June 4, 1946. E. EGER 2,401,626

METHOD FOR FORMING TANKS

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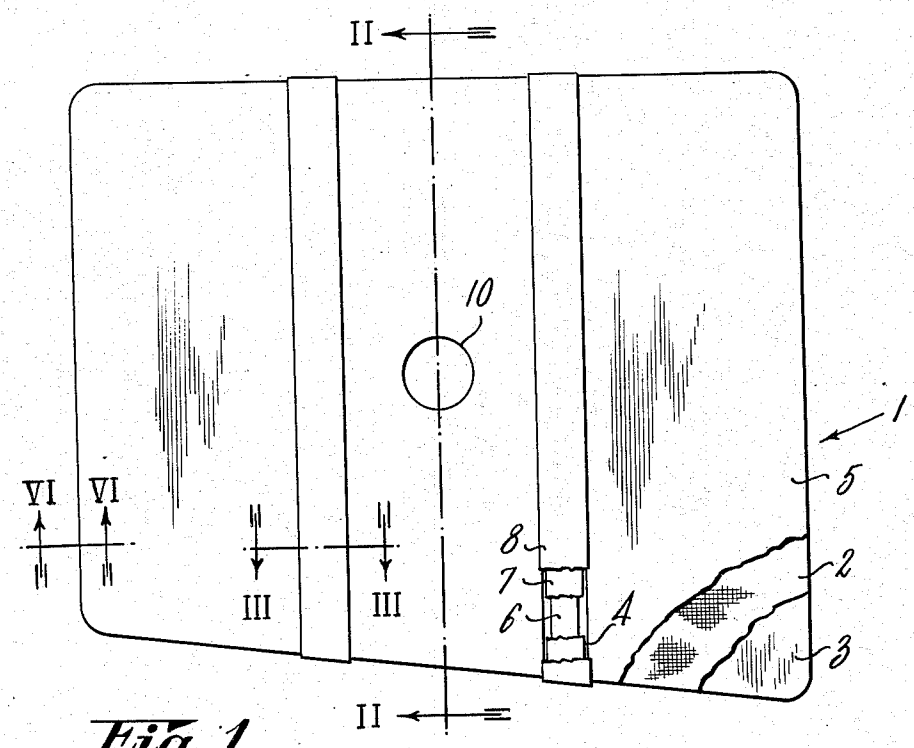


Fig. 1

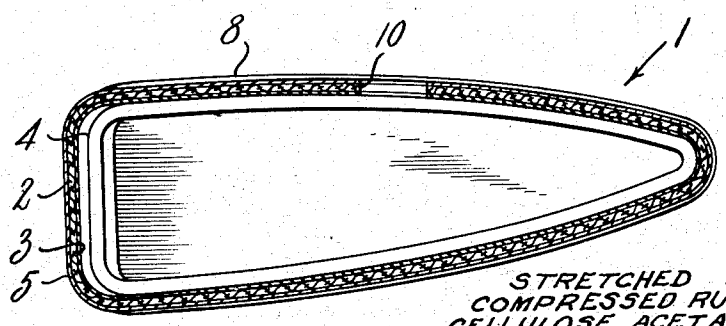


Fig. 2

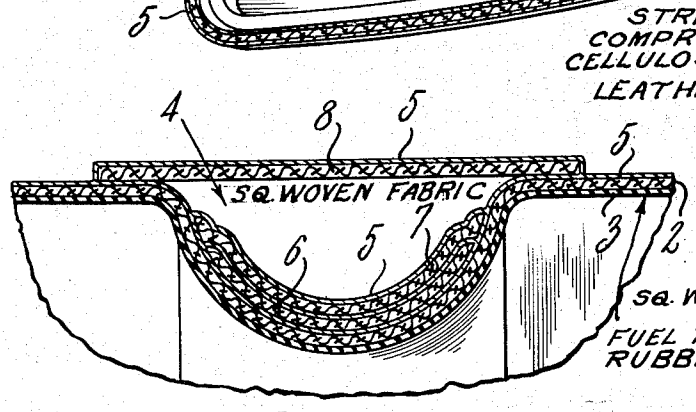


Fig 3

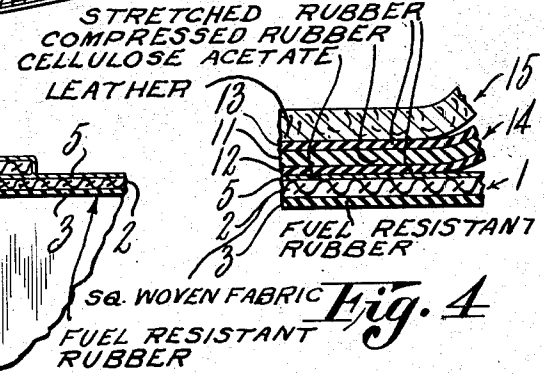


Fig. 4

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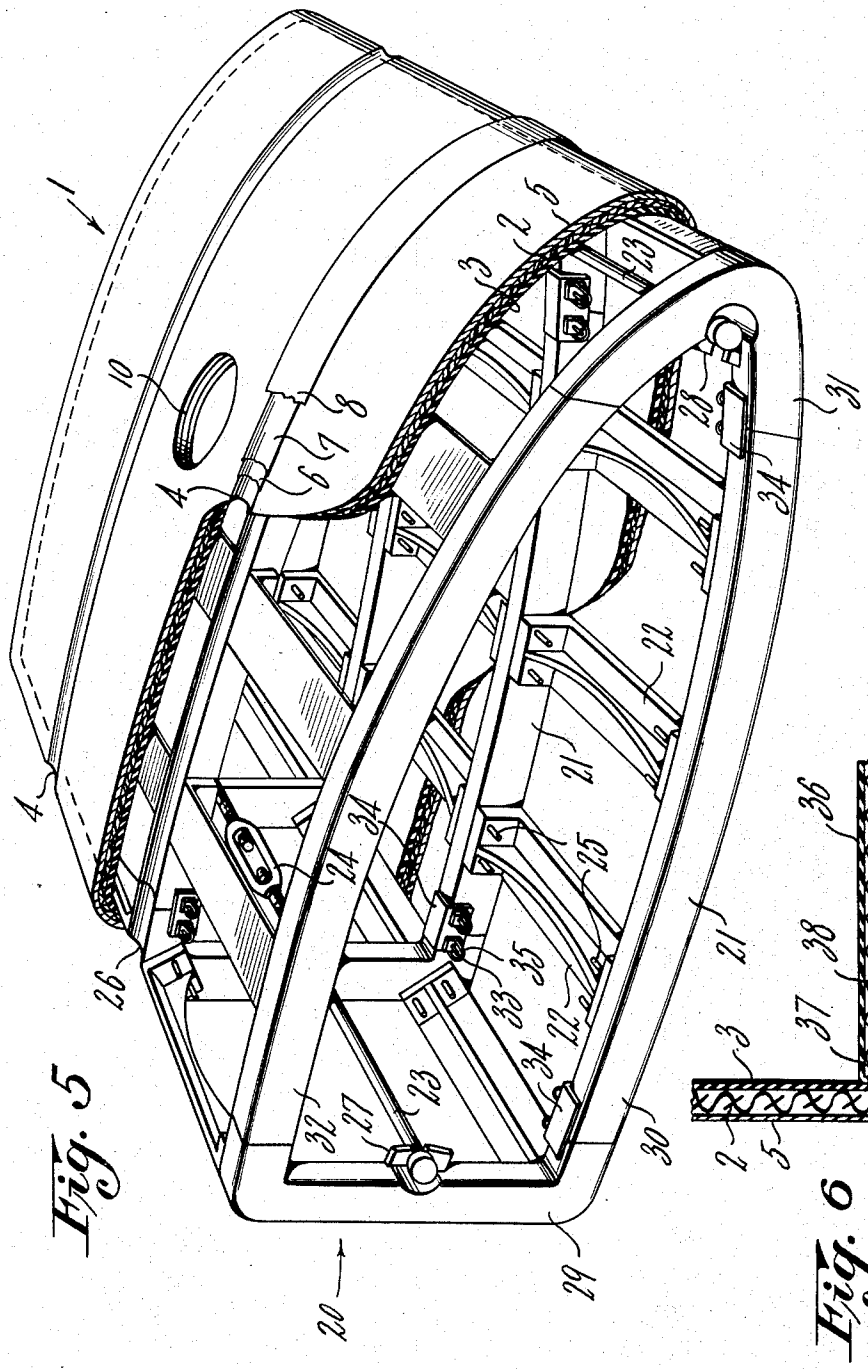


Fig. 5

Fig. 6

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Patented June 4, 1946 2,401,626

UNITED STATES PATENT OFFICE

2,401,626

METHOD FOR FORMING TANKS

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Application January 3 1941, Serial No. 372,973

1 Claim. (Cl. 154—43.5)

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This invention relates to a method for forming flexible tanks and the like, and such as the tank shown by my co-pending application Serial No. 364,774 filed November 8, 1940.

More particularly, the invention relates to a method for forming flexible, self-supporting tanks or like structures adaptable for use as linings within rigid housings, such as the wings of an airplane, the lining forming impermeable walls to provide a fluid-tight container for storing liquids.

Airplane wings are usually formed of sheets of light metal joined together by rivets or by a welding operation. Because of the many joints in an airplane wing, it is difficult to form a fluid-tight container from the wing itself. By utilizing the present invention, the flexible container can be made to form the fluid-tight medium for storing liquids such as gasoline or benzol. It is, therefore, unnecessary to provide a fluid-tight portion in the airplane wing, for in the use of the flexible tank lining it is merely necessary to provide a rigid means for maintaining the general outline of the container or lining.

More specifically, the invention comprises a method of making a fabric wall conforming to the outline of a tank or lining and having its entire inside surface coated with a layer of material impervious to the action of the fluid for which the tank is intended, and having the outer surface of the fabric coated with a stiffening material for increasing the rigidity of the tank lining. The stiffening material added to the outside of the fabric also functions to help prevent diffusion of the contents of the tank through the walls thereof. Furthermore, the invention contemplates the formation of strengthening ribs in wall portions of the tank or lining for the purpose of adding to the rigidity thereof, thus making the tank self-supporting and non-collapsible. Such ribs are needed only in tanks of large size requiring stiffening. In smaller tanks there is sufficient inherent rigidity in the tank walls so that ribs are not required for stiffening and supporting purposes. To produce such tanks or linings in a rapid and efficient manner, applicant employs a novel method of assembly and processing, using at such time a specially constructed detachable form or frame for supporting component parts of the tank in proper position.

In special cases where there is also the possibility that punctures will occur in the tank lining, such as from projectiles and the like, additional means in the form of layers of flexible material may be provided for rendering the structure self-sealing and tear resistant.

The invention will be more fully understood from the following detailed description when considered in conjunction with the accompanying drawings, in which:

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Fig. 1 is a plan view, partly broken away, of a completed tank or lining;

Fig. 2 is a transverse view thereof taken along lines II—II of Fig. 1;

Fig. 3 is an enlarged, transverse view, in section, of a ribbed tank or lining construction taken along lines III—III of Fig. 1;

Fig. 4 is an enlarged cross-sectional view of a portion of the tank or lining of Fig. 1, but provided with additional external layers of flexible material for rendering the construction self-sealing and more tear resistant;

Fig. 5 is a perspective and partly broken away view of a detachable form or frame within a partially completed tank or lining; and,

Fig. 6 is a somewhat enlarged cross-sectional view, taken along lines VI—VI of Fig. 1, of a corner construction employed in forming the tanks or linings.

Referring to the drawings, and, in particular, to Figs. 1 and 2, I show a tank or lining 1 having the general laterally tapered outline of a portion of an airplane wing. While the lining is illustrated to conform to an airplane wing, it is to be understood that this shape is illustrative of one practical application only, and that the tank lining may be shaped to conform to the outline of various types of storage vessels.

Essentially, the body of the tank or lining 1 is formed of a heavy, square woven fabric 2, such as a 21 ounce duck or canvas. The inside surface of the fabric 2 is coated with a layer of rubber or rubber-like material 3 which is resistant to the action of the liquid to be placed within the tank. In the present instance the tank is intended for use as a fuel storage means for airplanes and, therefore, the layer 3 is resistant to oils, gasoline, or benzol. This material 3 is preferably formed of an oil resisting, synthetic rubber composition, such as Neoprene a poly chloroprene composition, and is preferably applied to the fabric before the fabric is assembled to form the tank.

In order to obtain good adhesion between the fabric and Neoprene, the Neoprene is applied in a frictioning operation so as to form a thin coat on the fabric; thereafter a calendered layer of Neoprene is applied to the fabric, leaving a coating, the total thickness of which is approximately .015 inch to .045 inch. After the Neoprene is applied to the fabric, it is vulcanized while the fabric is still in sheet form. It is to be understood, however, that the Neoprene may be vulcanized after the coated fabric is assembled to conform with the general outline of the tank.

In order to increase the rigidity of the walls of the tank, I provide one or more lineal depressions 4 in the fabric 2, coat the outer surface thereof with cellulose acetate 5 and, as best shown in Fig. 3, reinforce these lineal depressions 4 so as to form ribs by the application of strips of

fabric 6 and 7. The strips of fabric 6 and 7, extending lengthwise in the well formed by the depression 4, are secured in place by cellulose acetate 5. As an additional means for maintaining the depression 4 in its ribbed formation, a strip of fabric 8 extends around the outer surface of the tank lining and bridges the gap formed by the lineal depression 4. The strip of fabric 8 is likewise secured in place by means of cellulose acetate 5. All of the strips 6, 7 and 8 are composed of the same fabric material as the body portion of the tank lining 2 and a coating of cellulose acetate 5 is also applied to the outer surfaces of the strips of fabric 7 and 8, in order to increase the rigidity of the entire assembly.

Various openings, such as the aperture 10, may be cut through the wall of the tank to serve as means for the entrance or exit of the liquid. These openings are also of aid during the construction of the tank.

The self-supporting tank lining, as thus described, may constitute the sole structure of the tank itself; or it may constitute a lining for use in a more rigid structure; or it may, in special cases, constitute the self-supporting body material with which flexible puncture sealing and tear resistant material of different types may be associated. One exemplary form of this puncture sealing and tear resistant material comprises preferably two layers, the first or puncture sealing layer having an intermediate lamination 11 (Fig. 4) of soft elastic rubber composition, of a hardness of approximately 15 durometers, permanently held in a state of compression by a pair of tensioned laminations 12 and 13 of comparatively tough elastic rubber composition, of a hardness of approximately 40 durometers. These laminations 12 and 13 are integrally bonded to the opposite sides of the soft lamination 11 and this soft material, being permanently compressed, possesses the natural tendency to expand and close any punctures caused in the layer by projectiles or the like. The reference numeral 14 represents generally this first or puncture-sealing layer and is similar to the puncture sealing material shown and described in my copending application Serial No. 324,820 filed March 19, 1940.

A sheet 15 of soft tough leather may form the second or tear resistant layer of material associated with the tank lining and serves to resist any tendency of the tank lining or the rubber composition to tear or split under the sudden shock caused by a projectile or the like striking the structure. The first and second layers 14 and 15 are each formed as enclosures to fit closely about the tank lining and, while they may be cemented thereto if desired, in actual tests it has been found preferable to omit such cement and thus leave the layers free from the tank or lining and free from each other so as to have a maximum of freedom for movement when struck.

A preferred method of construction of the self-supporting flexible tank 1 is accomplished by first cutting from a sheet of rubber or Neoprene coated fabric material a relatively large piece of fabric of proper size and shape so that when opposite edge portions thereof are brought together and overlap to form a joint a flexible tubular wall will be formed; which wall tapers somewhat from one end thereof to the other. One edge portion of the wall is completely covered with a vulcanizable rubber or Neoprene composition before it is pressed firmly into engagement with the coated side of the other edge portion thereof to form an overlapping joint. The joint thus formed is subjected to a vulcanizing heat to produce an integral union in the rubber or Neoprene composition and a fluid-tight interior surface. The tapered tubular wall is then placed upon a readily collapsible or detachable main frame 20, Fig. 5, which is similarly tapered from end to end, by slipping the larger end of the tubular wall over the smaller end of the frame.

The main frame 20 comprises a plurality of longitudinal frame sections 21 detachably maintained in laterally spaced parallel relation by a plurality of transverse braces or spacing members 22 clamped together by a plurality of tie-rods 23 having turn-buckles 24 threaded thereon. Each brace 22 has its oppoiste ends abutting, respectively, the sides of adjacent frame sections 21 and each brace is provided with removable pins 25 extending through aligned holes in the ends of the brace and through corresponding holes in the frame sections. In practice it has been found convenient to employ conventional U-shaped cotter pins for this purpose, since these pins are resilient and will frictionally engage and readily remain in place in the holes in the braces and the frame sections but can be easily withdrawn therefrom by a tool inserted into the bight portions of the cotter pins.

While the longitudinal frame sections 21 are of slightly differing sizes, each conforming generally to the shape of the interior of an airplane wing at the corresponding location therein, all of these sections 21 are of the same general construction and only differ from each other, in that, the intermediate frame sections are provided with recesses or grooves 26 while the end frame sections are provided with integral bifurcated brackets 27 and 28 for the reception of the enlarged ends of the tie-rods 23. The grooves 26 are of substantial depth and extend partially, or even completely, around the peripheries of the intermediate frame sections.

Each of the frame sections 21 comprises a plurality of frame members 29, 30, 31 and 32 arranged to fit together in end-to-end relation and these members are provided with detachable securing means for holding the members firmly but releasably in aligned assembled position. The securing means comprises threaded bolts 33 which extend from and are integrally secured in the sides of the frame members near opposite ends thereof. Over the bolts 33 of adjacent members are placed apertured angle plates 34 and these plates 34 are held in engagement with the side and inner surfaces of the frame members by removable nuts 35. The nuts 35 are provided with integral upstanding bales so that the nuts may be readily gripped and removed without difficulty. The ends of the frame members 30 and 32 are so shaped relative to the shape of the individual frame section that, when the securing plates 34 and nuts 35 have been removed from the bolts 33, these members can be moved inwardly towards each other and disengaged easily from the ends of the frame members 29 and 31, even though the latter members may be surrounded by the tank 1 and prevented from moving outwardly relative to each other.

After the main frame 20 has been assembled and firmly secured together by the tie-rods 23 and turn-buckles 24, it assumes the general shape disclosed by Fig. 5 and at this time the tubular

wall of rubber or Neoprene coated fabric referred to above may be placed upon the frame with the opposite open ends of the wall extending laterally beyond the opposite ends of the main frame **20** equal amounts. Next the depressions **4** are formed in the tubular wall at locations immediately adjacent the grooves **26** in the intermediate frame sections. This is accomplished by placing a rope or the like about the fabric, drawing the ends of the rope tightly together to force the fabric into the grooves **26** and tying the rope in this position. When all of the required depressions have been forced into the tubular fabric wall, the outer surface thereof lying intermediate the ends of the frame are coated with several layers of cellulose acetate, the first coat preferably being relatively thin, that is, diluted in a solvent such as ethyl acetate, in order that it may penetrate the interstices of the fabric. It has been found that a total of five coats of cellulose acetate will function as a desirable stiffening medium with the total thickness of the five deposits measuring approximately .005 inch. Besides functioning as a stiffening agent for the fabric, the cellulose acetate inhibits the diffusion of the gasoline, benzene or the like, being used in the tank or lining. Still further, as the fabric coated with cellulose acetate dries it is caused to shrink to some extent, thereby removing any bagginess from the fabric, and at the same time the tear-resistance of the fabric is increased.

The removal of the rope or other binding material from the grooves **26** leaves depressions **4** in the fabric. These depressed portions of the tubular wall are then reinforced by applying another coat of cellulose acetate thereto and adhering strips of the fabric **6** to the cellulose acetate before it has had time to dry. A second strip of fabric **7** of a width slightly greater than that of the strip **6** may also be adhered in a similar manner to the outer surface of each strip **6** by cellulose acetate. After the outer surfaces of these strips **7** have been coated with cellulose acetate to further stiffen them, flat strips of fabric **8** may be adhered by cellulose acetate to the outer surface of the tank in such a manner as to bridge the depressed portions **4** and form reinforcements which permanently maintain the depressed portions in proper shape. The outer surface of the strips **8** are also coated with cellulose acetate.

Pieces of rubber or Neoprene coated fabric **36** are next cut to conform to the shape of the end portions of the main frame **20**, and after the edges and adjacent marginal portions thereof have been coated with a tacky vulcanizable rubber or Neoprene composition, as is shown by the numbers **37** and **38** in Fig. 6, the end portions **39** of the tubular wall extending beyond the ends of the frame **20** are folded over the end pieces **36** and lie against the coated edge portions **38** to form fluid tight joints of substantial width which extend completely around the peripheries of the end pieces at opposite ends of the tank. After the ends of the tank have been so closed to form a complete enclosure, the ends and adjacent portions of the tubular wall are coated with cellulose acetate **5** and allowed to dry. Thus a self-supporting tank or lining is produced.

Vulcanization of the end joints, individually, can be readily accomplished by placing the assembled tank or lining **1** with the frame **20** therewithin, or removed if desired, upon a hot curing plate, weighting the upper end of the tank sufficiently and then piling steel shot or the like five to six inches deep around the outside of the tank to form a heat conductor for the curing operation. The curing operation does not in any way detrimentally effect the fabric **2**, or the rubber coating **3** and the cellulose acetate **5** carried thereby.

Suitable openings **10** are cut in the wall of the substantially completed tank **1** for the attachment of filling pipes, fuel lines and the like, and these openings may be used advantageously for access to the interior. The collapsible and removable frame **20** can thus be readily removed from the tank by first withdrawing the cotter pins **25** and loosening the turn-buckles **24** to relieve the tension on the tie-rods **23**. After the tie-rods **23** and braces **25** have been taken out piece by piece, the removable nuts **35** and angle plates **34** can be removed from the several joints formed in the frame sections **21**. Thereafter the individual frame members **29**, **30**, **31** and **32** can be easily maneuvered around to proper positions and removed individually through the opening **10**.

While it is preferable to vulcanize the various joints of the tank or lining **1** by the application of heat, it should be noted that all such joints could be made with a self-vulcanizing rubber or Neoprene composition, if desired. However, the time of vulcanization in the latter instance is much longer and accordingly objectionable, particularly where the removable form **20** is to be used successively in the production of a number of these tanks.

It will be readily apparent that the puncture-sealing layer **14** and the tear resisting layer **15** may be added as additional enclosures about this self-supporting flexible tank structure **1** before or after the frame is removed from the interior thereof. These layers **14** and **15** are placed closely around the outer surface of the tank **1** by placing a plurality of pieces of such material thereon and cementing their adjacent edges together, but these layers **14** and **15** are not attached to each other nor to the tank **1** for reasons previously described.

Although the invention has been disclosed in connection with the specific details of a preferred embodiment thereof, it must be understood that such details are not intended to be limitive of the invention except in so far as is set forth in the accompanying claim.

Having thus described my invention, what I claim and desire to protect by Letters Patent is:

The method of forming a self-supporting flexible tank or lining comprising the steps of placing pieces of rubber coated fabric material about a collapsible form so as to completely enclose the form and to overlap along their adjacent edges, bonding the adjacent edges together to form fluid-tight tank or lining, coating the exterior surfaces of the fabric with cellulose acetate, cutting one or more openings in the fabric, removing the collapsible frame from the interior of the tank after the cellulose acetate has at least partially dried, applying additional layers of puncture sealing material and tear-resistant material to the exterior of said tank or lining, and cutting openings in said last mentioned layers which are in alignment with the first mentioned openings.

ERNST EGER.