April 5 1932. J. H. TYLER 1,852,987

DIRIGIBLE AIRSHIP

Filed June 30, 1931 3 Sheets-Sheet 1

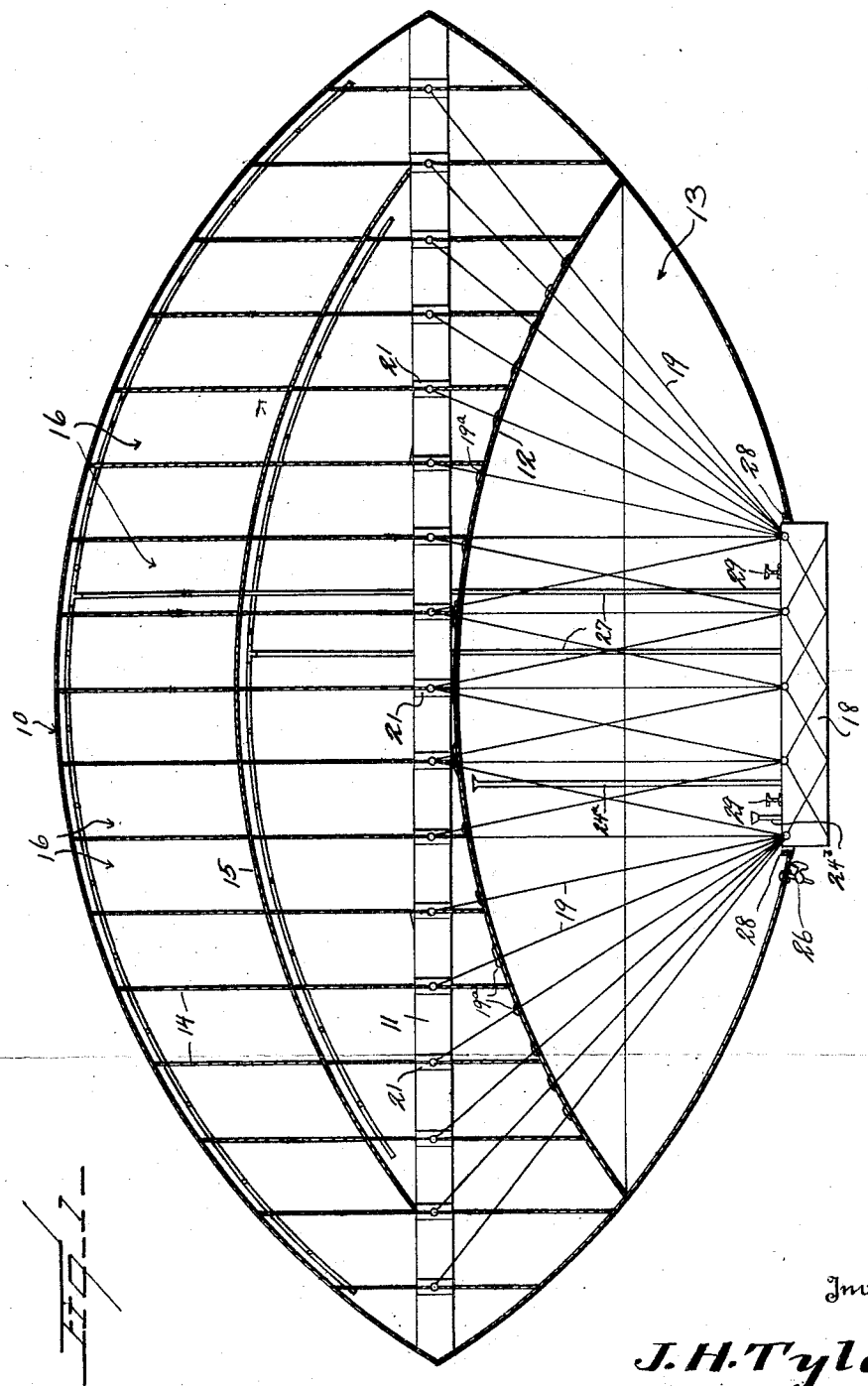

Fig. 1

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April 5 1932. J. H. TYLER 1,852,987

DIRIGIBLE AIRSHIP

Filed June 30, 1931 3 Sheets-Sheet 2

Fig. 2.

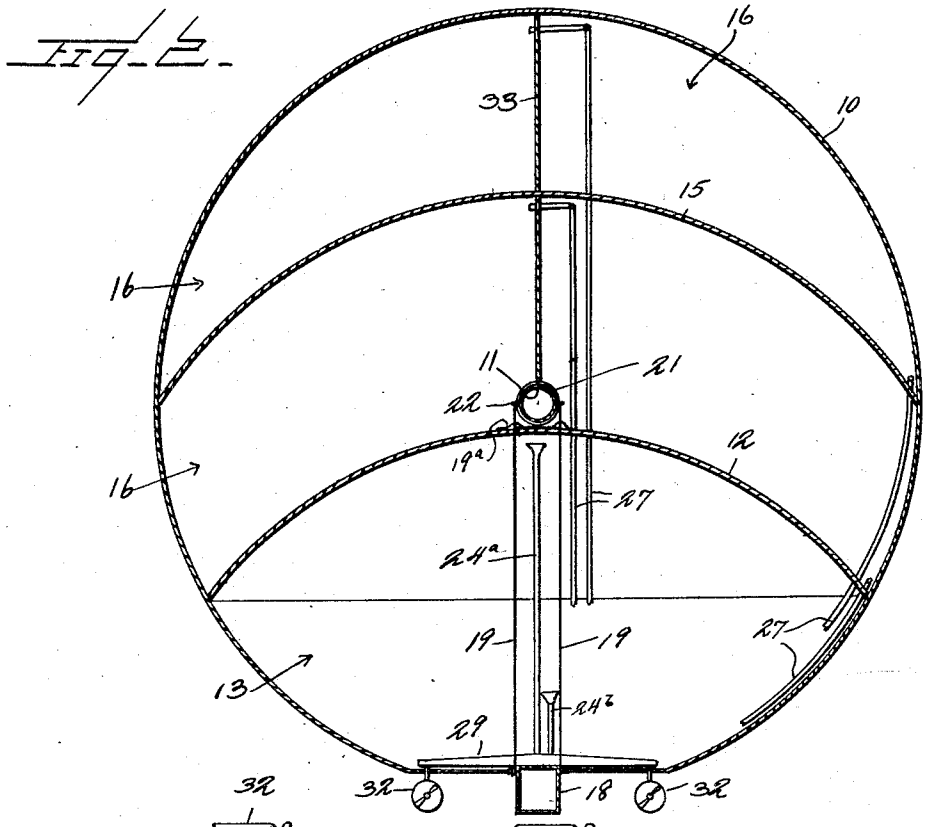
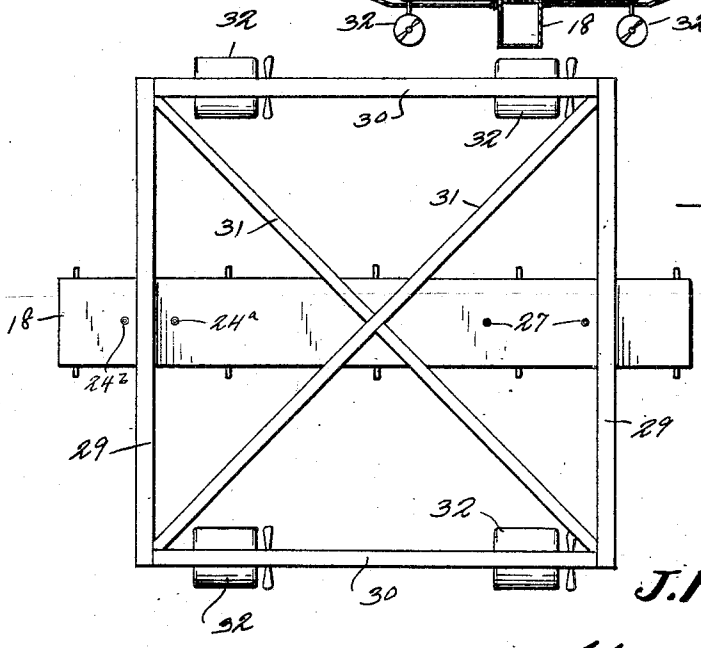


Fig. 4.



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Filed June 30, 1931 3 Sheets-Sheet 3

Fig. 5.

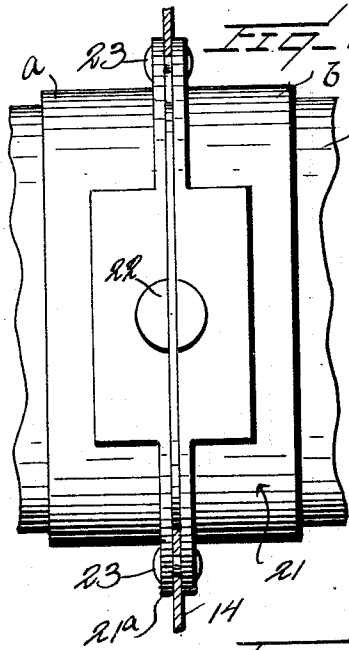


Fig. 6.

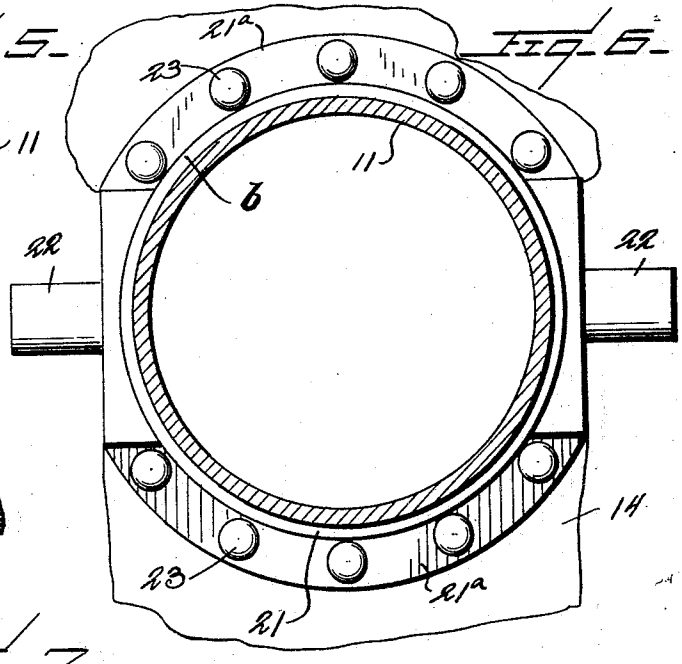


Fig. 7.

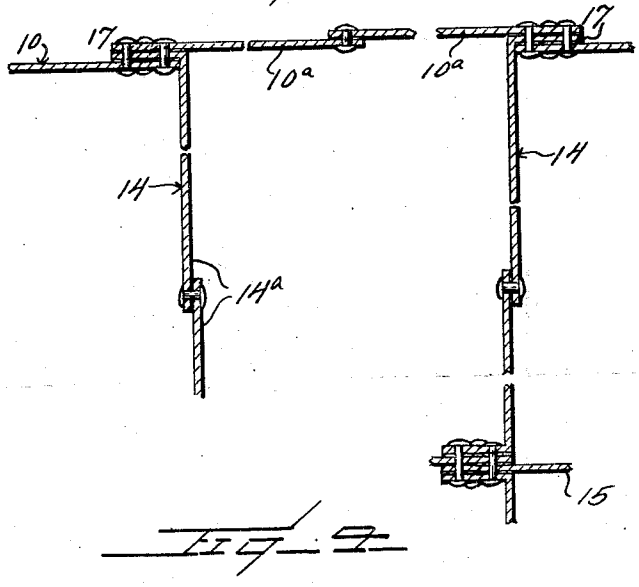


Fig. 8.

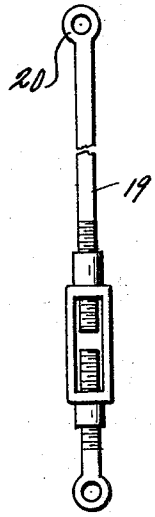
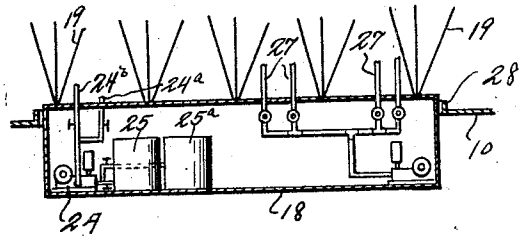


Fig. 9.



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Patented Apr. 5, 1932 1,852,987

UNITED STATES PATENT OFFICE

JOHN HARVEY TYLER, OF LOS ANGELES, CALIFORNIA

DIRIGIBLE AIRSHIP

Application filed June 30, 1931. Serial No. 547,972.

This invention relates to aircraft and particularly to dirigible balloons or structures of this nature.

The general object of this invention is to provide an all-metal dirigible having an entirely different structure from the ordinary dirigible, which structure will permit the vessel to be made of relatively great strength and diameter.

A further object is to provide a dirigible having an outer envelope of metal with an internal keel extending centrally through the envelope and provide a plurality of gas containing compartments disposed above the keel and concentric thereto, which compartments are designed to contain very light gas such as hydrogen and provide a large compartment or chamber below the keel designed to contain a slightly heavier lifting gas such as helium whereby the inflammable hydrogen gas will be separated from the gondola and from the nacelles containing the motors by a chamber filled with the noninflammable gas helium.

A further object is to provide a structure of this character wherein the hydrogen gas chambers which extend transversely from side to side of the envelope and longitudinally from end to end thereof are divided into a plurality of smaller vertically extending chambers by partition plates which extend downward from the outer envelope to the partition dividing the helium containing chamber from the hydrogen containing chambers, these transverse plates being attached to the keel and to the envelope so that the stresses and strains to which the envolope and keel are subjected will be thoroughly distributed.

A further object is to provide means connected to the keel for supporting a gondola just below the envelope but closely associated therewith and provide sets of downwardly convergent supporting trusses engaging the gondola with the keel and distributing the weight of the gondola and, therefore, the weight of the engine and other apparatus along the whole length of the keel.

A further object is to provide in connection with an envelope having a helium compartment, means mounted in the gondola whereby the helium may be pumped out of the helium compartment and compressed when it is necessary to cause the vessel to descend and whereby the reverse operation may take place when it is desired to cause the vessel to rise.

Other objects will appear in the course of the following description.

My invention is illustrated in the accompanying drawings, wherein:—

Figure 1 is a longitudinal sectional diagrammatic view of my improved airship;

Figure 2 is a vertical sectional view through the middle thereof;

Figure 3 is a top plan view of the framework for supporting the motors and showing the gondola;

Figure 4 is a sectional diagrammatic view through the gondola;

Figure 5 is a side elevation of a portion of the keel and one of the reinforcing collars thereof;

Figure 6 is a section through the keel looking toward one of the reinforcing collars;

Figure 7 is a fragmentary detailed section on an enlarged scale through the envelope and two of the transverse partitions;

Figure 8 is an elevation of one of the supporting trusses.

My improved construction is illustrated generally and diagrammatically in Figures 1 to 3 and from these figures it will be seen that my improved dirigible consists of an outer envelope designated generally 10 which is circular in cross section and which is "cigar-shaped" longitudinally or in other words, the ship has approximately the shape of the ordinary dirigible.

Extending longitudinally through the en-

tire length of the envelope 10 and connected at its ends to the envelope is a tubular keel 11 whose diameter would depend entirely upon the length of the airship. For instance, assuming that the ship has a length of 900 ft., then this tubular keel would have a diameter of approximately 25 ft. This keel would be, of course, of built up sections having sufficient rigidity for the purpose. Assuming that the ship was 900 ft. in length, it would have a diameter of 500 ft. at the middle of the ship which is assumed to be the point of greatest diameter and have an average diameter of approximately 375 ft.

Connected marginally to the envelope 10 is an upwardly curved partition 12 which extends up to and touches the keel at one point, that is, at the middle of the ship. This partition 12 is not only transversely curved but is longitudinally curved as shown in Figure 1. This partition, with that portion of the envelope below it, constitutes a chamber 13 for the reception of helium gas.

Extending transversely across the length of the envelope above the partition 12 are a plurality of transverse walls 14 spaced any desired distance, as for instance 50 ft. apart. These walls extend from the envelope to the wall 12 and are attached in any suitable manner to the envelope and to the wall 12. These walls are preferably parallel to each other as shown in Figure 1. The walls 14 would define a relatively long chamber 50 ft. long by 250 ft. high and as wide as the envelope. It is advisable, therefore, to divide these vertical chambers defined by the walls 14 by a second wall 15 approximately concentric to the wall 12, but, of course, eccentric to the curvature of the envelope.

This second wall 15 is also transversely curved and longitudinally curved so that the walls 12 and 14 together form segments of spheres. These walls 12 and 15 with the upper portion of the envelope constitute lifting surfaces and the vertical walls 14 together with the longitudinally and transversely extending wall 15 divide the interior of the upper portion of the envelope into a series of gas containing compartments 16. These transverse walls 14 are attached to the keel in any desired manner and thus these walls 14 engaging as they do the lifting walls 10, 12 and 15 not only divide the interior of the upper portion of the envelope into a plurality of gas cells or compartments but also transmit strains vertically to and from these lifting walls to the keel. The gondola is suspended from the keel and thus the weight of the gondola is transmitted almost directly to these vertical walls 14 and thus to the walls 10, 12 and 15.

I do not wish to be limited to any particular manner of forming the envelope 10 or the walls 15 and 12 nor to any particular material therefor. In actual practice, however, I contemplate that the metal used for forming the envelope and these walls shall be a nickel-copper-aluminum alloy known to engineers as y-metal, such a metal having all the desirable qualities, being light, strong and tough. I do not wish to be limited to any particular construction for the keel but this with the dimensions of the envelope previously given will be approximately 25 ft. in diameter and if made of quarter inch material will be more than equivalent to a 12 by 20 beam.

The envelope or outer shell 10 will, of course, be made of sheets of metal, the sheets being lapped upon each other as shown in detail in Figure 7.

The vertical walls 14 will be angularly bent each at its upper end and this angular flange 17 will be inserted between the overlaps of the sheets 10^a which form the envelope 10. The upper edge of the wall 14 will, of course, be curved to conform to the transverse curvature of the envelope. Each of the walls 14 will preferably be formed of sheets of metal having any desired height but preferably a length equal to the width of the envelope at its intersection with the particular transverse strip constituting part of the wall 14. In actual practice, I contemplate that the transverse strips or sheets from which the walls 14 are made shall be approximately six feet in width. The sheets $14a$ from which the walls 14 are made are overlapped and riveted and at their ends, these sheets are attached to the envelope in any suitable manner, as for instance, by flanging the ends of the sheets and riveting or welding them to the material of the envelope. The wall 15 is made up of transversely curved sheets disposed between the vertical walls 14 and riveted or otherwise attached thereto. The joints between the plates or where the plates overlap each other will preferably be riveted together by three staggered rows of rivets and a well dried coat of rubber cement or shellac on each section of the lap before the parts are laid and riveted on these surfaces between the overlapping parts of the joints may be covered with one of the tough and very dense synthetic resins or bakelite or a gas impervious cement may be spread over the seam of the inner surface and then shellaced.

The gondola 18 is supported just below the bottom of the outer envelope and extends along the middle of the ship, and may have a length, for instance, assuming the dimensions stated before for the gas bag of 200 feet.

The gondola is supported by sets of converging truss rods designated 19. The truss rods engaging the ends of the gondola radiate upward and outward toward the bow or stern of the ship but the truss rods engaging the intermediate portions of the ship are arranged in sets of three or more, one truss rod of each set extending vertically upward and

the other two extending forward and rearward so that these truss rods cross in the manner of truss rods on bridges, thus holding the gondola from any longitudinal swinging movement relative to the gas field.

These truss rods are attached at their upper ends to the keel and extend straight downward through the wall 12. While I do not wish to be limited to any particular means for engaging the truss rods with the keel, I preferably surround the keel at intervals with reinforcing collars 21 having outwardly projecting pins or trunnions with which the eyes 20 at the upper ends of the truss rods engage. These collars are preferably arranged at distances of 50 ft. apart on the keel and are disposed immediately below and are connected to the vertical walls 14. Each collar, as illustrated in Figure 5 is formed in two lateral sections *a* and *b*, each section having a collar portion engaging around the keel and an outwardly projecting flange 21ª. Each collar is also formed with one-half section of an outwardly projecting pin 22. The lower ends of the walls 14, therefore, are cut so as to fit between these flanges 21 and these flanges are then riveted to the walls 14 by rivets 23, thus rigidly connecting the walls 14 to the keel and disposing the truss rods so that they extend downward to the gondola from points immediately in line with the several walls 14, the eyes 20 of the truss rods engaging around these pins or trunnions 22.

These trunnions 22 may be screw-threaded to receive a nut or may be turned over upon the eye or otherwise formed to hold the eyes of the truss rods firmly in place. The lower ends of these truss rods are riveted, bolted or otherwise connected to the framework gondola. Turn buckles may be disposed in the length of each truss rod so that the truss rods may be taken up or lengthened in order that the strain upon each truss rod shall be equalized and the gondola held as rigidly as possible in proper relation to the gas field.

For the purpose of removing the helium gas from the helium gas chamber 12, I provide the gondola with a compressor pump shown diagrammatically in Figure 9 and designated 24, these pumps being connected by any suitable means, as for instance pipes 24*a* and pipes 24*b* to the upper and lower portions of the chamber 13 and the pumps being also connected to tanks 25 and 25*a* shown diagrammatically in Figure 9 into which the helium gas may be compressed. Any suitable valve indicated diagrammatically at 26 may be used for allowing air to enter the helium gas chamber 13 near the lower portion of the chamber. I have thus provided the airship with means whereby the helium may be pumped out of the chamber 13 by the compressor pumps and compressed in containers while air for replacement is allowed to enter into the chamber 13. Thus the airship may be controlled to permit of a gentle landing and by the entire removal of the helium, the ship will come to rest with sufficient weight upon the ground to be entirely rigid, it being assumed that the hydrogen gas in the upper portion of the envelope is not of sufficient buoyancy to lift the entire ship, but simply to partially counterbalance, as it may be termed, the weight of the ship, but that when the helium gas entirely fills the chamber 13, the lift will be in excess of the weight of the ship and when the helium gas has been partially removed and displaced by air, the weight of the ship will be perfectly counterbalanced.

It will be noted that the lifting force is applied ideally where it should be and that this lifting force is distributed uniformly along the length of the keel. The arrangement of the tank 13 is analogous to the arrangement of the ballast tanks of a submarine and theoretrically not a cubic foot of the helium need ever be wasted as the helium is being pumped back into the tanks and when the ship is about to leave the ground, the helium is pumped back into the upper portion of the compartment 13, forcing out the air and the ship rises on an even keel to any desired elevation within its range.

I contemplate also that a pair of like tubes 27 shall leave one at the top and the other at the bottom of each of the gas-tight compartments 16 and lead to a master pump in the machine-shop engine room. While I do not wish to be limited to any particular means whereby the gondola or car shall be connected to the envelope, I have illustrated in Figure 1, the envelope at its lower portion being turned upward slightly at 28 so as to have a slight overlap against the walls of the car, the car not being fastened to this overlap in any way but being entirely supported by the suspending trusses. This will take care of any actual swaying as might be present even in the best manner of connecting the car. Furthermore, the wide control of elevation that is planned by means of this bottom chamber containing helium is projected on the last third of this chamber being filled with air, which when pumped out is replaced by helium which supplies the extra liftage for extreme emergencies and furthermore an opening at the bottom of the envelope at the point of insertion of the car would not cause leakage inasmuch as the helium would occupy the upper portion of the chamber 13 entirely.

Preferably the motors will be supported on a rectangular supporting frame having beams 29 extending above the gondola and beams 30 extending parallel to the gondola, these beams being rigidly connected to each other and being trussed by trusses 31. From the beams 30, the motors will be supported and I have illustrated two nacelles 32 on each

beam 30. The motors may be of any suitable character and shall, of course, be suspended from the beams 30 by suitable sustaining means which will dispose the nacelles below the envelope, the framework consisting of the beams 29 and 30 and the trusses 31 being disposed within the envelope and above the top of the car. This framework formed of the beams 29 and 30 is, of course, primarily supported by the suspenders or suspending trusses which depend from the keel. The exact construction which I have described and shown in the drawings is only illustrative of a means by which the airship may be fabricated and I do not desire to be limited to the details of construction stated inasmuch as many variations may be made in the details of construction without departing from the spirit of the invention as defined in the appended claims.

It will be seen that I have provided a lighter than air flying machine which is provided with a plurality of lifting surfaces as they may be called, namely the transverse partition 12, the parallel partition 15 and the upper portion of the envelope, that the chambers for the reception of hydrogen are divided into compartments, these hydrogen gas compartments, however, being separated from the gondola and from the passengers by a lower compartment filled with the safe helium gas.

By attaching the transverse walls 14, which are the perpendicular units of liftage to the same arrangements on the keel that afford anchorage for the upper ends of the trusses leading to the gondola, we have a perfectly distributed weight suspension from the lifting aerofoils 12, 15, and the upper portion of the outer envelope. At the junction of these walls 14 with the envelope, the great diameter of the envelope makes for a safe distribution of the weight per square foot. Converging to the keel, the liftage increases gradually per square foot and under these circumstances, I contemplate having these walls from the second lifting surface 15 down to the keel of greater thickness per square foot. Thus from the envelope to the lifting surface 15, these walls would be one-sixteenth of an inch thick while from the partition 15 to the keel, these walls would be one-eighth inch thick. It is to be understood that these figures are purely illustrative and in actual practice, the thickness would be determined by the strength of the materials.

While I do not wish to be limited thereto, under some circumstances, a vertical longitudinally extending partition wall designated 33 may be attached at its lower edge to the keel and extend straight upward and be attached to the intermediate wall 15 and to the outer envelope, thus further tending to rigidify the structure and connect the lifting surfaces formed by the outer envelope and the wall 15 with the keel.

In the operation of this airship, on arriving over a landing place, the helium will be pumped out by compressor pumps from the top of its chamber and compressed in containers to a weighable density while air for replacement is fed in at the bottom of the helium containing chamber. This permits a gentle landing but the removal of the helium does not stop until the ship raises with sufficient weight upon the ground to be rigid.

On leaving, the air is drawn out or forced out, the helium takes its place and gradually lifts the ship on an even keel of its wanted elevation. My construction allows sufficient space for the gas to offset the difference in liftage of heated gas by daylight and cold gas at night, but at night pumping more helium into the helium containing chamber and by day reducing this amount of helium. The use of the tubular keel eliminates a danger which is present in all dirigibles as now constructed, many of which, as experience has shown, tend to break in two. Many cells filled with hydrogen and three lifting surfaces make possible greater control of gas to prevent surging of the gas and compression. The large helium chamber and the compression pumps, together with means for replacing helium in the chamber by air, make for an elasticity of control equal to that of submarines with their ballast tanks. The helium is not wasted but is very carefully conserved and used over and over again.

It will be seen from Figure 4 that I use a double pipe connection to pump 24, one pipe 24*b* leading to the bottom of the compartment 13 and the other 24*a* leading to the top of the compartment 13. These pipes lead to two separate compression tanks. One of these tanks is designated 25 and the other 25*a*. The pure helium gas may be withdrawn from the upper portion of compartment 13 and compressed in the tank 25 while the mixed air and helium withdrawn from the lower portion of the compartment 13 will be compressed in the tank 25*a*. By this means no helium need be lost for while there is a natural tendency for gases to admix, the same air and helium are being used over and over again and when it comes to a point that too much helium has been absorbed by the air, the mixed gases may be compressed to liquifaction and the pure helium reclaimed.

In the actual practice of this invention, of course, the so-called pure helium at the top of the chamber 13 will become more and more foul with air and provision should, therefore, be made for taking this foul helium into the air helium tank 25*a* whenever necessary.

The struts or suspenders 19 pass through the wall 12 and this leaves openings in this wall 12. However, the gas in all the chambers is at atmospheric pressure and, there-

fore, there will not be any cause for the gas to pass from one cell to any other, other than the natural tendency of gases to admix. This can be readily prevented by placing balloon cloth 19*a* around the openings through which the suspending rods 19 pass, this balloon cloth being tightly fixed to the lifting surface 12 and tightly fastened to the trusses or suspenders 19.

Obviously ships of very large size may be built and with a very great carrying capacity relative to the ordinary dirigible.

I claim:—

1. An airship comprising an envelope circular in cross section and approximately elliptical in longitudinal section, the interior of the envelope being divided to provide a lower helium gas containing chamber extending longitudinally and transversely of the field for the full width thereof and an upper gas containing chamber divided into separate cells, a gondola depending from the envelope, and means carried by the gondola for pumping the helium gas out of the chamber and compressing it or causing it to pass back into said chamber and expand.

2. An airship having an envelope circular in cross section and approximately elliptical in longitudinal section, a tubular keel extending longitudinally centrally through said envelope, a helium gas containing chamber disposed below the keel and extending longitudinally of the ship, the space above the keel being divided to provide a plurality of hydrogen gas containing compartments, the vertical walls of said compartments being attached at their upper ends to the envelope and extending downward and being connected to the keel.

3. An airship having an envelope circular in cross section and approximately elliptical in logitudinal section, a longitudinally extending tubular keel centrally disposed within the envelope and extending to the ends thereof, a partition wall constituting a lifting surface attached at its margins to the envelope and extending upwardly and centrally to the keel and defining the upper wall of a helium chamber, and vertical partition walls extending transversely the full width of the envelope and extending vertically downward from the top of the envelope to said keel and dividing the space within the envelope above the keel into a plurality of vertical gas containing chambers, the vertical walls being attached to the envelope and to the keel.

4. An airship having an envelope circular in cross section and approximately elliptical in longitudinal section, a longitudinally extending tubular keel centrally disposed within the envelope and extending to the ends thereof, a partition wall constituting a lifting surface attached at its margins to the envelope and extending upwardly and centrally to the keel and defining the upper wall of a helium chamber, and vertical partition walls extending transversely the full width of the envelope and extending vertically downward from the top of the envelope to said keel and dividing the space within the envelope above the keel into a plurality of vertical gas containing chambers, the vertical walls being attached to the envelope and to the keel, a gondola and suspenders therefor attached to the keel at the junction thereof with said vertical walls, and extending downward through the helium gas chamber and engaged with said gondola.

5. An airship having an envelope circular in cross section and approximately elliptical in longitudinal section, a longitudinally extending tubular keel centrally disposed within the envelope and extending to the ends thereof, a partition wall constituting a lifting surface attached at its margins to the envelope and extending upwardly and centrally to the keel and defining the upper wall of a helium chamber, and vertical partition walls extending transversely the full width of the envelope and extending vertically downward from the top of the envelope to said keel and dividing the space within the envelope above the keel into a plurality of vertical gas containing chambers, the keel having reinforcing elements with which said vertical walls engage, a gondola disposed below the envelope and suspenders extending upward from the gondola and engaged with said reinforcing elements.

6. An airship having an envelope circular in cross section and approximately elliptical in longitudinal section, a longitudinally extending tubular keel centrally disposed within the envelope and extending to the ends thereof, a partition wall constituting a lifting surface attached at its margins to the envelope and extending upwardly and centrally of the keel and defining the upper wall of a helium chamber, and vertical partition walls extending transversely the full width of the envelope and extending vertically downward from the top of the envelope to said keel and dividing the space within the envelope above the keel into a plurality of vertical gas containing chambers, the keel having reinforcing elements with which said vertical walls engage, a gondola disposed below the envelope and suspenders extending upward from the gondola and engaged with said reinforcing elements, said suspenders being in the form of a plurality of sets of divergent truss rods, certain of the rods extending vertically upward and certain of the rods extending forward or rearward from the gondola.

7. An airship comprising a gas field consisting of a metallic envelope circular in cross section and approximately elliptical in longitudinal section, a tubular cam extending cen-

trally through the envelope from end to end thereof, a lower partition wall extending from the envelope upward and centrally to the keel and defining a helium gas chamber between said partition wall and the lower portion of the envelope, a second wall extending upward and centrally above the keel and approximately concentric to the first-named partition wall, the space between said second-named wall and the first named wall and between the second named wall and the envelope being divided by vertical partitions into a plurality of gas containing compartments, said vertical partitions extending straight downward from the envelope to which they are attached and being connected at their lower ends to the keel and to the first named wall and having a width equal to the width of the envelope, a gondola disposed below the envelope, suspending means extending downward from the keel in alinement with said vertical walls and operatively connected to the gondola, said suspending means at the ends of the gondola extending upward and forward and upward and rearward to the keel, motors associated with the gondola, and means carried by the gondola for withdrawing the helium gas from the helium gas chamber and compressing it and simultaneously admitting air to said chamber or for forcing out said air and forcing in the helium gas to said chamber.

8. In a dirigible airship having an envelope circular in cross section and approximately elliptical in longitudinal section, the keel extending centrally of the ship from end to end at which the envelope is engaged, a gondola, suspending members attached to the keel and extending downward through the envelope and operatively connected to the gondola, a rectangular frame supported by said suspending members and the gondola and disposed inward of the envelope and including beams extending longitudinally of the envelope, and motor nacelles supported by said beams on each side of the gondola.

9. An airship having an envelope approximately circular in cross section and approximately elliptical in longitudinal section, a keel extending longitudinally centrally through the envelope, a helium gas containing chamber disposed below the keel and extending longitudinally of the ship, the space above the keel being divided to provide a plurality of hydrogen gas containing compartments, the vertical walls of said compartments being attached at their upper ends to the envelope, at their lower ends to the upper wall of the helium gas containing chamber and being connected to the keel.

10. An airship having an envelope approximately circular in cross section and approximately elliptical in cross section, a keel extending longitudinally centrally through said envelope, a wall extending approximately parallel to the upper wall of the envelope, said wall being disposed, however, relatively adjacent the lower wall of the envelope and below the keel, vertical partitions extending down from the upper wall of the envelope and attached thereto and at their lower ends attached to the second named wall, a gondola disposed within an opening formed in the lower wall of the envelope, and stays extending from said gondola to the keel and connected with the keel at spaced distances from end to end thereof.

In testimony whereof I hereunto affix my signature.

JOHN HARVEY TYLER.