June 10, 1930. R. H. UPSON 1,762,845

DIRIGIBLE

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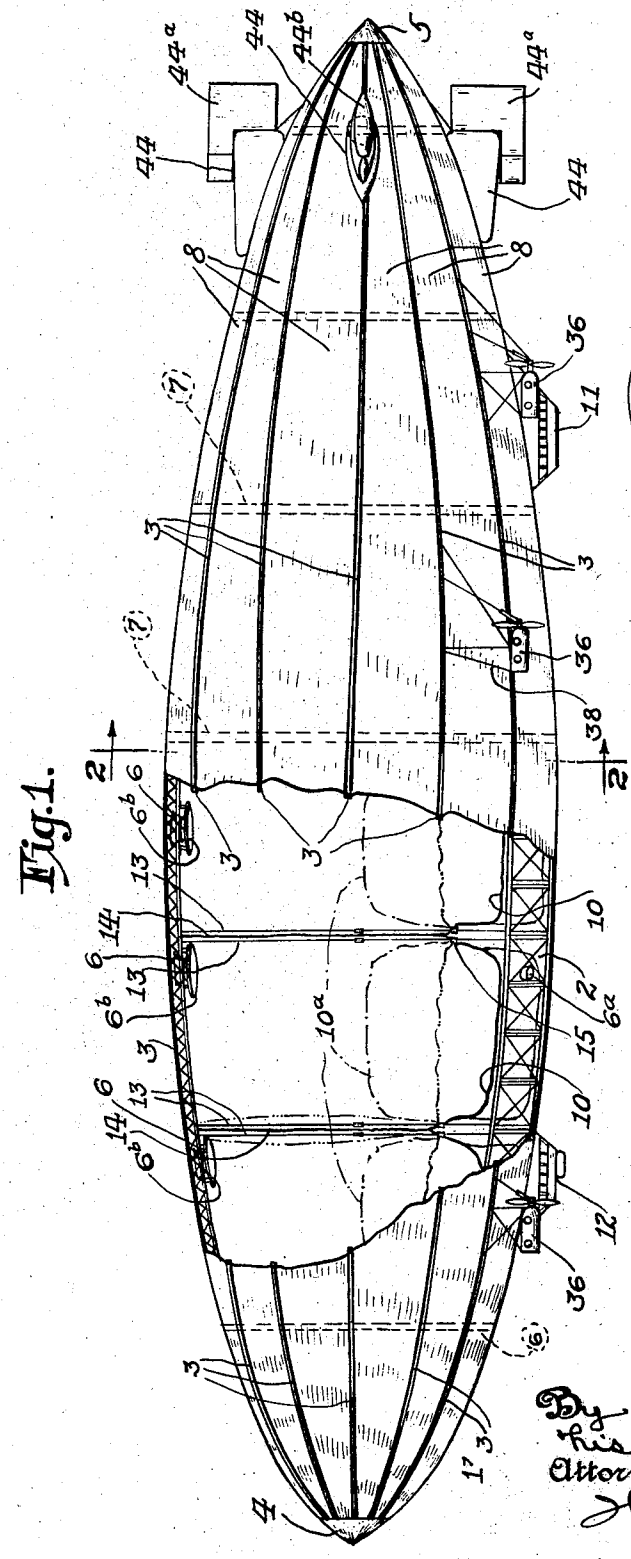


Fig. 1.

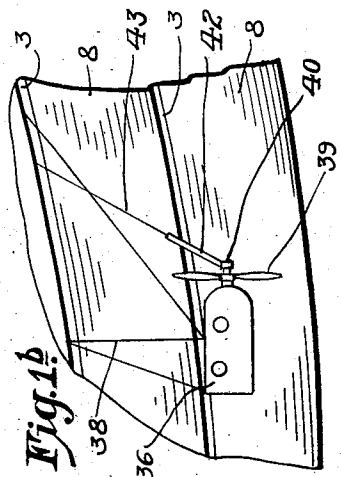


Fig. 1b.

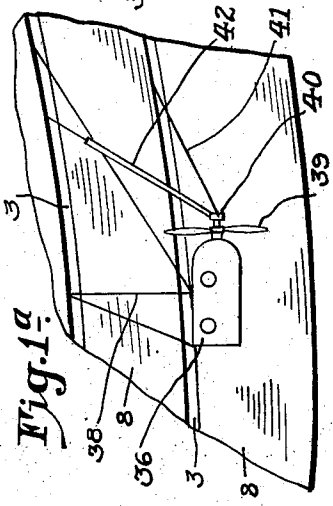


Fig. 1a.

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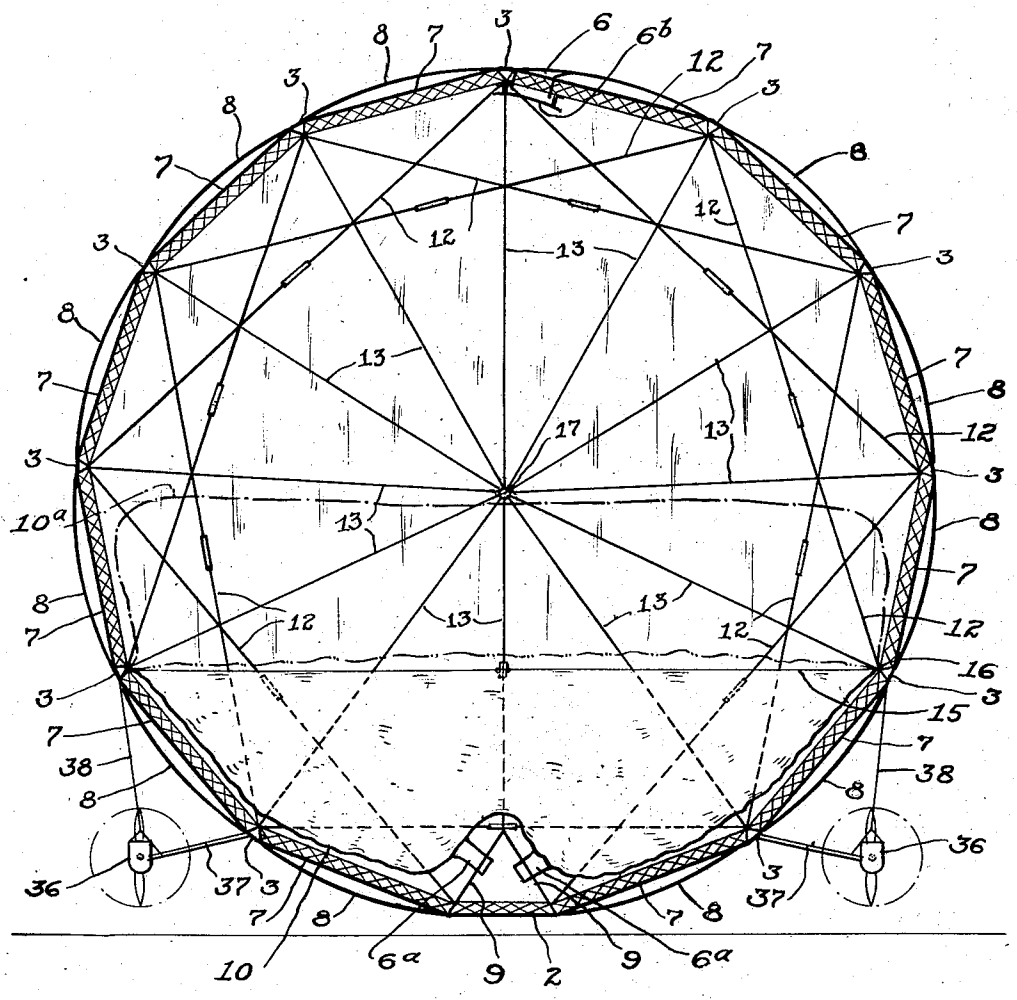
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Fig.2.



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Fig. 3.

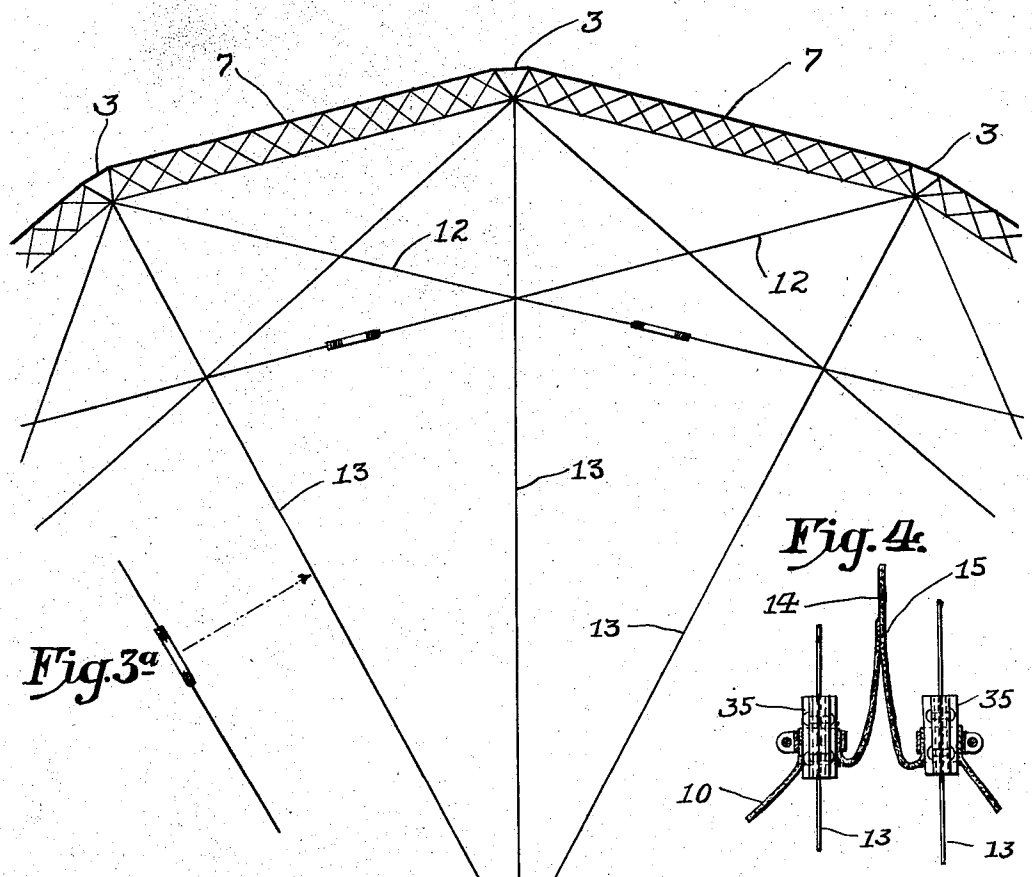


Fig. 3a

Fig. 4.

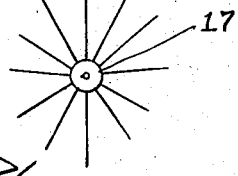


Fig. 6.

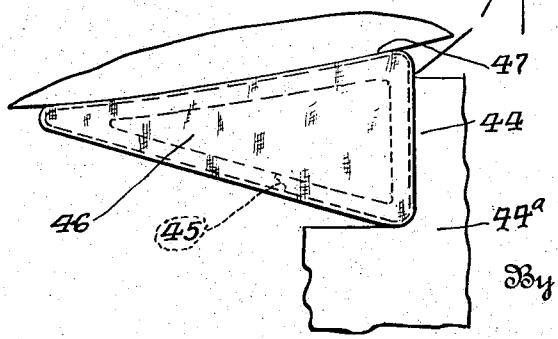
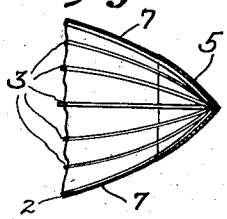


Fig. 5.



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Fig. 7.

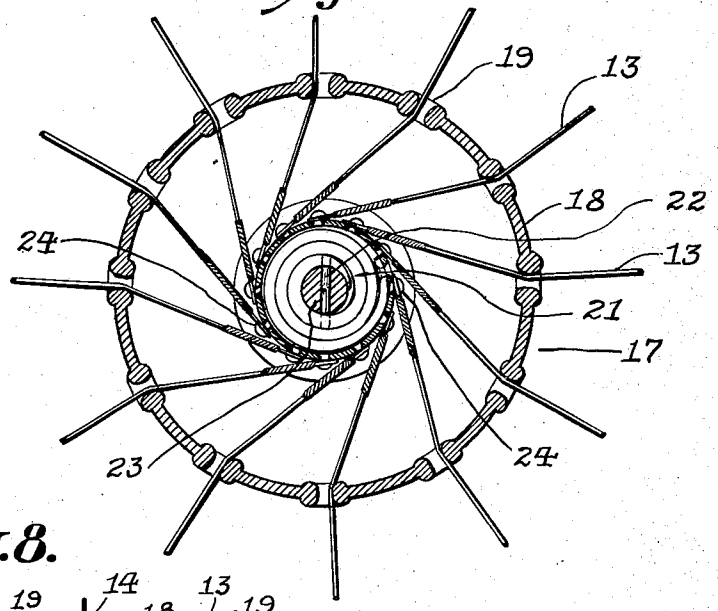


Fig. 8.

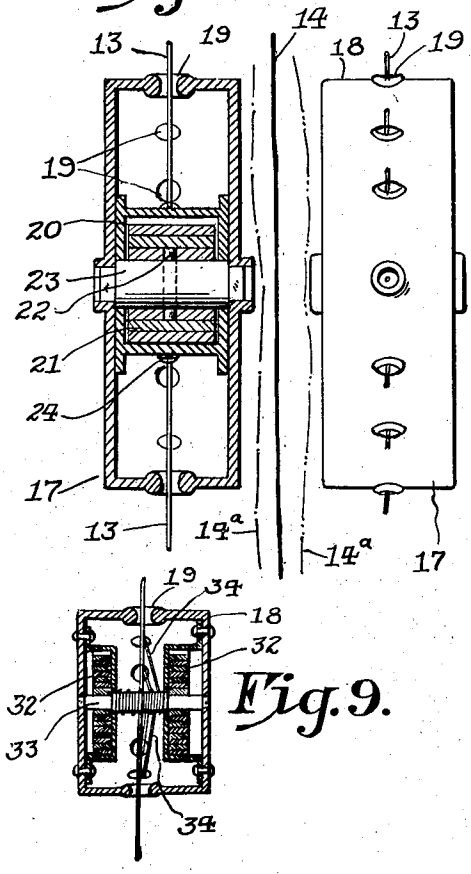


Fig. 9.

Fig. 10.

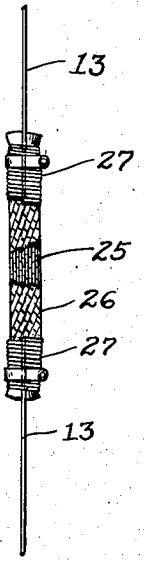


Fig. 11.

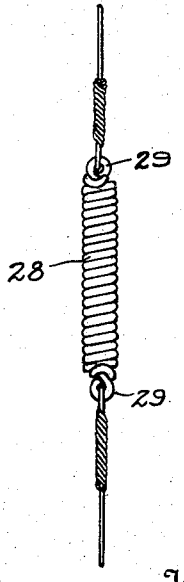
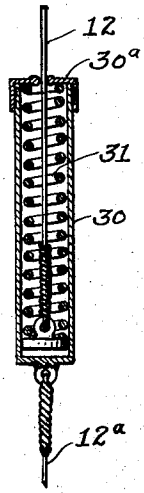


Fig. 11a.



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UNITED STATES PATENT OFFICE

RALPH H. UPSON, OF BROOKLYN, NEW YORK, ASSIGNOR TO AIRCRAFT DEVELOPMENT CORPORATION, OF DETROIT, MICHIGAN, A CORPORATION OF MICHIGAN

DIRIGIBLE

Application filed May 4, 1922. Serial No. 558,541.

This invention relates to airships which are commonly termed dirigibles, and involves the lighter-than-air craft with means of propulsion. More particularly it relates to the rigid type of lighter-than-air craft, and among the objects are the production of such craft which will be safer with respect to fire than constructions heretofore used, more durable under the variations of weather conditions, and to produce a ship of maximum strength and stability with minimum of weight and sailing resistance.

Of the various objects, features of construction to attain the same may be used independently, and such objects involve features of internal construction assuring facility of production, assembly and operation, providing for the accommodation throughout the structure of proper electrical conditions, advantages and adequate gas-holding properties, and certain features of advantage regarding motor support exterior to the hull, and various other features, the objects and advantages whereof will hereinafter appear from the detailed specification and the accompanying drawings.

While many or all of the features herein shown and described may be embodied in a single structure, I have illustrated in the accompanying drawings forming a part hereof a particular embodiment which I will now specifically describe with respect to the figures in which:

Fig. 1 is a side elevation with fragmentary vertical section. Fig. 1[a] is a fragmentary view, on enlarged scale, of gondola and propeller propulsion. Fig. 1[b] is a view similar to 1[a] with slight modifications.

Fig. 2 is a vertical cross-section on the line 2—2 of Fig. 1.

Fig. 3 is a vertical cross-section, fragmentary, showing a portion of Fig. 2 on enlarged scale. Fig. 3[a] is a section of a radial strain cable of alternate construction.

Fig. 4 is an enlarged detail view of connections between cable members and partition and diaphragms.

Fig. 5 is an enlarged view, fragmentary, of one end or nose.

Fig. 6 is a plan view of a fin.

Fig. 7 is a sectional view transverse to the axis of a yielding tension ring for radial cables.

Fig. 8 is an elevation showing two yielding cable strain rings, one in section, and intervening partition member.

Fig. 9 is a section on the axis of a yielding cable strain ring of modified form.

Fig. 10 is a detail side view of a cable member expansion section.

Fig. 11 is a modified form of cable expansion member. Fig. 11[a] is a modified form of cable extension member of the type shown in Fig. 11.

The dirigible as illustrated embodying my invention, consists of an elongated cigar shape envelope, with stiff, substantially longitudinal rigid members or ribs which may extend from end-to-end, and with circumferential truss members intermediate the longitudinal stiff members, with the space between the stiff members covered by thin sheet metal, to form the envelope to hold the supporting gas in the dirigible. Inside the space is divided into a series of transverse sections by transverse partitions, and each section or compartment has at the bottom a ballonet formed by a substantially horizontal diaphragm adapted to yield with variation of gas content or with the expansion and contraction. Internal tackle or lacing between the structural members is so arranged and constructed that pressure differences between adjacent compartments in the direction longitudinal of the ship, will be accommodated and suitably resisted in order to preserve the separate gas compartment intact.

In order to meet the contingencies of construction and operation, various details of arrangement and construction with reference to the tackle or cables, the motive power suspension, fin and other arrangements, are, to an extent, advantageous or essential. When separate transverse gas compartments are involved, leakage or depletion of one compartment results in a great lateral strain on the adjacent compartment which involves the separating partition, and therefore the internal bracing or tackle of the hull, which in

turn involves various general features and details which will herein be more fully set forth.

The envelope 1 is built up from the keel or corridor girder 2 running longitudinally of the ship. At intervals, preferably uniform, on either side and the top are longitudinal girders 3 reaching substantially from end-to-end and suitably secured in the nose cap 4 or tail cap 5. A series of circumferential girder structures consist of the trusses 7—7—7 secured to the longitudinal girders 3—3, and with the assembly of these longitudinal and circumferential members the complete frame work is provided as a substantially rigid unit to form the foundation of the airship hull.

The outer side of girders 3 is preferably made of a broad plate member, thus providing longitudinal bands of plate, to the edges of which are attached thin sheets of metal which while flexible owing to the thin gauge, are made of very strong material and provide ample resistance for internal gas pressure, external wind pressure and general shearing stresses in the structure. These sheets of thin metal are secured to the edges of the girder plate by a gas and air-tight seam which may be such as shown and described in my copending application for patent serial number 547,598, or any suitable gastight joint. Likewise the adjoining sheets are secured together by a gas-tight seam in case of joints located intermediate the stiff longitudinal or circumferential members.

Thus the very thin sheets of metal joined with the plates forming the stiff members of the hull frame, constitute an entire metallic envelope on the outside of the hull which may completely surround the hull. This envelope may extend from one edge of the corridor girder 2 around the hull to the other edge. In any case the ballonet or the air space below the gas space, in cooperation with the diaphragm 10, is subject to regulation by suitable blowers or breather holes in order that the varying quantity or pressure of the gas may be properly compensated for during manipulation of dirigible under ordinary or extraordinary conditions. The keel 2 is preferably formed much larger than other longitudinal members in order to provide a corridor or companion-way from end-to-end of the ship, and establish communication between the different gondolas 11—12 and to provide for storage and communication to the motor equipment and generally for the crew or occupants' use.

With the longitudinal members 3 and the circumferential trusses 7 forming the predetermined exterior contour of the ship, the strains incident to operation, as well as assembly, are taken up principally by internal tackle, such as transverse members 12—12 running from junction joints of the circumferential girders, while some obliquely longitudinal members may in certain constructions be provided. In order to most effectually maintain the circular, or similar predetermined form of the circumferential girder system, a plurality of radial cables 13—13 are provided, and in the preferred form there are two sets or series of these, parallel and close together on opposite sides of a flexible partition 14 formed of gas impervious fabric in order to constitute a partition wall and divide the interior of the hull transversely into a series of compartments. When so arranged the bottom of each compartment has a diaphragm 10 substantially horizontal which may dilate or swell into the position 10^a in order to displace gas in its compartment. Such diaphragm is secured at its forward and after edge by seam 15 to the partition wall 14 and horizontally along the inner side of the envelope it is secured by seam 16, with sufficient surplus material in the diaphragm to permit its inflation and deflation to the predetermined extent required. Under the diaphragm the space between it and the lower section of the metallic envelope, forms the ballonet which may be inflated or deflated in conjunction with the valves or openings usually provided for meeting the contingencies of operating ballonets.

The system of radial tackle 13—13 may be secured at the hub to a ring which, as shown in Figs. 7 and 8, is a specially constructed tension ring which provides for the limited amount of yielding in the length of the cables 13—13 when under a predetermined excess of tension. This tension ring includes the outer drum 18 with a plurality of holes 19—19 through which cables 13—13 pass with a rounded ring edge to form a smooth guide for the cables and provide a gradual bend to permit movement and to prevent breakage. The inner ends of these cables are attached to a drum 20 which is secured by a spring 21, by means of a pin or like device, to a shaft 23 secured against rotation in the sides of the drum 18. The tension of spring 21 thus provides a resistance against tangential strains at the points of attachment 24—24 of the cable ends on the drum 20, the tension being such as to resist the ordinary strains in cables 13—13, but to yield slightly with excessive strain, but when so yielding to provide a uniform yielding of all of the cables attached to one particular stress ring.

Thus the partition 14, as shown in Fig. 8, has on either side a separate system of radial cables, and should the gas compartment on one side of the partition 14 be deflated or should its pressure become materially out of balance with the gas pressure on the other side, the compartment having the major pressure will cause a bulging of the partition 14 to press against the radial cables and the tension ring and produce excessive strains. By providing for yield under these extraor-

dinary conditions the liability to break the radial cables is minimized, and it also prevents the transfer of extraordinary strains to the circular girder structure.

To accommodate such excess strains there may also be included a yielding tension member, as shown in Fig. 3ª, at a suitable point in the radial cables 13—13, this tension member being shown in a larger scale in Fig. 10 as comprising a bundle of rubber strips 25, with a casing 26 and whipped ends 27—27, with clamps or other suitable means adapted to secure the approximate ends of the cable 13. In some cases, a spring, such as 28, with eyes 29, serves as a yielding member, with preferably an outside leather casing to prevent the chance of pinching or abrading the adjacent partition wall or any fabric involved in diaphragm or partition. As shown in Fig. 11ª, such an expansion section for cable may be made with the outer casing 30 and coil spring 31 with the cable end 12 passing through the spring 31, while the opposite cable end 12ª is secured to the casing 30 and engages by the cap 30ª the opposite end of the spring 31, so that the functioning of the expansion member involves spring compression to an extent that may be limited by the size and pitch of the spring to meet the particular requirements. Such expansion members may also be embodied in the tie cables 12—12 to meet similar conditions of excess pressure. In the form of expansion ring shown in Fig. 9, the casing 18 has two springs 32—32 attached inside, with one end secured to the side of the casing 18 and the other end secured to the shaft 33 and with the inner ends 34—34 of the cables 13—13 fastened to the shaft 33 and wound about the shaft to a sufficient extent to permit unwinding with the yielding of the springs 32—32 when subjected to the excess pressure above explained.

As the diaphragm 10 is secured by a gas-tight seal at 15 to the partition 14, a limited amount of slack is desirable to provide for relative movement of the diaphragm with respect to the radial cables 13, 13, and as shown in Fig. 4 these cables pass through the diaphragm 10 and are accommodated by gas-tight joints, such as 35—35, which may slide up and down on cables 13—13 without loss of gas above or without leakage of air from the ballonet space below the diaphragm. Or as an alternative I may put a certain surplus of fabric around the gas-tight joints.

While I have shown the partitions comprising one gas-tight partition wall with a series of radial cables on each side thereof, but a single series of cables may be used with a separate gas-tight partition on each side. The latter would involve double the weight of partition walls, and for these and other reasons might not in certain constructions have all the advantages incident to the arrangement shown in Fig. 1.

The motor gondolas 36—36 are secured outside of the rigid frame members by lateral truss members 37 and suspenders 38, and other suitable cable supports. To transmit the driving force of propellers 39 an end bearing 40 may be provided with a strain cable 41 and a strut 42 partly stiff and partly a cable section 43. These latter serve to transmit the propelling force of the motors to points of attachment of the frame best adapted to distribute the propelling strain throughout the structure and give rigidity of connection between the motor gondolas and the hull of the ship. The strut 42 is provided to prevent any tendency of the bearing 40 to turn with the propeller shaft.

The horizontal and vertical fins 44 may be variously shaped, and as shown in Fig. 6 I prefer to make them of a frame 45 completely covered by fabric 46, thereby providing a stiff structure and smooth outside surfaces presented by the enclosing fabric cover, while the frame also serves to connect the fin as at 47, with a rigid part of the surface structure of the hull. As shown, such fins support the rudders 44ª or the elevator 44ᵇ hinged to one side of the fin, the rigid frame member providing facility for this, and the thickness of the fin being the same as the rudder at their junction. Having the rigid fin frame covered by flexible material, the impact of the wind on one side at a time, depresses that side providing a concave surface.

With suitable flexible material this concave surface may vary with the degree of wind pressure, but in no case is the efficiency as an aerofoil greatly decreased by the concave deformation of the windward surface. The form that this surface takes under such pressure is dependent upon the shape of the frame and the material and its method of attachment. Some advantages are involved when using a single thickness of fabric with its opposite surfaces deforming in common. With fins of substantial thickness both sides are formed of separate sheets of fabric or other suitable flexible material, which are preferably interconnected so that their respective outside surfaces will be deformed substantially in parallel by the air pressure on the windward side.

At either end the nose 4 or the stern cap 5 may be made of sheet metal of the desired shape, and in view of the metal structure with members 3—3 and the end of the corridor truss 2, such end cap, as 5 in Fig. 5, provides the end of permanent shape well adapted structurally to connect up the members and form a desirable surface structure in conjunction with the trusses and the metallic sheathing.

It will thus be seen that the entire structure presents a rigid dirigible in which all major strains are accommodated by stiff members, while the gas pressure strain is

primarily resisted by thin metallic sheathing forming a single outside metallic envelope with the only exception that joints or seams may be covered and rough metallic connections may be protected by fabric or rubber sheathing for mechanical or electrical reasons. With the metallic gas envelope and the arrangement of internal strain resisting members, or interior tackle, provision is made for a series of non-collapsible compartments, by partitions peculiarly well suited to withstand normal and as well as abnormal conditions of operation. If one partition is ruptured it will not actually deflate, but the loss of buoyancy will be confined to that one compartment, still leaving the other compartments to perform their full functions.

While the above description relates principally to the structure, the arrangement of compartments is such that the inflation of the dirigible may involve novel features. With fixed sheathing around the sides and top, and partitions fixed in place by the attachment of their periphery, although yieldable and flexible, the gas-containing compartments cannot be deflated like a balloon. Therefore as shown, the inflation of the compartments is preferably accomplished by admitting gas through apertures such as 6—6 and allowing the air to flow out at the bottom through apertures such as 6^a—6^a, at or close to the lowest point in the diaphragm. The gas supply entering through opening 6 with suitable closing means, strikes the mushroom deflector 6^b which causes it to spread around the highest portion of the compartment and gradually displace the air in the compartment with the minimum chance of the inrushing gas mixing with the air. With the gas inlet at the highest point and the air inlet at the lowest point, inflation is effected and the gas valve and air outlet pipe then closed, after which the diaphragm is ready to serve its purpose in forming the ballonet, namely, with suitable controlled means to vary the air pressure below the gas and at the bottom of the hull.

With the various features of construction shown and herein described in detail, particular conditions arising in the structure are met to advantage in order to cooperate in completing a structurally serviceable metallic dirigible, or one in which the outer shell provides the complete envelope in conjunction with the stiffening girders of the hull frame. For the gas envelope, the metallic sheathing surrounds the top of the ship running down each side as far as desired, and in conjunction with the diaphragm on the inside, the complete enclosure of the gas space of the compartments is effected. The ballonet in the bottom, formed by the diaphragm and the sheathing around the lower portion of the ship, may have the complete outer metallic sheathing, or this may be modified in form and arrangement, while longitudinal and other girders and tackle, form a complete rigid structure. Likewise the corridor girder may have airtight sheathing on its sides or may be surrounded by airtight partitions providing open or usable space at the very bottom of the hull.

Some of the features herein shown and described may be independently used or used in combination, and may be modified to produce the same effect and gain the same or similar advantages. In various ways the inflation and deflation may involve modifications, and in the practice of my invention features may be variously modified to accomplish the novel results, as set forth in the description of the specific embodiment of my invention herein shown and described.

While various modifications may be made without departing from the spirit of my invention, what I claim and desire to secure by Letters Patent is:

1. In an airship, metallic sheathing forming an envelope and hull sheathing in one adapted to resist buoyant gas pressure from within extending completely over the lift-resisting area of the hull, a plurality of stiff meridian girders convexly curved throughout and spaced at frequent intervals from the top down both sides and having integral connections with the sheet metal envelope, a plurality of stiff tranverse circumferential ribs interconnecting the meridian girders and rigidly spacing the same, an inlet valve at the top of the ship, a ballonet diaphragm outlet valve positioned at a low point in the diaphragm when the ballonet is not inflated, cooperating with said metallic envelope whereby inside and outside air pressure on the sheathing is balanced before inflation, and whereby the internal gas pressure during operation can be varied to approximately balance the aerodynamic pressure in flight.

2. An airship comprising a plurality of stiff meridian girders convexly curved throughout and distributed from the top down both sides throughout the lift-resisting area of the air ship hull, a series of transverse circumferential frames interconnecting the longitudinal girders and permanently spacing the same, internal tackle each in one of the planes of a plurality of transverse frames interconnecting the different parts of its circumferential members, a thin metallic sheathing interconnecting the meridian girders and constituting therewith a complete gas-tight and shear-stress resisting metallic skin and lift-resisting enevelope, a plurality of partitions extending from said skin in the lift section, adjacent the transverse frame tackle and connected with the ballonet diaphragms, ballonet diaphragms in the lower half of said ship providing a ballonet of a minor capacity compared with the buoyant gas space, and means for permitting the exit of air at a low

point of such diaphragms upon the admission of buoyant gas at the top of the ship.

3. An airship comprising a plurality of transverse separated buoyant gas compartments formed by transverse yielding partitions, and a contiguous metal sheathing forming a gas-tight envelope and ship skin combined extending throughout the area of lift-pressure of the envelope, a plurality of stiff convex longitudinal members extending the length of the ship in rigid cooperation with the metallic sheathing and spaced apart from the top down both sides throughout the lift-resisting area of the envelope, circumferential transverse stiff members rigidly secured to the longitudinal members to space the same, and transverse tackle members lying in the plane of said transverse circularly stiff circumferential members to coperate with the flexible partitions when in abnormal distention.

4. A rigid airship comprising a plurality of compartments, stiff circumferential transverse frames forming brace members between meridian stiff girders associated with the outside surface of the ship, thin metallic plating connected therewith and forming the outer surface and the gas-tight envelope over the left portion of each compartment, a substantially vertical transverse flexible partition having gas-tight connection to the metallic envelope throughout the lift-resisting or gas-contacting area thereof, a flexible horizontal diaphragm in the lower portion of each compartment sealed throughout against ingress of air from below except for a downwardly outflow valve and automatically subject to displacement by the gas above and confined by the metallic ship skin.

5. In a dirigible a transverse partition flexible and sealed at its periphery to the hull skin, a circumferential stiff structure, a set of interior transverse reenforcements in close proximity to said partition and means whereby limited flexiblity of said partition is permitted without yeld in the circumferential stiff structure.

6. An airship comprising a corridor keel truss, a plurality of longitudinal trusses spaced around the hull with outwardly facing chord members, a plurality of braces in transverse planes between said longitudinal members, thin sheet metal plates secured intermediate the plates of the longitudinal members and to circumferential stiff ribs adapted to give in cooperation therewith a complete rigid hull structure with gastight seams connecting said plates whereby a complete metallic stress-resisting and gas-enclosing hull skin is provided.

7. An airship having a complete metallic hull skin forming at the same time the envelope for buoyant gas and to resist ballonet air pressure, a ballonet, a corridor truss in the lower portion of said hull and a plurality of substantially circular trusses rigidly associated each extending from the sides of the corridor truss around the hull transverse of the ship, said corridor truss extending on a meridian of the hull and having the airtight fairing coincident with the outer faces of said corridor truss forming with the hull skin adjacent the corridor the outside pressure-resisting wall of the ballonet.

8. In a rigid dirigible a plurality of compartments flexible transverse partition walls, a metallic outer envelope cooperating to provide rigidity, flexible ballonet diaphragms for the lower portion of adjacent compartments connected to and flexibly yiedable with the common partition wall of adjacent compartments, an opening in the flexible part of said diaphragm adapted to drop to the lowest level of the compartment and means for preventing ingress of air when the movement of said diaphragm is subject to automatic response of the buoyant gas pressure.

9. In a rigid airship, a plurality of spaced substantially circular frames adjacent the hull skin of nondeformable construction, a hull skin gas envelope between frames resisting radial buoyant pressure, a transverse flexible gas partition generally parallel and close to the same transverse plane of the frame, a plurality of guys interconnecting different points of said frame forming a cross-tackle generally in the plane of the frame and means in said tackle to permit uniform stretching without deforming the circumferential frame, whereby lateral bulging of the flexible partition is accommodated by bulging of the cross-tackle to a predetermined limit at which it provides positive resistance to the flexible partition.

10. In a dirigible a transverse flexible gas partition, a series of radial tackle members in cooperating proximity thereto and supported from a rigid substantially circular frame of the gas envelope, a central ring attaching means for said radial members and means associated with said ring to permit uniform stretching of said radial members upon the lateral strain exceeding a predetermined limit.

11. A rigid airship having a metallic hull skin with gas-tight joints to make the skin serve as the envelope, a plurality of partitions secured to the inner side of the ship's skin, expansible braces extending transverse the hull adjacent each side of said flexible partitions and means to limit the extension of said braces under predetermined excess strain.

12. A rigid airship having a metal outer envelope and hull fairing transverse frames connected to said hull skin, a plurality of gas compartments formed by transverse flexible partitions each secured to the ship's skin, brace wires extending in planes adjacent and on opposite sides of a flexible partition and

having means to permit a limited yield of said braces with lateral bulge of the flexible partitions in either direction.

13. In a dirigible a motor gondola, suspension and strut members securing the same in predetermined off-hull and longitudinal support exterior to the hull or envelope, a propeller, an out-board bearing beyond the propeller and a torque-resisting strut connecting said out-board bearing with the hull of the ship and a diagonal brace to resist movement of said bearing longitudinally of said ship.

14. In an airship, a power car and means of suspension from the hull, including off-hull spacing struts and means to resist longitudinal movement relative to the hull, a propeller at one end of said car, a collar-bearing associated with the out-board end of the propeller hub suspension members, and means of attachment to said collar-bearing leading therefrom and to the hull obliquely away from the car and connected and positioned to resist strains in the working direction of the propeller.

15. In a dirigible an aerofoil projecting outward from the hull surface consisting of a complete rigid frame, flexible material enclosing both sides of the frame and spanning without interior support the space surrounded by the rigid frame and providing two opposite spaced surfaces capable of common deformation, with varying concave and convex contour respectively under air pressure.

16. A variable camber fin or aerofoil surface consisting of a rigid outer frame with a flexible material providing an intervening unsupported surface on each side of the frame throughout the area within the periphery of the frame, whereby a uniform concave deformation on either side is automatically provided with like oblique air current on the respective side.

17. A fin or aerofoil for dirigibles comprising a rigid frame, means to attach the same to the outer side of the dirigible hull, flexible material providing two oppositely facing wind-resisting surfaces each yielding in conformity to wind pressure on said surface and secured to and covering the entire surface surrounded by the frame sides and supported by means whereby the flexibility of the material will automatically provide a concave surface on the windward side and a convex surface on the leeward side of the fin with a fixed rigid periphery.

18. In a dirigible, a plurality of gas compartments, a gas filling valve and a deflector plate adjacent the uppermost part of the compartment, a flexible diaphragm sealing the lower portion of each compartment and an air valve in said diaphragm.

19. A rigid airship comprising a plurality of substantially circular transverse frames, metallic sheathing secured to said frames and forming both the gas envelope and sole lift-resisting surface and the outer ship's skin and interconnecting the transverse frames to resist shear stresses of the hull and internal flexible means including a ballonet diaphragm having a valve opening whereby the rigid hull sheathing will have balanced inside and outside pressure when inflated and when not inflated.

20. A rigid airship comprising a series of transverse circumferential frames, a plurality of longitudinal trusses following the meridian lines of the hull and interconnecting the transverse frames, a metal sheathing rigidly secured to the transverse frames and the longitudinal trusses and forming both the outer hull sheathing and the buoyant-gas-retaining envelope and resisting shear stresses in the hull, a valve at the top level of the rigid sheathing for buoyant gas admission, a generally horizontal diaphragm forming a flexible partition between a lower ballonet space and gas space and valved whereby inflation with gas is permitted and no vacuum is created to cause deformation stresses on the rigid hull sheathing when not inflated.

21. An airship comprising a hull consisting throughout the gas-resisting lift-pressure area of thin metallic sheathing, longitudinal stiffening ribs secured to said sheathing and convexly curved throughout the middle portion of the ship, transverse stiffening members rigidly interconnecting the longitudinal ribs to maintain a substantially circular section, a ballonet diaphragm separating the lower portion of the stiff metallic hull and cooperating valves in the diaphragm and in the top portion of the metallic sheathing whereby the pressure on the sheathing before inflation of the ship is balanced inside and out, and after inflation the pressure due to the ballonet can be varied generally in proportion to the aerodynamic pressure in flight on the outside of the metallic sheathing to prevent rupture of the hull skin structure.

22. An airship having throughout its central portion a metal sheathing of substantially circular cross-section and convex in the axial direction of the ship throughout the major portion from the middle toward both ends, a plurality of longitudinal stiffening members secured to the inner surface of the sheathing and a plurality of transverse members rigidly spacing said longitudinal members to provide with them and with the sheathing a complete rigid hull with a non-deformable roof or lift area of envelope integral with the hull skin, gas-tight connections between the sheathing plates throughout the area resisting the internal pressure of the buoyant gas, and a diaphragm separating a ballonet space from the gas space in said non-deformable roof shell, with valving means cooperating with valving means near the top of said shell, whereby aerostatic balanced

pressure may be secured on both sides of the shell in flight to the extent of preventing rupture of the metal sheathing, and whereby air pressure on the outside may be balanced from the inside of the shell when the ship is not inflated.

23. An airship consisting of a stiff envelope formed of thin sheet metal plates rigidly connected and gas-tight forming the essential element of a rigid non-deformable structure wherein the envelope also constitutes the outside pressure and weather-resisting ship skin, in combination with a substantially horizontal flexible diaphragm extending through part of the lower portion of the ship hull and with gas-tight connection to the sheet metal envelope, and means to automatically resist any excess pressure from the outside with increased internal pressure and to automatically release excess internal pressure and prevent any degree of deformation of the thin sheet metal plate that would cause their rupture.

24. An airship consisting essentially of framing united with a contiguous metal gas-tight envelope and hull skin combined and together forming a rigid structure and the sole buoyant gas container, with a movable flexible diaphragm throughout part of the lower portion of the ship of a minor capacity of the total envelope, and valving connections cooperating with the diaphragm and the rigid shell to relieve excess external or internal pressures beyond the strength of the rigid hull or the metal envelope and skin.

In testimony whereof, I have signed my name to this application, this 15th day of April, 1922.

RALPH H. UPSON.