**Title:** FIBRE WOUND VESSEL

There is provided a vessel (10) comprising a plastics container (12) overwound with fibre to provide a first layer (35) of threads (32) overlain by a second layer (37) of hoop wound threads, wherein the threads within the first layer (35) are laid in at least two different orientations thereby to lock the threads in a fixed relationship to each other. The threads within the first layer are formed as a plurality of bands (34, 34'), each band containing threads of one orientation. If the container should be subjected to large external forces sufficient to crush the container over at least part of its surface, such a loose wound fibre wrap maintains its structural integrity with the threads remaining in a fixed relationship to each other and is sufficiently flexible that the container can restore to its original shape over time.
Fibre wound vessel

Field of the invention
This invention relates to a fibre-wound vessel comprising a plastics container for
holding liquid and/or gaseous substances, if desired under pressure.

Background to the invention
Pressure vessels overwound with fibre to reinforce them generally have the fibre
secured permanently in position with a binder or resin so as to create a substantially
rigid casing which can resist high pressures and is resistant to impact damage. If the
impact damage is such as to crush the fibre casing, the casing breaks and the vessel
must be replaced.

It is an aim of the present invention to provide a vessel that has a substantially rigid
casing that is resistant to externally applied forces but maintains its structural integrity
if crushed.

Summary of the invention
In accordance with one aspect of the present invention, there is provided a vessel
comprising a plastics container overwound with fibre to provide a first layer of
threads overlain by a second layer of hoop wound threads, wherein the threads within
the first layer are laid in at least two different orientations thereby to lock the threads
in a fixed relationship to each other. The threads are held in a fixed relationship by
intermeshing of the threads and thus no matrix material, such as resin or adhesive, is
needed to bond all the threads to one another as a rigid casing. Such a loose wound
fibre wrap is able to reinforce a pressurised container and to protect the container
from deformation by externally applied forces. If the container should be subjected to
large external forces sufficient to crush the container over at least part of its surface,
then the energy associated with the external force is dispersed throughout the wrap
surface, such that the wrap maintains its structural integrity with the threads remaining
in a fixed relationship to each other and is sufficiently flexible that the container can
restore to its original shape over time. By allowing dispersal of energy throughout its
structure, the fibre wrap thus enables the vessel to be crush resistant and comply with
official regulations relating to crush resistance, such regulations being mandatory for fire extinguishers and the like.

Typically the threads in the first layer form a continuous surface, covering all of the container surface area.

Preferably the threads within the first layer are formed as a plurality of bands, each band containing threads of one orientation. The bands form a continuous surface again, with typically each band overlying or overlain by a plurality of other bands.

The vessel may desirably be a pressure vessel containing pressurised substances or substances that will become pressured just before or at discharge. In particular the pressure vessel may be a fire extinguisher.

A proportion of the threads in the first and second layers may be further secured by a permanently flexible adhesive, typically a water-based latex adhesive. Typically the adhesives will be applied to the container before the fibre is wound, the adhesive being positioned over between 1 to 20% of the surface area of the container. The adhesive must be permanently flexible to ensure that the fibre wrap is able to restore its shape with the container after crushing.

When the vessel is under internal pressure, preferably the fibres in the first layer are loaded in both their axial and longitudinal directions.

The invention also lies in a method of manufacturing a vessel comprising a plastics container overwound with fibre, wherein the method comprises the steps of:

(1) winding threads in at least two different orientations to form a first layer;
(2) winding a second layer of hoop wound threads over a substantial portion of the first layer.

The method may further comprise applying a permanently flexible adhesive, typically a water-based latex adhesive, over at least one separate region of the container prior to
winding of the thread. The adhesive will preferably be applied to between 1 to 20% of the surface area of the container.

The invention will now be described by way of example, and with reference to, the accompanying drawings in which:
Figure 1 is a sectional view of a vessel in accordance with the present invention;
Figure 2 is a perspective view of the vessel during manufacture showing winding of a first layer of fibre threads;
Figure 3 is a perspective view of the vessel during manufacture showing winding of a second layer of fibre threads; and
Figure 4 shows an alternative embodiment of the vessel.

Description
A vessel in accordance with the present invention is shown in Figure 1. The vessel 10 comprises an inner container 12 with dome-shaped end portions 14, 16 and a central cylindrical section 18 and is made from blow-moulded or rotation-moulded plastics material. The container 12 holds substances such as gas, liquids, and/or powders. A metal collar 20 is screwed onto a neck 22 of the container 12 and attached to both the container 12 and collar 20 is a release mechanism 24 for dispensing the contents of the container, and which, if required, has a pressure gauge 26. A fibre wrap 28 surrounds the container 12 and if desired is in turn encompassed by a protective sleeve or coating 30. The release mechanism 24 is shown by way of example, there being a number of different types of release mechanism available depending on the substances held in the vessel and whether these substances are pressurised.

The fibre wrap 28 flexibly encases the container 12 and strengthens container 12 such that it can resist deformation from internal pressures and externally applied forces, is able to maintain its structural integrity if crushed. The container can hold non-pressurised substances, pressurised substances in the range greater than 0 to 900 bar or substances that are pressurised before or upon discharge. Thus by way of example, the container can be used for fire extinguishers with pressures around 6 bar, gas containers, hot water tanks and air brake accumulators.
Figure 2 shows the container 12 as fibre thread 32 is continuously wound at an angle to the central cylindrical axis from one domed end 14 to the other domed end 16. The fibre thread 32, such as Aramid fibres or similar, is secured to the container, typically by the thread being tied to itself, and the thread 32 is continuously wound around the container to give broad diagonal bands 34, 34' of closely spaced parallel fibres, there being two sets of bands orientated at different angles to the central axis, such that each band overlays or is overlain by a plurality of other bands. Winding continues until the diagonal bands overlay the entire surface of the container and form a first continuous layer 35 of threads.

After the container 12 and base of collar 20 are fully encased by the first layer 35 of angled bands 34, 34', the thread 32 is wound around cylindrical section 18 in a series of hoop windings 36, see Figure 3, until the full length of the cylindrical section 18 is covered by a second layer 37 of hoop wound thread. Layer 37 is shown partially completed in Figure 3.

By having a series of differently orientated, overlying bands 34, 34', the overlying threads mesh with each other and interlock, holding the threads in a fixed relationship to one another without the need for a binding matrix of resin or adhesive. The threads thus retain the correct orientation to strengthen the container 12 even if crushing occurs. This is particularly important if the container holds pressurised substances as if the wrap structure is compromised by displacement of threads, the internal pressure may cause container 12 to deform and even to rupture. If crushing does occur, the inner container 12 will be temporarily depressed in the region where crushing occurs, with the energy from the crushing force spread throughout the flexible wrap such that the wrap does not split in the region where the force is applied. After the crushing force is removed, the vessel will gradually restore to its original volume (under pressure from the internal contents when it is pressurised), with the fibre threads 32 retaining their orientation with respect to each other and maintaining the integrity of the wrap structure both during crushing and as the original container shape is restored. The container is thus able to comply with regulations relating to crush resistance which are particularly important in the field of fire extinguishers.
In another embodiment, small regions of adhesive are applied to container 12 before the fibre is wound, the adhesive being a thin permanently flexible adhesive, such as water-based latex adhesive, which permeates the fibre threads directly above it and retains a permanently flexible bond which further ensures that the fibres are kept in the correct orientation whilst still being able to flex with any deformation of the container. In Figure 4 adhesive is shown applied as two annular bands 38, 38' at distal and proximal ends of the cylindrical section 18.
Claims

1. A vessel comprising a plastics container overwound with fibre to provide a first layer of threads overlain by a second layer of hoop wound threads, wherein the threads within the first layer are laid in at least two different orientations thereby to lock the threads in a fixed relationship to each other.

2. A vessel according to claim 1, wherein the threads in the first layer form a continuous surface, covering all of the container surface area.

3. A vessel according to claim 1 or claim 2, wherein the threads within the first layer are formed as a plurality of bands, each band containing threads of one orientation.

4. A vessel according to any of the preceding claims, wherein a proportion of the threads in the first and second layers may be further secured by a permanently flexible adhesive.

5. A vessel according to any of the preceding claims, wherein when the vessel is under internal pressure, the threads in the first layer are loaded in both their axial and longitudinal directions.

6. A vessel according to any of the preceding claims, wherein the vessel is a pressure vessel.

7. A vessel according to claim 6, wherein the pressure vessel is a fire extinguisher.

8. A method of manufacturing a vessel comprising a plastics container overwound with fibre, wherein the method comprises the steps of:
(1) winding threads in at least two different orientations to form a first layer;
(2) winding a second layer of hoop wound threads over a substantial portion of the first layer.
9. A method of manufacturing a vessel according to claim 8, wherein the method further comprises applying a permanently flexible adhesive over at least one region of the container prior to winding of the thread.
**A. CLASSIFICATION OF SUBJECT MATTER**

**INV.** F17C1/06

According to International Patent Classification (IPC) or to both national classification and IPC

**ADD.**

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

F17C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

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Further documents are listed in the continuation of Box C. See patent family annex.

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

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**Date of the actual completion of the international search**

18 November 2010

**Date of mailing of the international search report**

06/12/2010

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**Authorized officer**

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