Aug. 28, 1928.

1,682,405

H. NAATZ

NONRIGID AIRSHIP

Filed March 30, 1923

Fig 2.

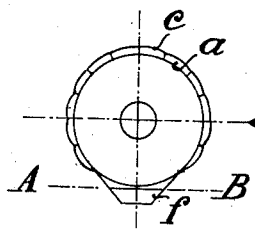


Fig. 1.

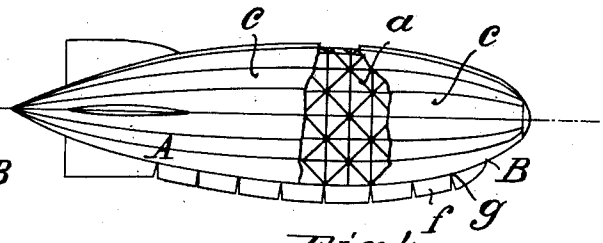


Fig. 3.

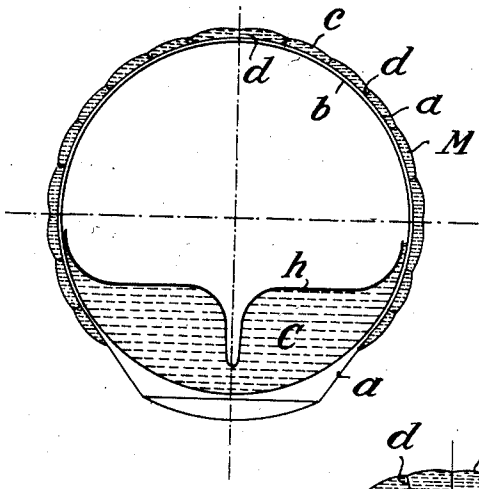


Fig. 4.

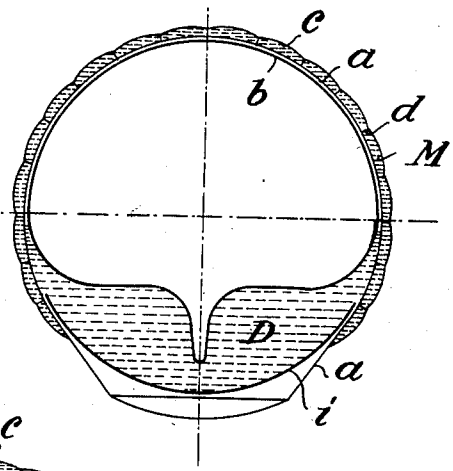
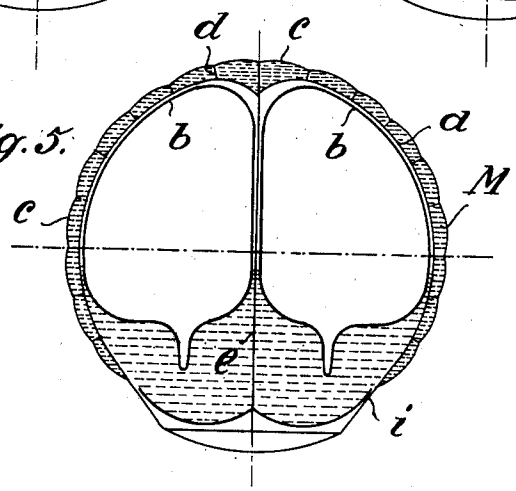


Fig. 5.



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UNITED STATES PATENT OFFICE.

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NONRIGID AIRSHIP.

Application filed March 30, 1923, Serial No. 628,851, and in Germany April 13, 1922.

This invention relates in general to airships and more particularly to airships of the non-rigid type. It is well known that the most important part of airships of the non-rigid type is the envelope, for this is the part that receives the gas charge and that has to resist the pressures produced thereby and also the external forces which are liable to arise when the load is unevenly distributed and when the ship passes through squalls and is steered by its rudder etc. The pressure of the gas in the envelope only gives rise to tensional stresses, while the external forces produce both tensional and pressure or thrust stresses, which generally spread in accordance with know laws over the surface of the envelope and are superimposed upon the stresses due to the gas pressure in the envelope, so that at some parts of the envelope the tensional stresses are increased while at others they are reduced. Consequently the envelope is not stretched equally at all points, and the stretching of the envelope is not symmetrical at all parts, so that the body of the balloon is deformed, or in other words it is subjected to thrust, bending and torsional stresses. As the envelope of a non-rigid airship is made of material such as fabric which is very easily deformed these thrust, bending and torsional stresses may often be very considerable, and they may become so great that the steerability of the ship is interfered with and on the other hand the structures, such as the gangway suspended from the body of the ship, are unduly pressed, pulled or bent. To avoid these undue stresses of the suspended structures they have to be made, in airships of the known kind, either of parts that slide into one another like telescopes, or of extremely strong parts. If the latter course is adopted, the suspended structure prevents deformation of the balloon by stiffening it, but it then has to be capable of resisting very great stresses. This plan is utilized in ships of the semi-rigid type. But the construction of stiffening structures or members of this kind involves great difficulties, because it is not certain what part of the external forces is coped with by the balloon and what part is received by the stiff structure, because the expansional properties of the material of the balloon are quite irregular and differ from those of metal to such an extent (woven material stretches 150 times as much as aluminium) that no rules regarding the distribution of the forces can be found.

These disadvantages of non-rigid and semi-rigid airships are avoided by the present invention. In accordance with this invention the envelope is made so as to be deformable to a slight extent only, and this is accomplished by making the envelope of three separate parts, one of which is constructed of members which are substantially non-expansible such as wire ropes, wire cords, wires, rods and the like. The part that consists of practically non-expansible members is made in the form of a network which covers or embraces an interior gas-filled envelope and which is surrounded by a second outer airtight envelope. The invention is shown by way of example in the drawing in which

Fig. 1 is a diagrammatic side elevation with a part of the external envelope broken away to show the network covering.

Fig. 2 is a diagrammatic section of the airship.

Fig. 3 is a cross section of an airship with a ballonet arranged inside the internal envelope for keeping the envelope taut,

Fig. 4 is a modification in which a ballonet is arranged outside of the interior envelope, and

Fig. 5 is another modification in which the interior of the ship is divided by a vertical partition.

The three parts of the envelope are arranged as follows: Referring to the drawing *a* is a network cover which embraces or surrounds a gastight envelope *b*. The network *a* consists of substantially non-expansible members, the transverse and diagonal members being tension members, while the longitudinal members may be subjected either to tension or thrust, or both. The envelope *b* consists of a gastight, flexible material which presses against the network *a*. The network *a* is coated externally by an envelope *c* which is also made of a flexible material which is airtight but need not be as tight as the envelope *b* which is tight enough to prevent the escape of extremely penetrative gases. The outer envelope *c* is fixed to the network covering *a* by partitions or webs *d* which extend lengthwise along the ship. The outer envelope *c* is made to float at a distance from the network covering *a* by air pressure maintained artificially in the space M. By this

construction the two envelopes *b* and *c* of fabric or flexible material are subjected to small tensional stress and nearly the whole of the tensional stresses, which is ordinarily taken by the envelope of airships of the non-rigid type, is taken in the airship according to my invention by the network *a* alone. As this network consists of members which are practically non-elastic and which extend transversely, diagonally and longitudinally as shown in Fig. 1, the body of the balloon will only be deformed very little by the influence of all external forces that may arise. The thrust or pushing together, bending, and torsion of the body of the balloon will be so slight that its steerability will not be impaired and structures connected to it, which serve to take the loads to be carried, will be stretched, compressed or bent very little, or not at all. Hence these structures can be made much lighter than in non-rigid airships equipped with elastic envelopes only.

In a particularly advantageous construction, the suspended structures are made of separate pieces *f* as shown in Fig. 1 interconnected by movable joints *g* suspended from the balloon in such a manner that the joints *g* all lie in a curved surface A—B that adapts itself to the contour of the balloon. The suspended structure will then exert tensional or pressure stresses on the network covering of the balloon in the surface A—B only, and its parts that lie beneath the surface A—B can then be made as light as possible. The balloon may be deformed, as by bending, very considerably without affecting the parts of the suspended structure. Besides, if it is considered necessary to increase the resistance to bending stresses, this can be accomplished by simply strengthening the upper booms of the suspended structure that lie in the surface A—B.

The body of the balloon may be constructed in various ways. In Fig. 3 the envelope *b* in the interior of the carrier network *a* consists of a gastight balloon *b* of fabric or the like and in the envelope *b* there is a ballonet *h*, and the surrounding chamber M is filled with air or another gas. The surrounding chamber M may be connected with the interior of the ballonet C or these two chambers C and M may be arranged to have air pumped into them separately by a blower. In Fig. 4 the inner envelope is divided up into a number of separate cells *b* and the bottom of the balloon is closed by a covering *i*. Here also the outer chamber M may be connected to the air chamber D containing air at the service pressure as shown in the drawing, or the chambers D and M may be separated by the covering *i* being made to extend further up into the balloon. In Fig. 5 an airship is shown in which a vertical partition *e* divides the interior of the body of the balloon into two longitudinal chambers. The partition *e* may consist of fabric or of network made of substantially non-expansible members such as metal rope, metal strands or the like, the object of the partition *e* being to hold down the top of the balloon. By providing the partition no substantial change of the construction of the envelopes is necessary as these may be inserted in the manner shown in Figs. 3, 4 or 5. If desired, several partitions *e* may be provided.

The external chamber M, Figs. 2, 3 and 5, besides providing a smooth enclosing external surface, also offers the advantage that it prevents rapid heating of the gases by the sun, for experience has shown that gas enclosed in balloons provided with only a single envelope heats up much quicker. This heating of the gas is delayed to a still greater extent or prevented altogether when the air in external chamber M is kept continually in motion, which may be done by pumping in fresh air from beneath and allowing the heated air to escape at the top through adjustable valves.

Another important advantage obtained by the network cover according to the invention consists in the fact that, in the event of individual members of the network being severed, the network cover does not continue tearing like the fabric of ordinary non-rigid airships generally does, because, if meshes of suitable width are chosen, only a few tension members will be torn asunder and the forces that were resisted by them are immediately transferred to neighboring members which then take the strain without being damaged, since the extra load does not subject them to more than double the ordinary stress, and they are generally calculated to take three times the normal stress.

I claim:—

1. In an airship of the non-rigid type, a gas-containing envelope, a network embracing said envelope for preventing deformation of same and consisting of longitudinal, diagonal and transverse non-expansible flexible members whose sections are interconnected so as to make the body of the ship pliable in all directions, an outer envelope over the network and a structure suspended from the network covering and comprising members connected to each other by movable joints that lie in a curved surface beneath said envelopes.

2. In an airship of the non-rigid type, a gas containing envelope, a network embracing said envelope for preventing deformation of same and consisting of longitudinal, diagonal and transverse non-expansible flexible members whose sections are interconnected so as to make the body of the ship pliable in all directions, an outer envelope over the network, and a structure suspended from the network covering.

In testimony whereof I affix my signature.

HERMANN NAATZ.