inelastic, plastic films other than polyethylene, such as polypropylene and polyethylene terephthalate and may be formed by any suitable and convenient method such as blowing, extruding, and so forth.

Any of the expansible envelopes conventionally employed for meteorological balloon purposes may be used in the present invention, such as those prepared according to U.S. Patents 2,378,882 and 2,461,271.

Other advantages gained by using a gas-inflated plastic strut include protection against dislodgement during ascent and also against premature rupture and occurrence of weak areas in the balloon since the stress against the envelope is gentle and uniform. In addition, the plastic strut has a comparatively low weight and, therefore, does not require any appreciable increase in the amount of lifting gas needed for launching the balloon. Furthermore, the manufacture of the balloons of the present invention is relatively simple and straight-forward as well as economical since the elastomeric envelope may be any of the spherical and near-spherical types commonly employed for meteorological purposes.

I claim:

1. A meteorological balloon comprising an expansible spherical envelope having an inlet adapted to pass a predetermined amount of lifting gas into said envelope and an elongated inflatable inelastic tube dependently secured within said envelope in axial vertical alignment with said envelope inlet with the inflatable end of said tube initially and during a substantial portion of the ascent of said balloon in contact with said inlet.

2. A meteorological balloon according to claim 1 wherein said expansible spherical envelope consists of neoprene rubber.

3. A meteorological balloon according to claim 1 wherein said elongated inflatable inelastic tube consists of polyethylene film.

4. A meteorological balloon according to claim 1 wherein said envelope has a thickened portion provided with an aperture diametrically opposed to said envelope inlet.

5. A meteorological balloon comprising an inflated expansible envelope having an inlet adapted to pass a predetermined amount of lifting gas and an inflated elongated tube of inelastic film dependently secured within said envelope in axial vertical alignment with said envelope inlet and in contact therewith initially and during a substantial portion of the ascent of said balloon, said tube being of sufficient length and adequately pressurized to maintain said expansible envelope in the shape of a prolate spheroid throughout a portion of the balloon's ascent.

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