

Sept. 8, 1959

W. H. COBI

2,903,016

FLEXIBLE FLUID PRESSURE CONTAINERS

Filed Nov. 22, 1954

2 Sheets-Sheet 1

Fig. 1.

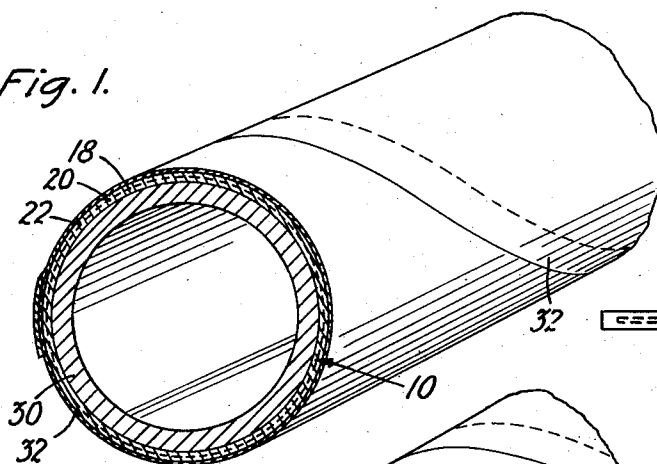


Fig. 2.

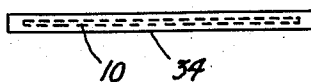


Fig. 3.

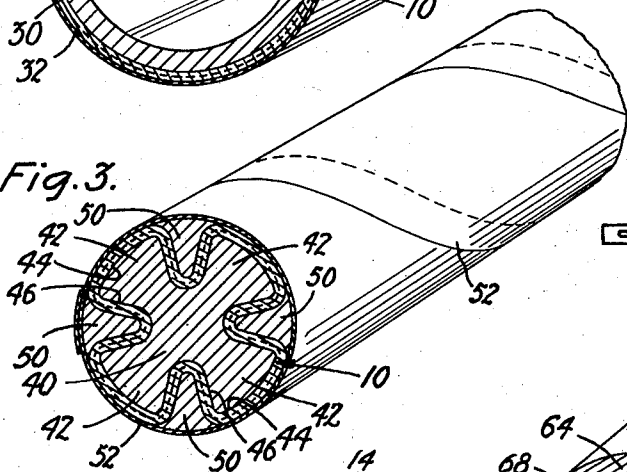


Fig. 4.

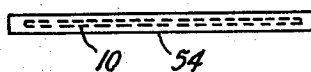


Fig. 5.

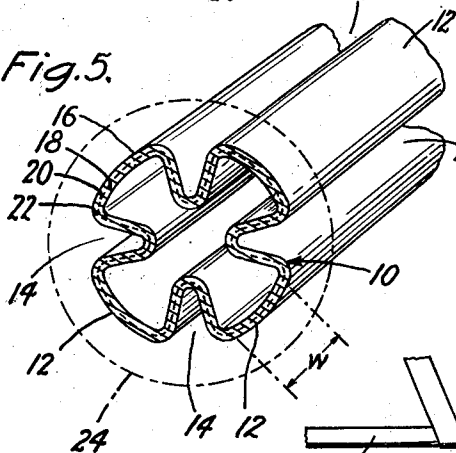


Fig. 6.

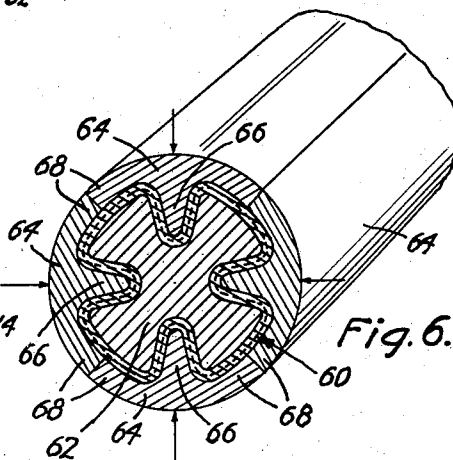
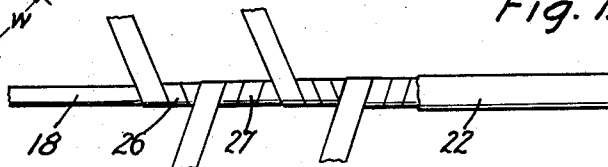


Fig. 7.



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Fig. 8.

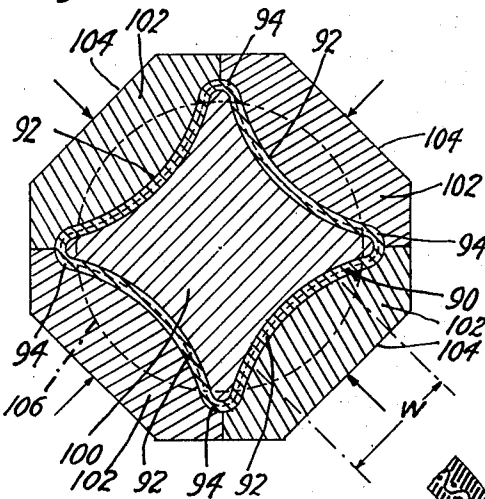


Fig. 9.

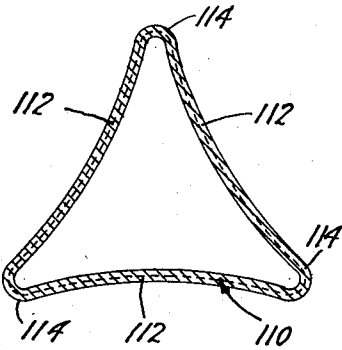


Fig. 13.

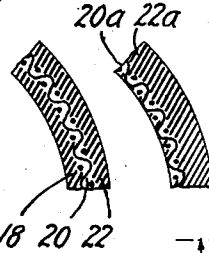


Fig. 14.

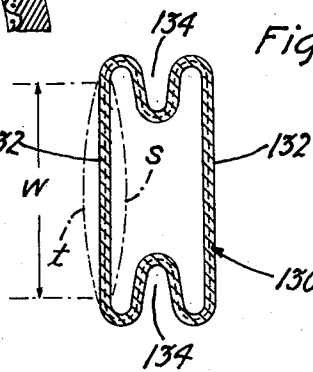


Fig. 11.

Fig. 10.

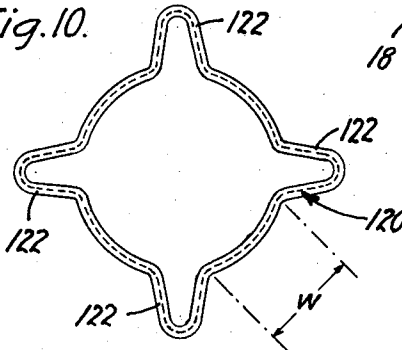
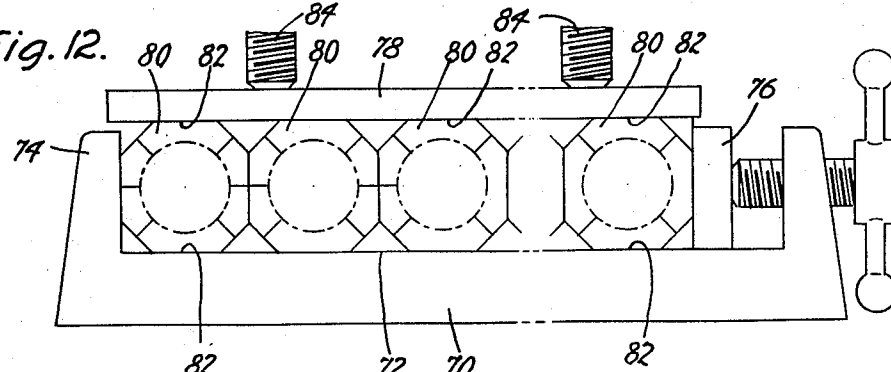


Fig. 12.



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FLEXIBLE FLUID PRESSURE CONTAINERS

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Application November 22, 1954, Serial No. 470,409

6 Claims. (Cl. 138—55)

The invention relates to long, flexible, fluid pressure containers or tubings of rubber-like, fabric-reinforced material, to methods of producing such containers and to means for carrying out the methods.

It is a main object of the invention to provide a container of this type the surface of which includes one or more concave, plane or slightly convex areas throughout a length of the container, the material in the wall of said container being substantially free from blisters.

It is another object to provide a method of substantially preventing the formation of blisters in the wall of containers of this type during the curing process of the fabric-containing rubberlike material.

It is a further object to provide equipment for shaping long concave plane or slightly convex areas in the wall of containers of this type and for applying opposed pressures to both sides of said areas, thereby substantially reducing or eliminating formation of blisters in said areas during the curing process of the fabric-containing, rubberlike material.

In the art of driving cast-in-place concrete piles into the ground an outer steel shell, usually of corrugated sheet, is driven into the ground by a collapsible driving mandrel extending through the interior of the shell to the driving point or boot attached to the bottom end of the shell. Upon collapse and removal of the mandrel the shell is filled with concrete.

A suitable driving mandrel or core for driving such shells or molds is disclosed in Patents 2,312,625, issued on March 9, 1943, and 2,625,015, issued on January 13, 1953. These patents particularly disclose a pneumatic type of collapsible mandrel where pneumatic means, which may comprise one or more long, fluid pressure containers, extend substantially the whole length of the mandrel between sectors of metal bars to press such sectors into operating contact with the inner surface of the shell throughout its length when expanded by fluid pressure. Upon collapse of the pneumatic means a plurality of springs withdraw the sectors from contact with the shell and the driving mandrel may be withdrawn.

The fluid pressure containers used in collapsible driving mandrels of this general type must be of gas proof, flexible material, such as rubber or rubber compounds, cured to a tough yet flexible condition and they must be capable of transverse expansion under internal fluid pressure and of contraction by cured-in inherent forces of the rubberlike material upon removal of the internal pressure.

It has now been observed that, in as much as the container is in intimate contact with elements of the long driving mandrel, it must be an essential requirement that its length should not vary appreciably with the varying internal pressure in order to prevent disfigurement and consequent premature wear and rupture of the container wall, and also to prevent dislocation of the container within the mandrel and interference with connecting parts for the fluid supply. For similar reasons any tendency of the container to twist should be substantially prevented.

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ency of the container to twist should be substantially prevented.

In accordance with a feature of the invention these important requirements are met by making the container wall substantially non-elastic, yet flexible.

This feature may be attained by the use of fabric-reinforced wall material. And it is a more specific feature of the invention that the fabric should be imbedded in the wall material or be on the inner side of the tubular wall. The reason for this is found in the fact that a rubberlike material in pressure engagement with a metal surface tends to effect a very intimate contact therewith, almost resembling an adhesion, so that the surface of the expanded tubing will practically follow the lengthwise oscillations of the long metal elements in the driving mandrel during driving operations. Under such conditions there will be very little tendency to frictional wear of the container wall. On the other hand a fabric material will not exhibit such an intimate contact with a metal surface, so that if placed on the outer side of the tubing wall it would be constantly rubbing and slipping against the engaged surface during driving operations and thus would wear through comparatively quickly.

The fabric must be of a type which will aid in keeping the length of the long container substantially constant during inflation and deflation. It is also a requirement that the fabric shall resist twisting of the long container when pressure is applied. It has been found that fabrics, such as generally used on the outer side of firehose are not suitable for the present purpose, since they have an appreciable factor of lengthwise expansion when the hose is put under internal pressure and also since they readily twist during inflation. Therefore, in accordance with still another feature of the invention the fabric layer of the container wall comprises a plurality of tapes applied to run helically in opposite directions and at substantially the same angle relative to the axis of the tubing. It has been found in general practice that this angle should preferably be between 45 to 60°.

The shape and dimensions of the cross-sectional area of the tubing will of course depend upon the construction, manner of operation and dimensions of the driving mandrel.

Thus the driving mandrel may have two or more sector bars having long surfaces more or less opposed to each other, which are to be forced apart by intervening fluid pressure container means having corresponding effective surface areas.

The non-elastic container means may be expanded by the internal pressure from a certain inherent shape of the cross-sectional area, imparted thereto during curing, and will obviously tend to assume a more circular shape which will effect the desired separation of the sector bars. It has been proposed to use a container with flat areas in engagement with flat surfaces of the sector bars and to bulge the flat surfaces of the container by the internal pressure to separate the flat surfaces of the sector bars. In as much as in such case the effective contacting areas become narrower during expansion and may approach linear contact, a comparatively high pressure will be required to keep the sector bars in tight contact with the outer casting shell.

It is a further feature of the invention to provide a fluid pressure container which, when expanded, will be capable of maintaining the effective contacting area at substantially the same width as in the deflated condition or even at a greater width than in the deflated condition, depending on the shapes of the effective surfaces of the driving mandrel, thereby greatly reducing the fluid pressure required per unit area for the fully expanded condition of the mandrel.

It is therefore a further feature of the invention to

provide a fluid pressure container having one or more effective pressure contact areas along its length in which each contact area is bordered by a fold along its length. With this provision each fold may hold sufficient or excess material between the contact areas to allow for the expansion, so that the contact areas need not become reduced for the fully expanded condition and may even become increased as the fluid pressure within the container is increased.

Turning now to the method of producing fluid pressure containers of the type embodied in the invention it has been observed that appreciable volumes of air become entrapped with the fabric when it is enclosed between layers of uncured rubberlike material or is pressed into the surface thereof.

During the curing process the air tends to expand and, unless special precautions are taken, the air will form large sealed-in blisters in the cured rubber which, as in the case of the container in a driving mandrel or other similar instances, would prevent most of the contacting areas of the container from making the desired close contact with the opposed parts.

In past practice such blister formations have been eliminated or greatly reduced in the case of substantially cylindrical fabric reinforced tubings by subjecting the walls of the tubing to pressure from both sides, as by the use of an inside mandrel and an outside tight fabric wrapping during the curing process, these elements being removed after the curing period. It is obvious that this method is applicable only to tubings having fairly deeply convex surfaces, that is tubings having circular or nearly circular shaped cross-sections, in order that the presser wrapping may be in effective contact with the entire circumference.

It is therefore a further, important feature of the invention to provide a practical method and means for curing a long, fluid pressure container of fabric-containing, rubberlike material and of cross-sectional area the shape of which includes straightline or concave portions or even convex portions with fairly flat curvatures, which will substantially reduce or prevent the formations of blisters within the wall of the container at any portion of the circumference.

It is a special feature of the invention to provide in such instances curing equipment including an internal mandrel for the whole length of the tubing having the outer surface shaped with concave, convex or plane portions, as each case demands, to conform with the desired final shape of the tubing, and including external presser bars for the whole length of the tubing having surfaces facing the tubing shaped with plane or convex surfaces or even with concave surfaces, as each case demands, to conform with corresponding final plane, concave or convex surfaces of the tubing wall. When, for example, a semicircular tubing is placed on the internal mandrel and the outer presser bars are pressed in position to reshape the tubing with folds or plane surfaces, the entire assembly may be shaped to resemble a body of substantially circular cross-section, and it may then be effectively subjected to external pressure, as by a presser wrapping of strong fabric. Thus substantially every point of the container wall will be subjected to opposed internal and external pressures during the final curing stage which will substantially reduce or prevent formation of blisters. In particular instances the presser bars may during final curing be held under pressure in a jig or other mechanical device rather than by a presser wrapping.

It is of course possible to shape the uncured wall as desired by means of a similar inner mandrel and similar presser bars, as referred to above, and then to subject the entire assembly to a complete curing process.

The assemblage of tubing with mandrel and presser bars lends itself to curing process involving either simultaneous curing of the whole length of the tubing or continuous progressive curing of successive sections thereof.

The features and advantages of the invention will be

better understood from the following description and the accompanying drawings which disclose preferred practical embodiments thereof. It should be understood that the invention is not intended to be limited by the terms or expressions used in this description, nor by the specific details or arrangements of parts shown in the drawings. The scope of the invention in its various aspects is defined by the attached claims.

In the drawings:

Fig. 1 shows in cross section a container on a circular mandrel and wrapped ready for pre-curing;

Fig. 2 shows diagrammatically the assemblage, shown in Fig. 1, within a pre-curing oven;

Fig. 3 shows in cross section the container in Fig. 1 reshaped on a grooved mandrel, with outer presser bars and wrapping ready for final curing;

Fig. 4 shows diagrammatically the assemblage, shown in Fig. 3 within the final curing oven;

Fig. 5 shows in cross section the finished grooved container, with an indication of its shape and relative size when fully inflated by an internal pressure;

Fig. 6 shows in cross section a container substantially similar to that shown in Fig. 3 and with grooved mandrel and modified presser bars, but without outer wrapping, before final curing;

Fig. 7 shows a portion of a container in the course of being built up from layers of uncured rubberlike material and fabric wrappings;

Fig. 8 shows in cross section a container reshaped to have four ridges on an inner mandrel with modified outer presser bars, before final curing;

Fig. 9 shows a cross section of a container similar to that in Fig. 8 but having three ridges;

Fig. 10 shows a cross section of a container similar to that in Fig. 5 but having external ridges;

Fig. 11 shows a cross section of a flat type grooved container;

Fig. 12 shows in cross section a pressure jig for applying pressure simultaneously to a plurality of containers with outer presser bars, such as shown in Figs. 6 and 8, the entire assemblage being adapted to insertion into a final curing oven.

Fig. 13 shows a section of the container wall in which the fabric is located between an inner and an outer layer of rubberlike material.

Fig. 14 shows a similar section in which the fabric layer is located at the inner surface of the wall.

An example of a tubular container embodying features of the invention is shown in Fig. 5. The container here shown partly in cross section and partly in perspective, is of a generally tubular shape, approaching the cylindrical shape. It has four external surfaces 12 with a common radius separated by four fairly deep grooves 14 throughout its length.

The wall 16 of the container, as shown in simplified form, comprises an inner layer 18 and an outer layer 22 of flexible material and an intermediate layer 20 of strands of thin, strong yarn.

It should be understood that these details of shapes, dimensions and layers are of importance only for the useful or effective length of the container and do not necessarily apply to end portions which may be modified for purposes of manufacturing or of mounting for practical use.

In a preferred form the material in layers 18 and 22 is of a rubberlike composition capable of heat curing for imparting thereto an inherent or cured-in tendency to retain any particular wall thickness and wall shape given thereto during the final curing. This material may include rubber, neoprene, Buna or other similar substances in any suitable proportions and should of course include such other ingredients as are well known in this art for curing of the said substances. In instances when the container will be subject to continuous severe surface wear in use, as in a driving mandrel, it may be

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desirable to add an abrasive agent to the compound to prolong the life of the container.

A long tubing or container, such as shown in Fig. 5 may be expanded throughout its length by the application of an inner fluid pressure. When fully expanded it will tend to assume a circular shape of increased diameter, as indicated by the dot-dash circle 24. However when the tubing is used to exert an outward force against external elements of a device, as for example, the four sector bars in a driving mandrel referred to herein before, the expanded shape will of course depend to a large extent upon the shape of the contacting surfaces of those elements.

Assuming therefor that the surfaces 12 in relaxed condition lightly contact the metallic surfaces over a width w , it will be apparent that during expansion this contact width will be maintained, since the folds 14 will allow for the separation of adjacent wall areas 12 until the maximum expansion circle 24 is reached.

Upon contraction the relaxed cured-in shape will be resumed.

In the production of a tubular container of the type shown in Fig. 5 a special problem arose, because air entrapped with the layer of strands 20 tends to expand during exposure to curing temperature, thereby tending to form blisters in the wall material which will appear on the outer wall surface. Such blisters would interfere with smooth contacting with metallic operating surfaces and would seriously shorten the life of the tubing.

It is therefore important to prevent formation of blisters during the curing. Thus, in the manufacture of a container of the type shown in Fig. 5 the following procedure may be followed.

Referring to Fig. 1 the wall of the tubing 10 is formed of layers of uncured material 18 and 22 with the intervening layer of strands 20 about a long cylindrical shaping mandrel 30.

The mandrel 30 is of a size to form the tubing 10 with a diameter substantially equal to that of the expanded circle 24 in Fig. 5. The purpose is to procure the tubing in this form to reduce softness of the material which will aid in working the tubing into its final shape.

In order to eliminate the possibility of blistering during the precuring stage the wall 10 on mandrel 30 is covered with a tight wrapping 32 with overlapping helical turns of a strong fabric. This wrapping will exert center-directed forces against the whole outer surface of the wall, which thus will be prevented from blistering due to the inner and outer pressures on the rubberlike material.

The long assemblage with the tubing 10, shown in Fig. 1, is then inserted in or passed through an oven 34, shown diagrammatically in Fig. 2, for precuring.

Upon cooling, the wrapping 32 is removed and the shaping mandrel 30 is withdrawn from the container 10 and replaced by a different shaping mandrel 40, shown in Fig. 3.

The long shaping mandrel 40 is of cross-sectional shape and dimensions corresponding to the inner surface of the finished container 10, as shown in Fig. 5.

The mandrel 40 thus has four sections 42 with outer surfaces 44 fitting a generally cylindrical shape and separated by four grooves 46 with tapering sides.

The precured tubing 10 may now be laid against the surfaces 44 with folds extending into the grooves 46.

A set of four presser bars 50 with tapering sides are then forced into the said folds in grooves 46 for shaping of them into grooves 14 of the container 10, in conformity with the final shapes shown in Fig. 5.

The assemblage thus obtained presents an outer substantially continuous cylindrical surface over which is placed a tight wrapping 52 with overlapping helical turns of a strong fabric. This again is for prevention of

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blistering during the final curing stage. The center-directed forces of this wrapping will press directly against the cylindrical portions of the tubing wall opposite the surfaces 44 of the mandrel 40. There will be similar center-directed forces acting on the wedge shaped presser bars 50 which thus will be kept in position as shown, to confine the wall material in the grooves 46 to the predetermined thickness, thereby preventing blistering also in these areas.

The long wrapped assemblage with the shaped tubing 10, shown in Fig. 3, is then inserted in or passed through an oven 54, shown diagrammatically in Fig. 4, for final curing, and after cooling the wrapping and the presser bars and shaping mandrel are removed from the tubular container 10, which thus will have the cured-in shape shown in Fig. 5 and which will have substantially blister-free surfaces.

The container 10 in the uncured form, shown in Fig. 1, may have its wall built up by first applying the layer 18 of the rubberlike material to the shaping mandrel 30, then tightly applying two helical tape wrappings 26 and 27 with opposite directions of lay and with some overlap, as shown in Fig. 7, to form the layer 20 and then by applying the outer layer 22 of the rubberlike material. Additional helical wrappings may be applied before the layer 22, if required. A sample of the resultant wall construction is shown in Fig. 13.

The tape used in the wrappings 26 and 27 which constitute the layer 20, is preferably made of woven strands of thin, nylon yarn in order that the wall of the container may be kept as thin as compatible with the required strength of the wall. The rigidity secured by the opposed helical turns of the tapes 26 and 27 serves to prevent any substantial change in the longitudinal dimension of the container and to prevent any substantial twisting of the container tubing when the container is being inflated or deflated to its extreme cross-sectional dimensions.

The angle of helical application of the tape relative to the axis of the container may therefore be between 45 and 60 degrees, and in the case of tape woven with longitudinal and transverse strands the preferred angle is about 54 degrees, as known to the art.

Alternatively the layer of strands 20 may be tapes wrapped directly upon the shaping mandrel 30 before application of the rubberlike material. A sample of this wall construction is shown in Fig. 14 with the inner fabric layer 20a and outer layer 22a of rubberlike material.

In the specific case of a container 10 with a diameter of about 4 inches when deflated as shown in Fig. 5, the manufacturing length may conveniently be 10-15 feet. With the necessary depth of the folds 14 the container may be expanded to have a diameter of 5-7 inches. The wall thickness may be $\frac{1}{8}$ - $\frac{1}{4}$ inch, which will enable the container to withstand with unbacked wall an internal fluid pressure up to 500 lbs./sq. inch for which purpose the wall should have 3-4 wrappings of nylon tape.

In the case of simple forms, as with comparatively wide and shallow grooves, the precuring stage may be omitted and the layers of the container wall applied directly to the final shaping mandrel 40 for complete curing under pressure from the bars 50 and wrapping 52.

The tubular container 60, shown in Fig. 6 is of nearly the same shape as container 10 in Fig. 5 and is shown in the shaping stage corresponding to Fig. 3. The shaping mandrel 62 is similar to the mandrel 40, but each of the presser bars 64 has a ridge 66 projecting inwards for shaping of the folds of the container and is extended to both sides along the outer surfaces of the container. The bars 64 thus meet at their edges 68 when pressed into position, and in this condition fit snugly all along the outer surfaces of the container, the mandrel fitting snugly along the inner surfaces of the container.

During the final curing the bars 64 may be held in position by a tight tape wrapping on the outer, substantially cylindrical surface presented by the bars, corresponding

to the wrapping 52 in Fig. 3, thereby opposing formation of blisters.

The assemblage shown in Fig. 6, forming a rigid structure, may be held together by other means than a tape wrapping. It might be tied together by wires about the outer surface at intervals along its length, or the assemblage may be placed between clamps to receive pressures at points and in directions as indicated by the arrows in Fig. 6.

Thus referring to Fig. 12, a suitable jig 70 is provided for the reception of the whole lengths of a plurality of assemblages 80, each corresponding to that shown in Fig. 6, arranged side by side on the bottom 72 of the long jig. For the present purpose it may be of advantage to shape the outer surface of each presser bar 64 with a plane area, as indicated at 82 in Fig. 12. The units or assemblages 80 may then be pressed together horizontally and along their whole length between a fixed barrier 74 and an adjustable bar 76, and vertically between the bottom 72 and a top plate 78, which may be weighted or otherwise pressed against the units, as by clamping screws 84 suitably mounted. The whole jig with assemblages may then be placed in a final curing oven, such as 54 in Fig. 4.

Fig. 8 shows a diamond shaped container 90 having four slightly concave sides 92 bordered along the length of the container by four ridge portions 94. The container may be assumed to have been built up in the same manner as the tubing 10 in Fig. 1. Fig 8 shows the tubing 90 in the assemblage of inner shaping mandrel 100 and outer presser bars 102, which fit tightly against the concave surfaces 92 and abut along their edges. The presser bars have flat outer surfaces, corresponding to the surfaces 82 in Fig. 12, so that a plurality of assemblages may be placed in a clamping jig, such as jig 70 in Fig. 12, for simultaneous final curing of the tubings without formation of blisters in the rubberlike material.

The tubing 90 may be assumed to present four nearly flat effective surfaces each of a width w as indicated in Fig. 8. When the tubing is fully inflated the shape and size will be as indicated at 106, with the effective surfaces remaining of the same width and the ridges withdrawn to fill in between the surfaces. When the tubing is operated within a driving mandrel with four sector bars having contacting surfaces of the same width w but of a different curvature, the contact under deflated condition may be limited, but will increase with the expansion to assume the full width w at a predetermined inner pressure.

Fig. 9 shows the cross-section of a tubing 110 with three sides 112 of the same general shape as the sides 92 of tubing 90 and separated by three ridge portions 114. The tubing may be produced and will function substantially in the same manner as described for tubing 90.

Fig. 10 shows the cross section of a tubing 120 of generally circular shape similar to tubing 10 but having four ridges 122 instead of the grooves 14 in Fig. 5. This container presents effective contact surfaces of width w similar to tubing 10 and during expansion the wall portions in the ridges will flatten, thereby permitting separation of the contact surfaces, which thus will retain their width.

Fig. 11 shows the cross section of a tubing 130 with only two flat effective contact surfaces 132 separated by grooves 134. The container is shown with plane contact surfaces, but may have concave surfaces s or convex surfaces t , as indicated by dot-dash lines for one side in Fig. 11. With any of these shapes the effective width w may be the same in deflated and inflated condition, the wall portions in the grooves 134 allowing for considerable separation of the two contact surfaces 132. The grooves 134 may of course also here be replaced by ridges.

The containers 120 and 130 may be produced in the same manners as described for the tubings 10 and 60. Thus for the final curing either tubings will surround a shaping mandrel and will be surrounded by tightly contacting presser bars, shaped to conform with the shapes

of the surface portions of the tubings, which they engage and confine. The bars may be held in position during final curing by an outer strong wrapping, as in Fig. 3, or in a jig, such as shown in Fig. 12.

The data given hereinbefore for the tubing 10 hold in substantially all respect for the tubings 60, 90, 110, 120 and 130.

It should be understood that fluid pressure containers in accordance with the invention may have other shapes and proportions than those shown in the drawing, for adaptation to various uses and devices and yet be included within the scope of the invention as defined in the appended claims.

I claim:

1. A tubular fluid pressure container for use as an expander comprising a wall of heat-cured rubber having embedded therein inside its outer surface a fabric reinforcement layer, said container having a plurality of pre-set, substantially flat, radially movable elongated contact areas on the outer face of said container, said contact areas extending substantially longitudinally only of said tubular container with the marginal edges of adjacent contact areas spaced peripherally from each other about the longitudinal axis of said tubular container and a pre-set, longitudinally-disposed folded portion joining adjacent marginal edges of each pair of adjacent contact areas, each one of said folded portions comprising a first portion extending angularly from the marginal edge of one of said pairs of adjacent contact areas and a second portion extending angularly from the marginal edge of the other of said pairs of adjacent contact areas, said first and said second portions being interconnected along a line extending axially only along said tubular container and spaced radially from the marginal edges of said substantially flat contact areas and forming a fold between each of said pairs of adjacent contact areas, said contact areas comprising at least forty percent of the peripheral area of said container when said container is deflated, said fold spreading as said container is inflated and contracting as said container is deflated, said substantially flat contact areas moving outward as said container is inflated and inward as said container is deflated without substantial change in shape to thereby transmit across the face of said contact areas, during inflation, an expanding force which is proportional to the fluid pressure within the container.

2. A tubular container constructed according to claim 1 having two substantially flat longitudinally disposed contact areas of equal width and two longitudinally extending fold portions, one of which joins the adjacent edges of said two contact areas and the other of which joins the other adjacent edges of said two contact areas, said flat contact areas lying in parallel planes when said container is in deflated condition.

3. A tubular container according to claim 2 in which said fabric reinforcement layer comprises at least two woven fabric tapes initially wound helically in overlapping relation and in opposite directions.

4. A tubular container according to claim 1 having four contact areas of equal width arranged symmetrically in a periphery about the central axis of said container and four longitudinally extending fold portions arranged symmetrically about said axis and each of which fold portions joins with adjacent edges of said contact areas.

5. A tubular container according to claim 4 in which said fabric reinforcement comprises at least two woven fabric tapes wound helically in overlapping relation and in opposite directions.

6. A tubular container according to claim 1 in which said fabric reinforcement layer comprises at least two woven fabric tapes initially wound helically in overlapping relation and in opposite directions.

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