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H. SCHNEIDERMAN ET AL

3,021,241

METHOD OF FORMING PERFORATED REINFORCED PLASTIC CONTAINERS

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3 Sheets-Sheet 1

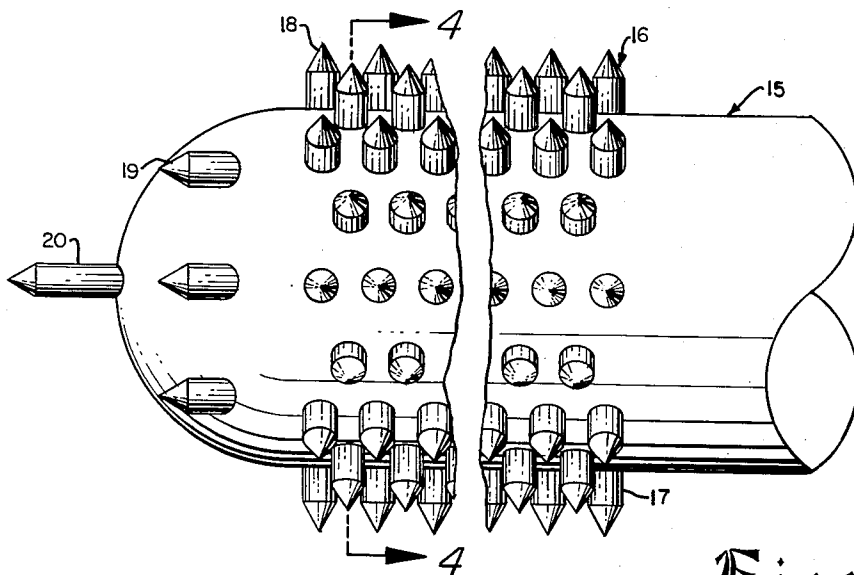


Fig. 3

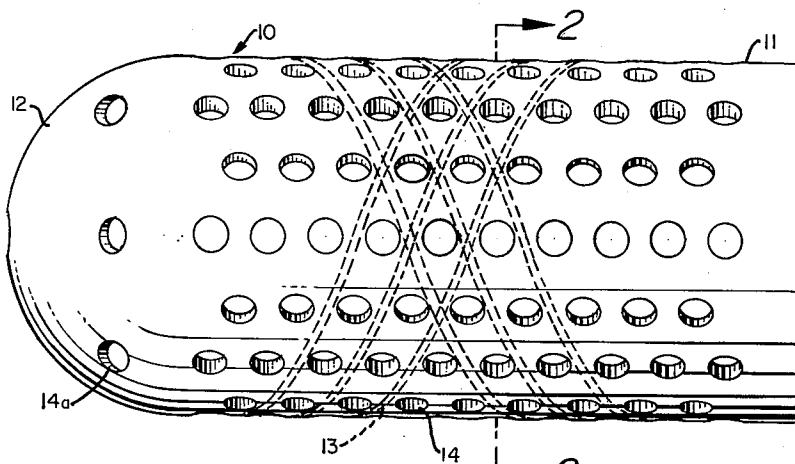


Fig. 1

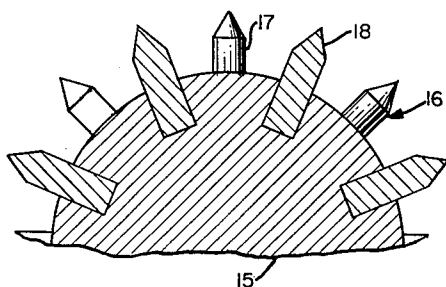


Fig. 4

INVENTORS
HERMAN SCHNEIDERMAN
ROBERT H. BENDARZEWSKI
JOHN D. BARNEY

BY

J. Gordon Rogers
ATTORNEY

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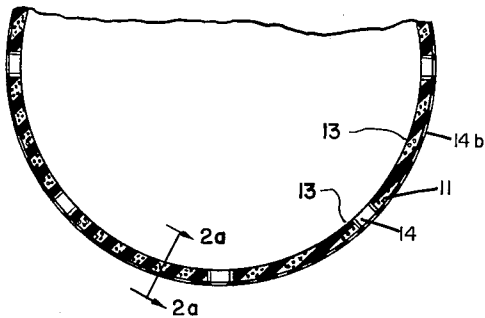


Fig- 2

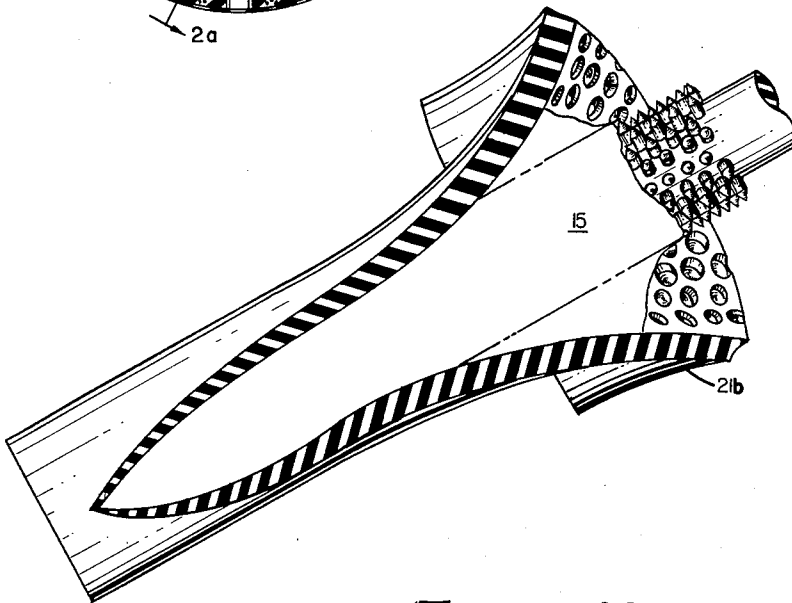


Fig- 5

INVENTORS
HERMAN SCHNEIDERMAN
ROBERT H. BENDARZEWSKI
JOHN D. BARNEY
BY
D. Gordon Angus
ATTORNEY

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H. SCHNEIDERMAN ET AL

3,021,241

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3 Sheets-Sheet 3

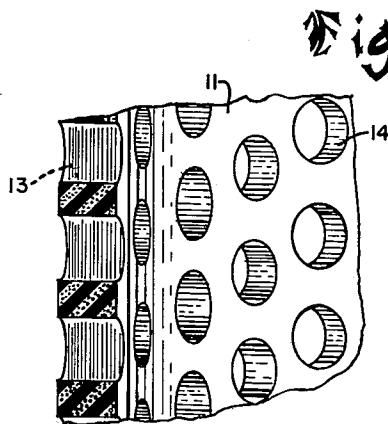
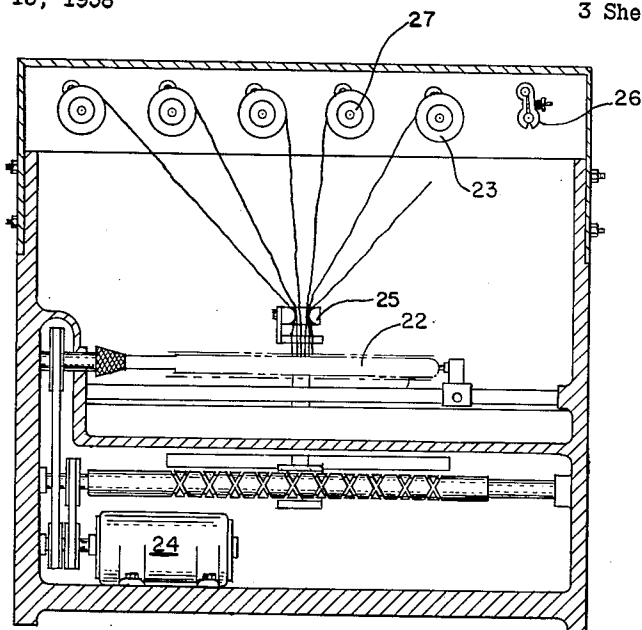


Fig-2a

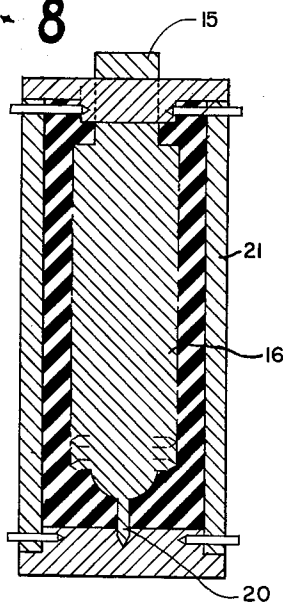


Fig-6

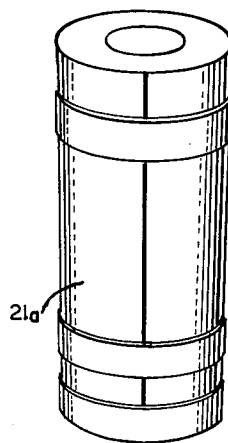


Fig-7

INVENTORS
HERMAN SCHNEIDERMAN
ROBERT H. BENDARZEWSKI
JOHN D. BARNEY

BY

J. Gordon Rogers
ATTORNEY

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METHOD OF FORMING PERFORATED REINFORCED PLASTIC CONTAINERS

Herman Schneiderman, Arcadia, Robert H. Bendarzewski, Monrovia, and John D. Barney, Altadena, Calif., assignors to Aerojet-General Corporation, Azusa, Calif., a corporation of Ohio

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9 Claims. (Cl. 156—173)

This invention relates to perforated containers and particularly relates to such containers produced from plastic impregnated material, and to a method of producing them.

The general object of the invention is to provide containers of light-weight but superior strength and having characteristics when exposed to flame and high temperatures of several thousand degrees which render them particularly valuable for use as igniter containers for liquid or solid propellant rocket charges; but it is to be understood that such containers are capable of many other uses in industry or in the home.

The novel container constructed according to the invention will therefore be described hereinafter as an igniter container or basket for liquid or solid propellant rockets by way of illustration, but not as limitative of the invention.

Igniter baskets for solid propellant rockets are conventionally made of metal or wire mesh and are used to position a body of highly combustible material in the combustion chamber of the rocket, usually projecting into an opening in the solid propellant or "grain."

The igniter basket should retain the combustible charge until completely consumed and should not become broken up or disintegrated since the impact of pieces of the container on the grain or upon the exhaust nozzle is undesirable, hile ejection of fragments of the basket from the rocket may constitute a serious hazard. The igniter baskets at present in use often do not meet these requirements.

An object of the invention is to provide a perforated container which possesses much lower heat transfer characteristics than one made of metal and will not melt when exposed to flame, but may burn at a very slow rate, thus producing only gas but no liquid droplets, although possible minute liquid glass particles may be formed which cannot have any adverse effects in the combustion chamber.

A further object is to produce a perforated container which possesses sufficient strength to resist fragmentation under the stresses to which it is subjected.

Another object of the invention is to provide a novel method of producing a perforated container of the kind described.

With the above objects in view the invention comprises a container made of plastic impregnated glass fiber rovings laid in elongated lengths to secure optimum hoop and longitudinal strength and in a pattern such as to provide a multiplicity of openings in its surface, and also comprises the novel method of producing such containers.

In the drawings:

FIG. 1 is a perspective view of a perforated container constructed according to the invention, the direction of glass fiber rovings being indicated thereon by dotted lines.

FIG. 2 is a fragmentary cross section on the line 2—2 in FIG. 1, drawn on a larger scale than FIG. 1.

FIG. 2a is a fragmentary perspective view of a piece broken out from the curved wall of a completed container.

FIG. 3 is a side elevation of a master core utilized in

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the novel method of forming the container, the view being broken to reduce its length, and the drawing being on a larger scale than FIG. 1.

FIG. 4 is a cross section on the line 4—4 in FIG. 3.

FIG. 5 is a perspective of a polyvinyl chloride mold made from the master core and in which a reproduction of the master core is made in low melting point metal. The mold is shown cut along one longitudinal line and is being stripped from the master core.

FIG. 6 is a vertical section through a cylindrical demountable mold in which a master core is enclosed and polyvinyl chloride or other suitable material poured around it to produce a production mold, drawn on a reduced scale.

FIG. 7 is a perspective view showing the polyvinyl mold after being split and stripped off the master mandrel, inserted in a thin split metal tube held closed by rings and the bottom closed by a cap, low melting point metal being then poured into the production mold to form a mandrel or core on which the container is wound and drawn on a smaller scale.

FIG. 8 is a front elevation partly in section of a machine on which the low melting point core is used as a mandrel on which is wound a covering of glass fibers impregnated with thermosetting plastic. The glass fibers are drawn from a plurality of spools provided with adjustable brakes by which a desirable tension is maintained on the glass fibers.

Referring now to FIG. 1, the container or igniter basket indicated at 10 is formed as an elongated cylindrical member having its sidewall 11 and end wall 12 integrally formed by rovings 13 of glass fibers impregnated with a thermosetting resin. The thickness of the wall of the container is controlled by the number of layers of roving which in a typical container may be, for instance, twenty.

The roving is helically wound alternately in opposite directions at an angle which affords maximum combined hoop and longitudinal strength, an angle of about 55° to the longitudinal axis having been determined to give good results in practice. The roving is laid evenly from end to end in a criss-cross pattern which results in reinforcement of the entire wall of the container except for symmetrically arranged apertures 14 through the wall which are formed by the method of producing the containers and not by piercing the walls. A typical thickness of wall may be .16".

The cylindrical container or basket when first produced may have a somewhat uneven surface, which may not be disadvantageous for certain uses, but since it is important in use as an igniter basket that the structure should be produced to accurate dimensions, the basket is machine finished, and may be either threaded exteriorly or internally for mounting in position, or may be fitted with a metal flange at its base secured by a suitable adhesive to the base of the cylindrical member.

The container is wound on a core made of a low melting point material, this core being formed with a pattern of projecting points 18 which produce the pattern of openings 14 in the wall of the container; and of projecting pins 19 and 20 which produce the pattern of openings 14a in the end of the container.

The low melting point core is used as a mandrel rotated between centers on a lathe-like machine having a traveling roving-feeding head traversed back and forth over the rotating meltable core to lay the impregnated fibers criss-cross thereon, the roving preferably being laid in a number of parallel strands encircling the container both clockwise and counterclockwise, and under sufficient tension to be evenly laid on the mandrel and in order to obtain a suitable glass fiber content in the container wall.

The rovings may be impregnated with the plastic in any

suitable way that will thoroughly fill all voids in the layers of rovings on the mandrel. 40% glass and 60% plastic, as a composition for the basket, gave best heat transfer for use in one particular rocket engine, but not necessarily for other uses or when used in other engines. When winding is complete, the mandrel is removed and the resin impregnated article is cured. The core with the cured plastic thereon is then machined to accurate outside dimensions, for instance by a sander, and the low melting point core is then melted out at a higher temperature than used to cure the resin.

Method

The perforated reinforced plastic container previously described may be manufactured in various ways, but the method now to be described has produced large numbers of rocket igniter containers or baskets which satisfactorily met the requirements of the specifications to which they were made.

A master core is first made from a cylindrical metal member 15, such as mild steel rod, the dimensions of which depend on the size and aperture arrangement of a batch of containers to be fabricated.

As shown in FIG. 3 the master core 15 is a relatively long and narrow member which is to produce containers having 8 holes in each circumferential zone, half of the projections being shown in FIG. 4, and the holes in each zone being located between those in the zones on either side. To produce these holes, the member 15 is drilled at the requisite points to receive pins 16 having cylindrical portions 17 projecting from the surface of member 15 to a height at least that of the rough finished thickness of the basket. The pins are tapered to points 18 above the cylindrical portion. One end of the master core may be rounded and also fitted with similar pins 19, the opposite end of member 15 being left plain for a distance sufficient to serve for handling the member. A center pin 20 of greater length than the other pins is inserted axially in the rounded end of the master core. The pin 20 serves to center the mold cast on the master core.

The member 15 is then inserted in a vertical cylinder 21 as shown in FIG. 6 having an interior diameter sufficient to leave enough thickness of the mold over the tips of the pins 16, and a flexible mold 21b is cast around the master core. A suitable material for this mold is P.V.C. or polyvinyl chloride commercially available under the trade name Elastomer 105. Suitable tooling for making this mold is shown in FIG. 6.

The steel core with its polyvinyl chloride covering is cured for three hours at $250^{\circ}\pm 10^{\circ}$ F. for the particular material given, and is then cooled and the elastic mold removed by slitting it along a longitudinal line and peeling it off the core as shown in FIG. 5. This flexible mold is used for producing a number of the low melting point metal cores or mandrels, on which the containers are formed, until it develops cracks, whereupon another is made. Suitable tooling for casting the low melting point cores are cast in the polyvinyl chloride mold is shown in FIG. 7. A center hole will be formed in the end of the mold by pin 20, and this hole is plugged with a stud projecting into the mold. The flexible mold is then inserted in a flexible tubular backing member 21a and a meltable core 22 is cast therein, the core being subject to dissolution under proper treatment. A suitable material is a low melting point alloy which melts at about $180^{\circ}\pm 10^{\circ}$ F., and the mold and meltable core are cooled to ambient temperature.

The meltable core 22 will then have accurately reproduced therein all projections of the master core 15 and serves as a form on which the basket will be formed by winding plastic impregnated glass roving made from glass filaments upon it.

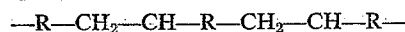
The meltable core is used as a mandrel, being mounted in a lathe-like machine, shown in FIG. 8, by the central end depression on the removable core formed by the inwardly projecting stud used to plug the hole made by pin

20 in the flexible mold formed on the master core, the smooth end of the removable core being gripped by the chuck of the machine. A small glass-mat patch, impregnated with plastic, is placed on the rounded end of the removable core and held in place by the pins projecting from the rounded end of the removable core.

The removable core is then wound with continuous rovings of glass fiber. The roving may be fed from a number of spools 23, in one actual case from six, and is drawn from the spools by having one end secured to the mandrel which is rotated by a motor 24 through a suitable transmission. The rotation of the mandrel draws the rovings through a travelling spacer head 25 which is reciprocated from end to end of the mandrel by any suitable means in timed relation to the rotation so that the glass fibers are laid in a helix at the desired angle to the axis of the core, in an actual case of 55° , which gives a good relation of hoop strength to axial strength.

The rovings are drawn under tension from the spools 23 caused by adjustable brakes 26 acting on the spindles 27 of the spools 23. The tension is sufficient to keep the rovings taut, but the operator can modify the travel of the roving manually and does so as the rovings reach the rounded end of the core, causing some of them to pass between the pins projecting from the end and pushing the patch of glass fiber mat firmly against the end of the core, others of the rovings wrap around the edge of the glass mat patch. The proportion of reinforcing fibers to plastic incorporated in the perforated container is adjusted to the requirements of the use to which the container is to be put. Suitable glass fiber roving is commercially available and roving comprising various numbers of fibers have been used, for example from 20 to 60, preferably with a chrome stearate finish sold under the trademark No. 12 Vitron finish as sold by the Libby-Owens-Ford Company, or equivalent.

A suitable resin for impregnation of the glass fibers or roving is a polyester resin having the structure of an unsaturated polyester, for example, ethylene glycol maleate:



where R is $OHOCH_2CH_2OCO$. One hundred parts by weight of the impregnating resin is mixed with an elevated-temperature curing agent such as 2% of 50% Benzoyl Peroxide in Tricresyl Phosphate sold under the trade name Garox by Ram Chemicals Company ($1\pm.5$ parts by weight), or Cumene Hydroperoxide sold under the trade name Duoprox by Thalgo Company ($.25\pm.6$ part by weight) and others equivalent.

The liquid plastic may be applied in any suitable manner; for instance, by brushing it onto the mandrel as the roving is laid thereon, or by running the rovings through a tank of liquid plastic. When sufficient layers have been wound on the mandrel, as indicated by the covering of the cylindrical portions of the pins projecting around the core, winding is stopped, the roving cut, the mandrel removed from the machine and the plastic cured by placing the removable mandrel and winding thereon in an oven at a temperature of $150^{\circ}\pm 10^{\circ}$ F. for a period of 14 to 30 minutes, which temperature is below the melting point of the meltable core. Alternatively the plastic covered core may be allowed to gel at ambient temperature for at least two hours.

The core with the cured plastic basket thereon is then machined, for instance by using a travelling-band sander, to bring the outside diameter to size and the end to proper contour after which the mandrel is hung with open end downward in an oven heated to about 200° F. for about one hour to melt out all the meltable core material and to cure the plastic.

The finish machining of the outside of the container may leave the surface of the container with a certain amount of fuzz due to the cutting of surface strands of glass fiber, which in some uses of the containers may not be disadvantageous. However, to give a good appearance it is preferred to cover the fuzz and provide a smooth sur-

face by giving the container a flow coat of thinned plastic 14b (FIG. 2) mixed with a low temperature curing agent which produces an even surface over the whole exterior surface and edges of the holes, and the flow coat is then cured at ambient temperature. Any suitable low temperature curing agent such as methylethylketone peroxide sold under the trade name "10A Setting Fluid" or "Garako 100 (cobalt naphthenate, 2% solution)" both sold by the Thaco Company, and the polyester resin thinned, for instance, with acetone, may be used for the flow coat. The proportion of "10A Setting Fluid" to 100 parts by weight of the plastic being 1_{-0}^{+1} by weight and of "Garako" being $.5_{-0}^{+.5}$ by weight.

The container or basket may be worked to provide means for mounting it in position by threading it or by securing a mounting member to it by a suitable plastic adhesive.

It is to be understood that various changes in detail may be made in carrying out the novel method of making a perforated reinforced plastic container; for instance, rovings of glass fiber embedded in partially cured plastic, and in the form of narrow tape, may be wound upon the removable core instead of winding glass fiber rovings and impregnating them with liquid plastic. If this modification is used, the heat of the curing oven will cause the partially cured plastic to soften and melt into a uniform layer before becoming cured.

In igniter containers for rocket motor combustion chambers it is to be noted that the stresses are greatest at the end of the container by which it is mounted and that if one basket at a time was produced the optimum lay of the reinforcing fibers might not be secured at this point. To guard against this possible weakness it is preferred to produce two meltable cores, securing them base to base by forming axial conical holes into each, inserting the butt ends into a sleeve provided with a side opening communicating with the conical holes and pouring Cerrobend a fusible alloy having a composition of 26.5% lead, 13.5% tin, 50% bismuth, and 10% cadmium into the conical space to provide a single core unit of this material. The two cores then form a single mandrel and the winding of the plastic impregnated rovings of glass fiber is continued over the mounting ends of the cores in a manner to give a maximum hoop and axial strength to the baskets when cut apart.

Other suitable plastic and hardening materials than those specifically mentioned may be made use of as will be understood by those skilled in the art of producing articles from plastics. Further, the reinforcing filaments utilized may be other than of glass. For some uses of the receptacle, for instance, fine metal wires might be used. As examples of such other materials which are suitable for use may be mentioned epoxy type resins, phenolics, urea-formaldehyde resins, melamine resins and alkyd resins. It may be advantageous to use such plastics prepared by any suitable treatment to be somewhat resilient to better withstand excessive vibration.

A preferred embodiment of the perforated container and methods of producing it have been described herein by way of illustrative example and not as limitative of the invention, the scope of which is defined by the appended claims.

We claim:

1. A method of forming a perforated reinforced plastic container comprising the steps of: wrapping a plurality of rovings between projections on a removable core, impregnating the rovings with a bonding material, curing the bonding material, and removing the core.

2. A method of forming a perforated reinforced plastic container comprising the steps of: wrapping a plurality of

rovings in a helical pattern between projections on a removable core, impregnating the rovings with a bonding material, curing the bonding material, and removing the core.

3. A method of forming a perforated reinforced container comprising the steps of: wrapping a plurality of rovings in a crisscross pattern between projections on a removable core, impregnating the rovings with a bonding material, curing the bonding material, and removing the core.

4. A method of forming a perforated reinforced container according to claim 2 in which the rovings are wound in helices having an angle of 55° relative to the longitudinal axis of the container.

5. A method of forming a perforated reinforced container comprising the steps of: applying a mat to the end of an elongated removable core having a plurality of projections thereon, circumferentially wrapping a plurality of rovings between projections on the removable core, wrapping the rovings on the mat, applying an impregnation material on the rovings and mat, curing the impregnation material, and removing the core.

6. A method of forming a perforated reinforced container according to claim 5 which comprises the further step of painting a layer of bonding material to the core before applying the mat and rovings thereto.

7. A method of forming a perforated reinforced plastic container, comprising the steps of: wrapping a plurality of glass fiber rovings in a crisscross pattern between projections on a removable core impregnating the glass fiber rovings with a plastic material, curing the plastic material, and removing the core.

8. A method of forming a perforated reinforced container comprising the steps of: applying a glass fiber mat to the end of an elongated removable core having a plurality of projections thereon, circumferentially wrapping a plurality of glass fiber rovings between the projections on a removable core, wrapping the glass fiber rovings on the glass fiber mat, applying a plastic material on the glass fiber rovings and mat, curing the plastic material, and removing the core.

9. A method of forming a perforated reinforced plastic container comprising the steps of: painting a plastic coat on a removable core having a longitudinal axis and a plurality of projections thereon, applying a mat of glass fiber on the projections on the ends of a removable core, wrapping a plurality of rovings between the projections on the removable core and over the mat of the glass fiber in a crisscross manner at an angle of 55° to the longitudinal axis of the core, impregnating the rovings and mat with a plastic material, curing the plastic material, and removing the core.

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