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LIQUID CONTAINER

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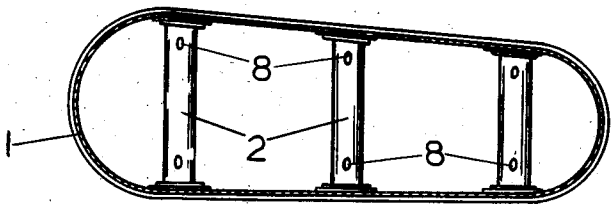


FIG. 1

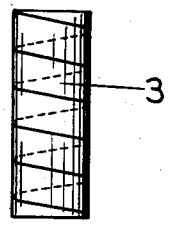


FIG. 2

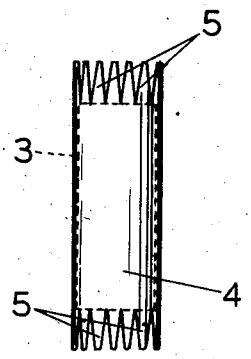


FIG. 3

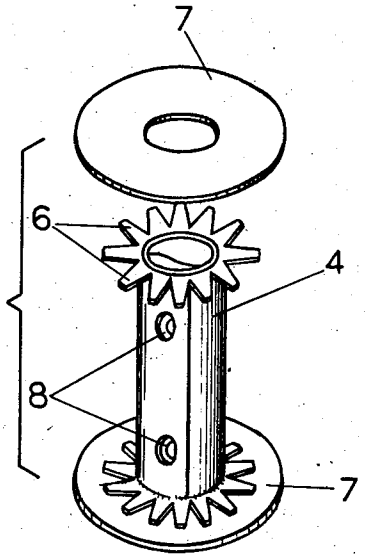


FIG. 4

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LIQUID CONTAINER

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9 Claims. (Cl. 220—71)

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This invention relates to liquid containers and more particularly to containers for the storage of fuel and the like in aircraft, of the kind comprising an envelope of flexible non-metallic material which is impervious to or which has been treated to render it impervious to petrol fuels.

It has already been proposed to provide a fuel container comprising a collapsible envelope which is contained within a rigid structure, the said envelope being prevented from collapsing when empty or only partly filled by means of a plurality of flaps secured to the walls of the collapsible envelope and adapted to engage hooks secured to the rigid structure. However, this method of supporting the collapsible envelope is inapplicable in the case of such containers which are not provided with a substantially rigid external structure, and moreover even where a rigid external structure is employed, the hooks are liable to chafe and eventually puncture the material of the envelope.

The object of the present invention is to provide an improved liquid container of the kind described in which the aforesaid disadvantages are overcome in a simple and effective manner.

According to the present invention we provide an improved liquid container of the kind described in which a plurality of supporting members or struts are inserted between and secured to oppositely disposed portions of the container, the said members comprising flexible non-metallic material which is rolled, folded or otherwise fabricated to an elongated tubular or non-tubular structural form having a high moment of inertia of section in relation to the cross-sectional area of the said material consistent with stability of the wall.

Thus the said members may comprise tubes of circular, rectangular, triangular or other cross section, with or without internal or external webs, ribs or the like, or may comprise non-tubular members of H-section, X-section, or other cross-sectional form calculated to provide the required amount of support for the purposes of the invention. The said members may be formed by rolling or folding flexible sheet material to the required cross-section form, or may be formed by extrusion of a thermoplastic non-metallic material. The said flexible sheet material may be single or multi-ply, and the members may comprise a single layer of sheet material or two or more superimposed layers thereof, secured together if desired by means of an adhesive or mechanical or other securing means. It may conveniently comprise fabric material impregnated with a compound resistant to the action of the liquid to be contained within the container. The members preferably possess a sufficient degree of resiliency, so that in the event of the accidental imposition of a heavy load they are able

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on release of the load to revert to their original condition without permanent deformation. They may be disposed all in the same direction or some in different directions to others, for example some may be arranged vertically and others horizontally with respect to the normal position of the container. Tubular members may also be provided with small apertures in their walls to allow liquid to flow into or out of the space within the member, in order to equalise the pressure on both sides of the wall and prevent the possibility of the exertion of a crippling stress on the member due to the liquid pressure.

When the said members comprise tubes of circular cross section, their dimensions are preferably maintained wtihin the following limiting ratios, since we have found the optimum wall stability for the purposes of the invention to be attained thereby:

$$\frac{\text{Wall thickness of tube}}{\text{outside diameter of tube}} \text{ ---------- } \tfrac{1}{12} \text{ to } \tfrac{1}{8}$$

$$\frac{\text{Length of tube}}{\text{outside diameter of tube}} \text{ ---------- less than 12}$$

By way of example a cylindrical tube 20'' in length for use in the construction of a fuel container in accordance with the invention is formed from 5-ply impregnated fabric material, the outside diameter of the tube being 1.75'' and its thickness $\frac{3}{16}$'', while tubes less than 12'' in length are conveniently formed from 4-ply material, the outside diameter of the tube being 1.25'' and the thickness $\frac{1}{8}$''.

The collapsing load for the supporting members of the present invention may be taken as proportional to I_{NA}, the moment of inertia of section about the neutral axis, for a given length of member, and the ratio I_{NA}/A, where A is the cross-sectional area of the material of the member, may be employed as a measure of the stability of the member for the purposes of the invention.

Thus for a cylindrical tube this ratio is

$$I/A = \frac{D^2 + d^2}{16}$$

where D is the external and d the internal diameter of the tube, and substituting the first of the above-mentioned limiting ratios there are obtained the following limits:

$$I/A \text{ must be greater than } 6.25t^2$$
$$I/A \text{ must be less than } 15.25t^2$$

where t is the thickness of the tube.

The application of these limits may be shown for example by considering the case of a tubular member of circular cross-section which may be resolved into a corresponding series of members of elliptical cross-section with the same thickness by deformation. Taking the two examples of

material mentioned above, namely tubes of thickness $\frac{3}{16}$" and $\frac{1}{8}$", the limits for I/A become:

I/A must be greater than 0.218 but less than 0.54, and I/A must be greater than 0.098 but less than 0.237, respectively. Taking now tubes of these thicknesses and specific outside diameters of 1.75" and 1.25" respectively, and calculating the values of I_{NA}/A for the series of corresponding tubes of elliptical cross-section produced by progressive flattening of the said cylindrical tubes, the cross-sectional area of the material of the tubes remaining substantially constant, it is found that these values diminish rapidly and even when the degree of flattening is only such that the ratio of the major to the minor axis of the ellipse is about 1.5, the values of I/A are already below the lower limits given above for the respective cylindrical tubes.

Again, as the diameter of a tubular cylindrical member is increased, the thickness of the material remaining constant, the values of I/A will increase beyond the preferred maximum limit and the member will be unstable for the purposes of the present invention.

In other words the moment of inertia of section of the member must be relatively high in relation to the cross-sectional area of the material, but on the other hand not so high that the stability of the member is again reduced.

The above considerations have been based on a constant length of tube: the stability of the member will of course be further influenced by its length, which will be determined in accordance with the second of the above-mentioned limiting ratios.

Preferred limiting ratios may correspondingly be found for tubes of other than circular cross-section, and for members of non-tubular cross-section.

One preferred embodiment of our invention is illustrated in the accompanying drawing in which

Figure 1 is a sectional end elevation of a fuel container constructed in accordance with the invention.

Figures 2–4 illustrate stages in the fabrication of internal supporting members for the container shown in Figure 1.

Referring to the drawing, a flexible envelope **1** for a fuel container comprises fabric material impregnated and coated with a synthetic rubber material known in the trade as "neoprene." The said envelope may be manufactured in any convenient way, for example by tailoring and assembling suitably shaped pieces of the said fabric material. A plurality of supporting members **2** are provided in the interior of the envelope to prevent it collapsing when empty or only partially filled. The said members comprise cylindrical tubes which are manufactured from material similar to that employed for the envelope. In manufacturing the said members, an elongated strip of the fabric material is wound to form a spiral **3** around a suitable former (not shown in the drawing). A broad band **4** of the fabric material is then superimposed around the spiral, and is secured thereto by a suitable adhesive, for example a solution of neoprene in carbon tetrachloride. The width of the said band is greater than the overall length of the spiral, and consequently when superimposed on the spiral, a portion extends over each end of the spiral. The extended portions are cut to form a series of serrations **5**, which serrations are then deflected radially outwards in the manner of spokes **6**. Apertured discs **7** of the aforesaid fabric material are then secured to the spokes **6** by means of the aforesaid adhesive. Small apertures **8** are formed in the cylindrical portion of the said members to allow fuel to flow into or out of the space within the members. The members are then inserted and disposed in suitably spaced relation within the envelope, and the end discs **7** adhesively and/or mechanically secured to the upper and lower portions of the envelope. If desired, the envelope may be provided with a self-sealing cover (not shown) of any convenient known form, for example a cover incorporating one or more layers of swellable rubber composition.

It is to be understood that wherever the phrase "whereby said envelope is supported against tensional and compressional stresses" appears in the claims, we mean that the supporting members have both sufficient rigidity to withstand the stresses encountered in normal operation of the container and sufficient resiliency to yield to an abnormal load and revert to their original condition on release of the load.

We claim:

1. In a liquid container which includes an envelope of flexible non-metallic material, a plurality of supporting members inserted between and secured to oppositely disposed portions of the envelope, said supporting members each comprising a flexible tubular core of spirally wound non-metallic material, a surrounding sheath extending longitudinally beyond the ends of said core, slit at its ends and formed as radially extending fingers defining end flanges, a pair of annuli secured on opposite surfaces to said end flanges and to opposite walls of said envelope, respectively, whereby said envelope is supported against tensional and compressional stresses.

2. In a liquid container which includes an envelope formed entirely of flexible non-metallic material, a plurality of flexible, spaced, separate supporting members formed entirely of flexible non-metallic material inserted between and secured at their ends to oppositely disposed portions of the envelope, said supporting members being of an elongated, hollow, preformed, column-like structure and extending continuously from one wall to the opposite wall of the container, said supporting members preventing collapse of the container when empty or partially filled.

3. A liquid container in accordance with claim 2, in which the flexible, hollow supporting members have apertures therein in communication with the hollow interior of the envelope.

4. In a liquid container which includes an envelope of flexible non-metallic material, a plurality of flexible supporting members inserted between and secured to oppositely disposed portions of the envelope, said supporting members each comprising a flexible non-metallic material fabricated to a hollow tubular form of circular cross-section, whose dimensions are within the following limiting ratios:

$$\frac{\text{Wall thickness of tube}}{\text{outside diameter of tube}} = \frac{1}{12} \text{ to } \frac{1}{8}$$

$$\frac{\text{Length of tube}}{\text{outside diameter of tube}} = \text{less than } 12$$

whereby said envelope is supported against tensional and compressional stresses.

5. A liquid container in accordance with claim 2 in which the non-metallic material of the flexible supporting members comprises a fabric impregnated with a substance resistant to the action of the contained liquid.

6. A liquid container in accordance with claim 2 in which the flexible supporting members are fabricated from a plurality of superimposed layers of flexible non-metallic material.

7. A liquid container in accordance with claim 2 in which the flexible non-metallic material of the flexible supporting members comprises a thermoplastic material.

8. A liquid container in accordance with claim 2 in which the flexible supporting members are provided with radial fingers for securement to the walls of said envelope.

9. In a liquid container which includes an envelope of flexible non-metallic material, a plurality of flexible supporting members inserted between and secured to oppositely disposed portions of the envelope, said supporting members each comprising a flexible tubular core and a surrounding sheath extending longitudinally beyond the core at both ends and being slit and outwardly flanged forming radial fingers for securement to the walls of said envelope, whereby said envelope is supported against tensional and compressional stresses.

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