V. C. RICHMOND ET AL

CONSTRUCTION OF AIRSHIPS

Filed Dec. 15, 1927 3 Sheets-Sheet 1

FIG. 1.

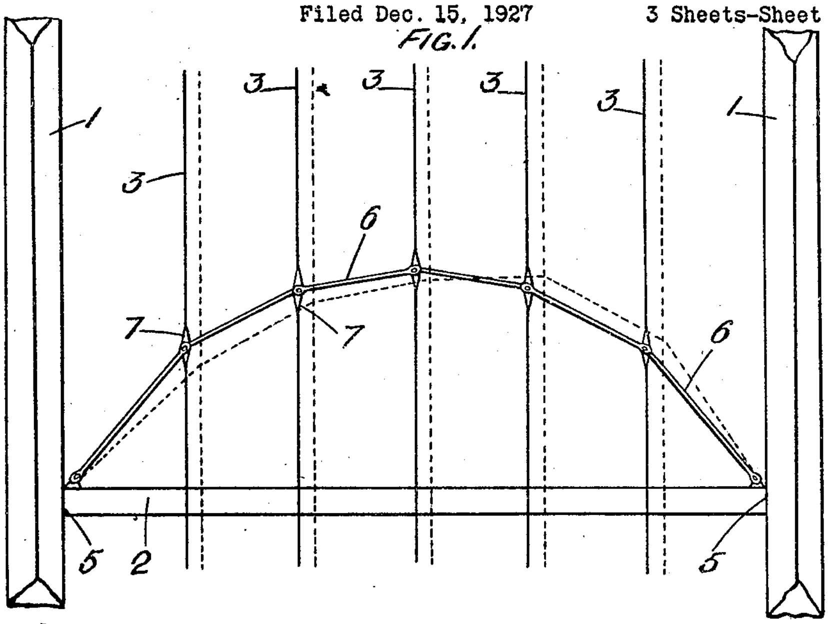


FIG. 5.

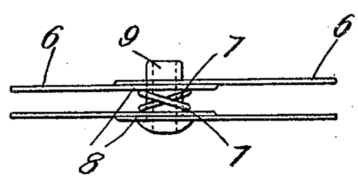
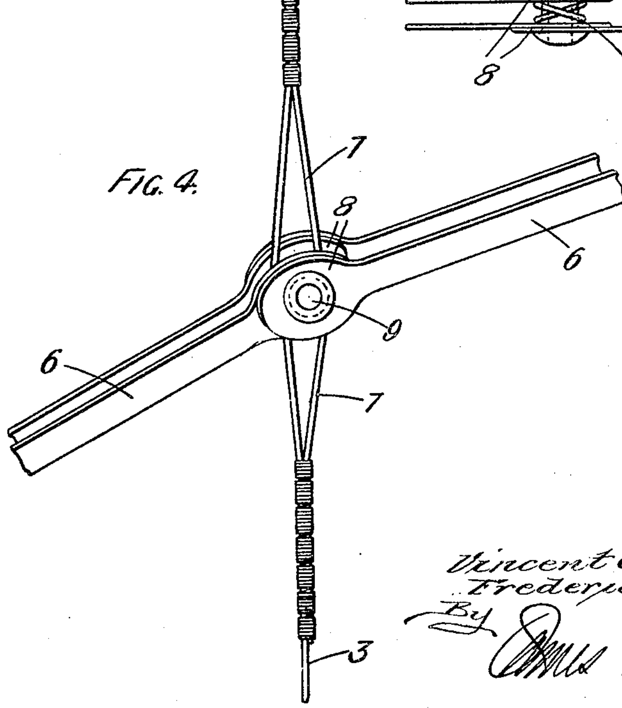


FIG. 4.



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Sept. 4, 1928. | V. C. RICHMOND ET AL | 1,683,490

CONSTRUCTION OF AIRSHIPS

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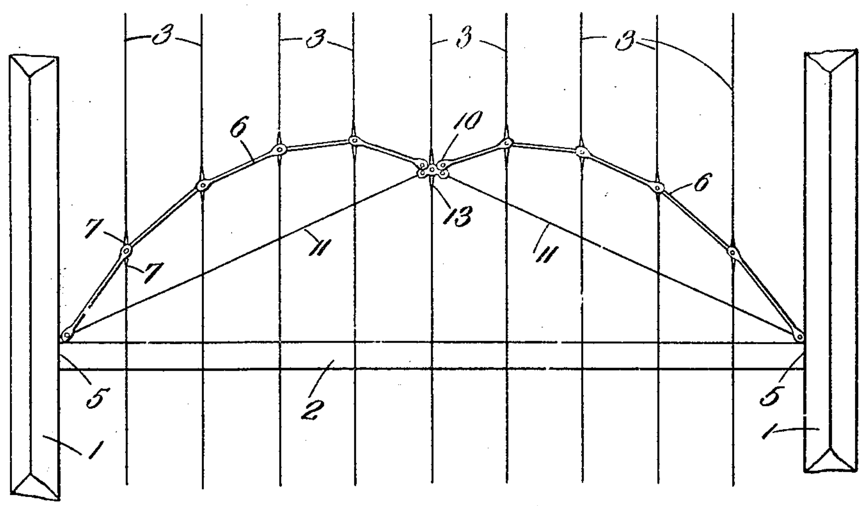
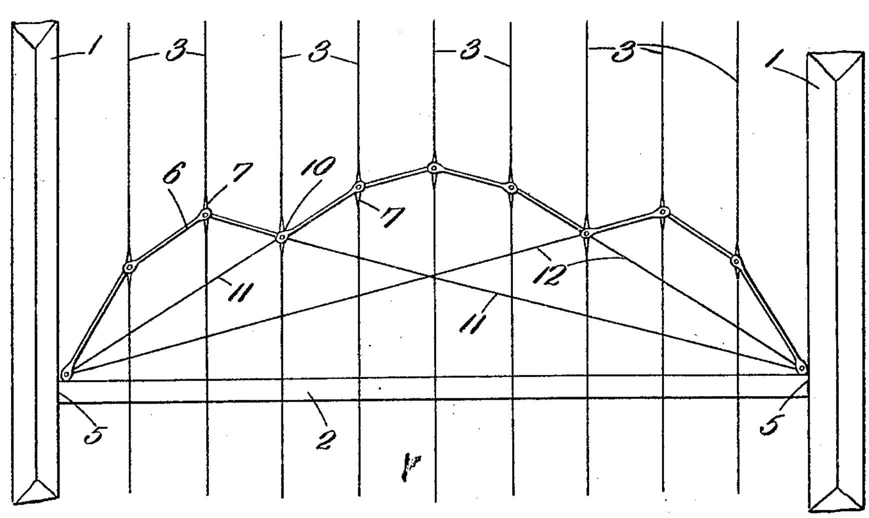


FIG. 2.

FIG. 3



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CONSTRUCTION OF AIRSHIPS

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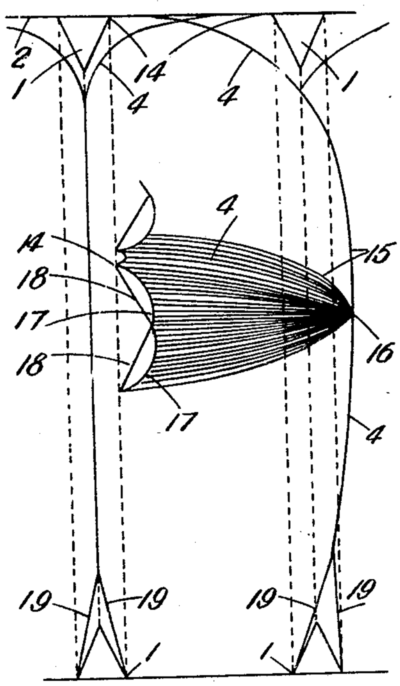

FIG. 7

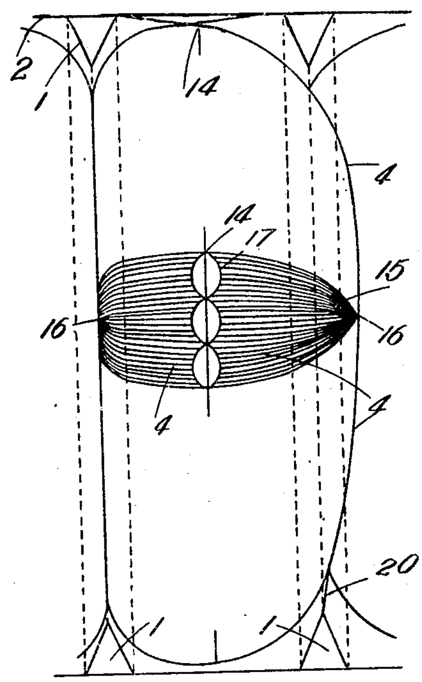

FIG. 8

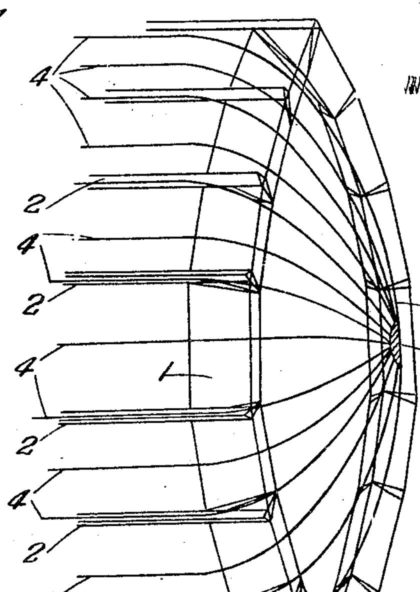

FIG. 6.

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Patented Sept. 4, 1928. **1,683,490**

UNITED STATES PATENT OFFICE.

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CONSTRUCTION OF AIRSHIPS.

Application filed December 15, 1927, Serial No. 240.302, and in Great Britain August 12, 1926.

This invention relates to improvements in the construction of rigid airships wherein the hull framework comprises transverse rings or frames (hereinafter referred to as rings) disposed across the axis of the airship and secured to longitudinal girders disposed parallel to the axis, the gas being carried in a number of separate bags or cells. The invention relates more particularly to a system or an arrangement of wires for supporting or restraining each gasbag or cell against the pressure of the gas, radially, tangentially and longitudinally of the airship, and for transmitting the resulting loads to anchor points on the framework.

The present invention comprises a system of wires or the like (hereinafter generally referred to as circumferential wires) lying in planes normal to the axis of the airship, for dealing with the radial and tangential forces due to the pressure of each gasbag, speaking relatively to the axis of the airship, with which may be used a system of wires or the like (hereinafter generally referred to as bulkhead wires) extending over, around or under the gasbag so as to more or less embrace it for dealing more particularly with the axial pressure of each gasbag speaking relatively to the axis of the airship.

The invention is illustrated diagrammatically and by way of example in the accompanying drawings, in which Fig. 1 is a plan showing part of the hull framework of a rigid airship fitted with a system of wires for taking the radial and tangential forces due to the pressure of a gasbag; Fig. 2 is a plan of a modification; Fig. 3 is a plan of another modification; Figs. 4 and 5 are respectively a perspective view and a plan of a detail; Fig. 6 is a perspective view showing part of the hull framework of a rigid airship fitted with a system of wires for taking the axial forces due to the pressure of a gasbag; Fig. 7 is a longitudinal sectional elevation of the arrangement shown in Fig. 6; and Fig. 8 is a longitudinal sectional elevation of a modification.

Like reference numerals indicate similar parts wherever repeated in the drawings.

The numeral 1 indicates transverse rings of the hull framework of a rigid airship, 2 indicates longitudinal girders, 3 are circumferential wires, and 4 are bulkhead wires.

In the system of wires or the like according to the present invention for taking the radial and tangential forces due to the pressure of each gasbag, as shown in Figs. 1 to 5, a number of wires 3 for restraining each gasbag extend circumferentially around the inner surface of the hull framework between consecutive transverse rings, the circumferential wires being secured by suitable means to the main joints 5 of the framework where the transverse rings and the longitudinal girders meet, so as to take the radial and tangential loading and transmit it to the main joints.

The circumferential wires may be secured to the main joints by being attached to a number of longitudinally arranged catenary or parabolic wires or chains 6 (hereinafter referred to as catenary chains), a separate catenary chain connecting each main joint 5 at each main transverse ring with the corresponding respective main joint 5 at the next main transverse ring or rings. The catenary chains bow in similar directions on opposite sides of the vertical plane of symmetry of the airship.

The catenary form of each chain 6 enables it to transmit the radial and tangential loading applied by the gasbag to the circumferential wires 3 to the main joints only.

The advantage of using a number of catenary chains is that the gasbag is restrained approximately to a cylindrical form in transverse section, and is kept from touching the longitudinal girders 2.

The circumferential wires may be discontinuous where they meet each catenary chain and provided with connecting eyes 7 at the ends of the wire lengths at such points. The catenary chains may also be discontinuous at such points and similarly provided with connecting eyes 8 at the ends of the catenary chain lengths. A bolt, pin or similar means 9 (Figs. 4 and 5) may be employed for connecting the two sets of eyes in the circumferential wire lengths and the catenary chain lengths at each junction. With this arrangement no slipping or other displacement of the wires and chains can take place.

The eyes 7 of the circumferential wire lengths may be crossed (as in Fig. 5) or otherwise formed or arranged at each junction, so that the load applied by the circumferential wire lengths to the joint pins 9 does not tend to tilt the pins and thereby twist the lengths of the catenary chains.

According to another feature of the invention, in order to prevent the catenary chains from being distorted by being bulged more acutely at one end than at the other (as shown by dotted lines in Fig. 1) when the airship is inclined or flying at an angle due to the lift of the gas still acting vertically under such conditions, each catenary chain may be located or positioned at one or more points 10 (Figs. 2 and 3) along its length, where it meets the circumferential wires, by means of one or more pairs of straight wires or rods 11 or 12 (hereinafter referred to as bridle rods). The bridle rods are connected at one end 10 with the catenary chains and at the other end with the main joints 5 of the hull framework and thus virtually divide the chain into a number of separate catenary chains, namely two in Fig. 2 and three in Fig. 3. At the junction where the circumferential wires, the catenary chains and the bridle rods meet, special junction pieces 13 (Fig. 2) may be provided having separate eyes for connection by joint pins or otherwise with eyes on the circumferential wires, the catenary chains and the bridle rods.

According to an alternative feature of the invention, each circumferential wire may be secured to the respective main joints of the hull framework by means of a pair of straight bridle rods (such as 11 or 12) connected at one end with the circumferential wire lengths at a joint 9 and at the other end with the main joints 5 of the hull framework.

In order to aid in locating the circumferential wires parallel to each other normal to the axis of the airship, longitudinal spacing wires arranged parallel to the axis of the airship may be employed.

The present arrangement of circumferential wires thus avoids increasing the strength of the longitudinal girders of the hull framework to resist any lateral loading by the internal gas pressure.

In the system of wires or the like according to the present invention, especially for taking the unbalanced axial pressure of each gasbag, when the pressure in neighbouring gasbags is unequal due to inclination of the airship, the deflation of one gasbag, or any other cause, as shown in Figs. 6 to 8 a number of wires 4 for restraining the gasbag are arranged as a slack bulkhead, each wire of each set of bulkhead wires being connected at one end 14, hereinafter called the point of origin, with the longitudinal girders 2 or the outer edge of the main transverse rings 1 or the equivalent at the respective bay, and at the other end 15 converging on a centre plate or fitting 16, not necessarily concentric with the longitudinal axis of the airship. The wires forming each bulkhead extend from their points of origin 14 approximately parallel to the longitudinal axis of the airship and then to the centre fitting 16, over, around or under the gasbag in the respective bay, so as to embrace it more or less. The points of origin of the bulkhead wires may be displaced longitudinally relatively to the centre of the gasbag (as in Fig. 7), or may be in the transverse plane containing the centre of the gasbag (as in Fig. 8).

Various methods of connecting the bulkhead wires with the framework of the hull may be employed; for example, a system of catenary wires or chains 17 connecting the wires 4 (which extend from the centre fitting 16 in the plane of one main transverse ring 1 at one end of the gasbag) to points 14 in the main transverse ring 1 at the other end of the gasbag, as shown in Fig. 7, or with points 14 in the longitudinal girders between these two rings (as shown in Fig. 8). Bridle rods 18 may be used with the catenary chains 17.

The bulkhead wires are slack so far as the hull structure is concerned, and are so arranged as to take tensions applied longitudinally and radially, there being no circumferential restriction of their movement, speaking relatively to the axis of the airship. The curvature of the bulkhead when pressure is exerted on one side only, is therefore, as shown at the right-hand end of Figs. 7 and 8, an elastica, i. e., a parachute form, slightly modified by reason of the variation of pressure of the gas from the bottom of the bag to the top. This form reduces the amount the bulkhead bulges in the extreme case of full pressure on one side and no pressure on the other side of the bulkhead, and reduces to a minimum the longitudinal displacement relative to the airship of the bulkhead between the balanced and the unbalanced conditions. At the left-hand end in Figs. 7 and 8, the bulkhead is shown flat where the two adjacent gasbags are full.

In order to reduce the distortion of the curvature from the elastica form, due to variation in the pressure between the top and the bottom of the gas bag, and also to transmit to the main transverse ring the lift of the gas carried in this portion of the bag, the wires 4 in the bottom section of the bulkhead may be carried direct to the main transverse ring 1, directly below the centre fitting of the bulkhead. These wires may be secured to the ring by running bridles 19 (Fig. 7) the arms of which lie in a fore and aft plane and straddle the cross section of the ring, so that as the configuration of the wires 4 changes, their tensions are transmitted to the ring in a manner which does not cause an undue local twisting action of the ring. Alternatively, tapping wires 20 (Fig. 8) may be carried from the bulkhead wires in the bottom section to the main transverse rings. In a modification these two arrangements may be used together or in combination.

The attachments of the bottom section of the bulkhead to the main transverse frame are so designed as regards position and length as to distribute the forces applied by these attachments to the transverse frame in such a manner as to balance forces which may act upon the transverse frame from other causes. For example, the lift in the portion of the gasbag constrained by the bulkhead is transmitted to the bottom part of the transverse ring where it is able to resist the downward forces due to the loads which are slung to the airship in this region, such as passenger cars, machinery cars, tanks for fuel and the like. Owing to this balance between upward and downward forces, the distorting actions which would otherwise occur in the transverse ring are considerably reduced. The present improvements are therefore particularly applicable for use with transverse rings of the type described in United States patent application Serial No. 745,464, which rings do not require taut transverse bracing to keep them stiff, and avoid the use, especially in airships of large diameter, of heavy transverse rings which otherwise would have to be used to resist the heavy compressive stresses in the peripheral members of the ring resulting from the pressure of the gasbags parallel to the axis of the airship on the taut bracing.

According to another feature of the invention, the wires in each bulkhead may be pulled by the tapping wires 20 into close proximity with the transverse ring.

In order to aid in locating the bulkhead wires with respect to one another, circumferential spacing wires or the like may be used.

Longitudinal wires may be fitted through the gasbags and connected together at the centre fitting in each slack bulkhead to provide the effect of a continuous axial wire from end to end of the airship for the purpose of further reducing the longitudinal displacement of the bulkheads.

An important advantage of the bukhead system is that the wires in each bulkhead are at no time slack, the bulkhead automatically offering progressive resistance to axial displacement, when the pressure difference between adjacent bays varies owing to the airship being inclined or from other causes. Further, the disadvantage is avoided of a slack bulkhead which is only stable in either of its extreme positions, so that, consequently, a small movement in pitch of the airship may cause the bulkhead to surge rapidly from one extreme position to the other.

Having thus described the nature of the said invention and the best means we know of carrying the same into practical effect, we claim:—

1. In a rigid airship wherein the hull framework is composed of transverse rings secured to longitudinal girders, a system of wires or the like for restraining each gasbag and for transmitting the resulting loads to anchor points on the hull framework comprising circumferential wires lying in planes normal to the axis of the airship for dealing with the radial and tangential forces due to the pressure of each gasbag, speaking relatively to the axis of the airship.

2. A gasbag restraining system as claimed in claim 1, wherein the circumferential wires extend around the inner surface of the hull framework between consecutive main transverse rings, and are secured by means of a catenary to the main joints of the hull framework where the main transverse rings and the longitudinal girders meet, so as to take the radial and tangential loading and transmit it to the main joints.

3. In a rigid airship wherein the hull framework is composed of transverse rings joined to longitudinal girders, a system of wires for restraining each gas bag and for transmitting the resulting loads to anchor points on the hull framework comprising circumferential wires extending around the inner surface of the hull framework between consecutive main transverse rings and lying in planes normal to the axis of the airship for dealing with the radial and tangential forces due to the pressure of each gas bag, speaking relatively to the axis of the airship, and a plurality of longitudinally arranged catenary chains each extending between the main joints of a longitudinal girder with a pair of consecutive transverse rings and connecting said joints to the circumferential wires lying between the respective pair of transverse rings.

4. A gasbag restraining system as claimed in claim 3, wherein the circumferential wires are discontinuous where they meet each catenary chain and are provided at such points with pin-jointed connecting eyes at the ends of the wire lengths.

5. A gasbag restraining system as claimed in claim 3, wherein the catenary chains are discontinuous where they meet each circumferential wire and are provided at such points with pin-jointed connecting eyes at the ends of the catenary chain lengths.

6. In a rigid airship wherein the hull framework is composed of transverse rings joined to longitudinal girders, a system of wires for restraining each gas bag and for transmitting the resulting loads to anchor points on the hull framework comprising circumferential wires extending around the inner surface of the hull framework between consecutive main transverse rings and lying

in planes normal to the axis of the airship for dealing with the radial and tangential forces due to the pressure of each gas bag, speaking relatively to the axis of the airship, a plurality of longitudinally arranged catenary chains each extending between the main joints of a longitudinal girder with a pair of consecutive transverse rings and connecting said joints to the circumferential wires lying between the respective pair of transverse rings, the circumferential wires each comprising separate sections extending between the meeting points of said wires and consecutive catenary chains and the catenary chains each comprising separate sections extending between the meeting points of the catenary chains with consecutive circumferential wires, said sections having eyes at said meeting points, and pins extending through and joining the eyes of the sections of the circumferential wires and the catenary chains at their meeting points, the eyes of the circumferential wires at said meeting points being crossed and thereby avoiding tendency of the joining pins to tilt and the catenary chains to twist.

7. A gas bag restraining system as claimed in claim 3, wherein each catenary chain is positioned at one or more points along its length, where it meets the circumferential wires, by means of a pair of bridle rods each connected at one end with the catenary chain and at the other end with a main joint of the hull framework.

8. In a rigid airship wherein the hull framework is composed of transverse rings joined to longitudinal girders, a system of wires for restraining each gas bag and for transmitting the resulting loads to anchor points on the hull framework comprising circumferential wires extending around the inner surface of the hull framework between consecutive main transverse rings and lying in planes normal to the axis of the airship for dealing with the radial and tangential forces due to the pressure of each gas bag, speaking relatively to the axis of the airship, a plurality of longitudinally arranged catenary chains each extending between the main joints of a longitudinal girder with a pair of consecutive transverse rings and connecting said joints to the circumferential wires lying between the respective pair of transverse rings, a pair of bridle rods for each of said catenary chains, each of said bridle rods having one end connected to the joint of one of the longitudinal girders with one of the transverse rings, and a junction piece at the meeting point of said bridle rods, catenary chains and circumferential wires and having separate eyes for connecting it with said bridle rods, catenary chains and circumferential wires.

9. A gasbag restraining system as claimed in claim 1, wherein each circumferential wire is secured to the respective main joints of the hull framework by means of straight bridle rods connected at one end with the circumferential wire ends at a joint and at the other end with the main joints of the hull framework.

10. A gasbag restraining system as claimed in claim 1, wherein longitudinal spacing wires are employed normal to the circumferential wires.

11. A gasbag restraining system as claimed in claim 1, comprising bulkhead wires for dealing more particularly with the axial pressure of each gasbag, speaking relatively to the axis of the airship, the bulkhead wires being arranged as a slack bulkhead, each set of bulkhead wires at the point of origin being connected with the outer edge of the main transverse rings or the like at one bay, at the other end converging on a centre fitting or the like, and between the ends extending over, around and under the gasbag so as more or less to embrace it.

12. In a rigid airship embodying a hull framework composed of longitudinal girders and main transverse rings secured thereto and providing gas bag bays between them, a gas bag restraining system for dealing particularly with the axial pressure of each gas bag with respect to the axis of the airship, comprising bulkhead wires arranged as a slack bulkhead, said wires at the point of origin being connected with the outer edge of the main transverse rings at one bay and converging at the axial center of the airship and having a fitting connecting them at said center, the portions of said wires between their ends extending over, around and under the gas bag so as more or less to embrace it, the bulkhead wires in the bottom section of the bulkhead being carried direct to the main transverse ring at a position below the center fitting of the bulkhead.

13. A gasbag restraining system as claimed in claim 12, wherein the wires in the bottom section of the bulkhead are secured to the main transverse ring at a position below the centre fitting of the bulkhead by running bridles, the arms of which lie in a fore and aft plane and straddle the cross section of the main transverse ring.

14. A gasbag restraining system as claimed in claim 12, wherein the wires in the bottom section of the bulkhead are secured to the main transverse ring at a position below the centre fitting of the bulkhead by tapping wires carried from the bulkhead wires to the main transverse ring.

15. A gasbag restraining system as claimed in claim 12, wherein each bulkhead wire is secured to a main transverse ring by a tapping wire.

16. A gasbag restraining system as claimed in claim 12, wherein spacing wires are employed in locating the bulkhead wires.

17. A gasbag restraining system as claimed in claim 1, wherein the bulkhead wires are connected with the framework of the hull by means of a system of catenary chains connecting the bulkhead wires, which extend from the centre fitting in the plane of one main transverse ring at one end of the gasbag to the main transverse ring at the other end of the gasbag.

In testimony whereof we have signed our names to this specification.

VINCENT CRANE RICHMOND.
FREDERICK MICHAEL ROPE.